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Redescription of the Australian metallic-green tomato fly, *Lamprolonchaea brouniana* (Bezzi) (Diptera: Lonchaeidae), with notes on the Australian *Lamprolonchaea* fauna

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Abstract

The twenty-four species of Lonchaeidae (lance flies) known from Australia commonly breed in a wide variety of organic matter, including fruit and vegetables. The metallic-green tomato fly (*Lamprolonchaea brouniana*) is the best known species, being an agricultural pest. However its common name is also applied to other similar bright metallic golden-green lance flies. Australian lance flies are generally relatively poorly understood taxonomically, with few species descriptions including (1) both male and female adults, (2) detailed descriptions of larval diagnostic morphological characters, and (3) molecular characterisation of the barcoding COI mitochondrial DNA region (no lance flies having been sequenced to date). The latter two could provide valuable tools to assist in identifying this species from larvae found in food produce, the most common life stage encountered, which are currently sometimes confused with economically important tephritid fruit fly larvae. In the current study we redescribe the morphological characteristics of adults, larvae and pupae as well as characterise the COI gene from the most common Australian lonchaeid fruit pest, *L. brouniana*, to enable an accurate species diagnosis. We provide a key to known Australian *Lamprolonchaea* species, and clarify the taxonomy of *L. brouniana*, including designating type material. This species appears to be restricted to Australia, and has been most commonly collected from the temperate south. Life history characteristics, including the timing of occurrence and host plant use, were also examined. Over the last decade south-eastern Australian larval samples were found over the warmer summer and autumn months from various fruit, most often (>70%) from tomato fruit, and not normally in association with other serious primary pests, such as Queensland Fruit Fly (*Bactrocera tryoni*).

Key words: Diptera: Lonchaeidae, Australia, pest of fruit, larval morphology, DNA barcoding, metallic-green tomato fly

Introduction

Over 500 species of Lonchaeidae (lance flies) have been described, in nine genera, from most forested regions of the world apart from New Zealand (Ferrar 1987). Almost sixty new species have been described in recent years from Asia / Middle East (MacGowan 2004, 2005b, 2006, 2007, 2008a), Africa (MacGowan 2005a) and Europe (MacGowan 2008b, 2009), however the taxonomy of Australian lonchaeid flies has not been recently reassessed, with the last new species being described thirty-five years ago (McAlpine 1975). In Australia there are currently twenty-four species recognised in four genera—*Lonchaea* Fallén, *Lamprolonchaea* Bezzi, *Silba* Macquart and *Dasiops* Rondani (Pitkin 1996), however taxonomically they are relatively poorly known with very few species descriptions including both male and female adults, and no detailed descriptions of larval stages.

Most of the twenty species of *Lamprolonchaea* occur exclusively in the Pacific / Australasian region and are rather similar morphologically, with golden-green or blue shining metallic bodies (McAlpine & Steyskal 1982, MacGowan 2005a), and species identification is generally dependant on the examination of the male genitalia (McAlpine 1964, MacGowan 2005a). However the metallic-green tomato fly, *Lamprolonchaea brouniana* Bezzi (1919), one of the most common species of lance fly in Australia (Colless & McAlpine 1991), possesses a distinctive pitted frons, which assists in distinguishing this species from other members of

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the genus. However another species, *L. smaragdi* (Walker, 1849), a cosmopolitan primary invader of tomato fruit that has reputably been recorded from Queensland, is also often referred to by this common name and these two species have been confused in the literature (e.g. Bezzi 1919, 1923, Pitkin 1996), with each also having multiple junior synonyms (e.g. Pitkin 1996), outlined below.

Problems associated with species identification are important, as correct species identification is an essential step in characterising an organism's geographic range and ecological requirements (e.g. Blacket *et al.* 2008). The metallic-green tomato fly has long been recognised as an agricultural pest of tomatoes in south-eastern Australia with French (1911) noting reports of large volumes of infested fruit in New South Wales (NSW) and even attacks on undamaged fruit in Victoria, causing considerable damage with hundreds of acres of tomato crops being ruined. There are some records of them being commonly found in decaying tomatoes and potatoes in New Zealand, where they have been reported as being introduced from NSW (French 1911, Tillyard 1926), but this appears to be an historical error (see below).

Identifying metallic-green tomato flies from larvae is even more problematic, and they are regularly mistaken for more economically important tephritid "true" fruit flies (e.g. noted by French 1911, Hely *et al.* 1982). Larvae are often found on the same host plants as "true" fruit flies and they are superficially similar morphologically, and also share the capability of skipping (springing or leaping) for a distance of several centimetres, believed to be a mechanism for avoiding patches of unsuitable habitat (Malloch 1928, Hely *et al.* 1982). However, the larvae of *L. brouniana* are quite distinctive morphologically (illustrated in Hely *et al.* 1982), exhibiting a characteristic projection of the posterior spiracles on very short horn-like projections, that viewed dorsally have three spiracle-slits that are almost at right-angles to one another (Hely *et al.* 1982, Ferrar 1987), in common with other Lonchaeidae which usually have the upper and lower slits at a 180° angle to each other (White & Elson-Harris 1992).

The main aims of this paper were: (1) To clarify the taxonomic confusion that existed within the closely related species within *Lamprolonchaea* that are commonly called metallic-green tomato flies; (2) To provide morphological redescriptions for adults as well as descriptions for other life stages (egg, larva and pupa) of the common Australian lonchaeid pest species, *L. brouniana;* (3) To characterise the COI (DNA barcoding) gene, for which no lonchaeid species has been sequenced to date, to enable accurate species diagnosis; and (4) To determine certain economically relevant ecological and life history characteristics of this pest species, such as the geographic range, timing of larval infestation and use of host plants.

Material and methods

This study is based on adult specimens held at: (AMS) Australian Museum, Sydney; (DAFWA) Department of Agriculture and Food Western Australia, South Perth; (MVM) Museum of Victoria, Melbourne; (NTDR) Northern Territory Department of Resources, Berrimah Farm, Darwin; (NZAC) New Zealand Arthropod Collection, Auckland; (VAIC) Victorian Agricultural Insect Collection, Department of Primary Industries (DPI), Knoxfield. Studied larval specimens, preserved in 70% ethanol, are held at the VAIC.

Measurements, in millimetres, of adult specimens were obtained from six male (Fremantle, WA; Bronte, Sydney, NSW; Northmead, NSW; Horsham, Vic; Thornbury, Vic; Vic reared Wellington NZ) and six female (Fremantle, WA; Bronte, Sydney, NSW; Sydney, NSW; Horsham, Vic; Yarrawonga, Vic; Vic reared Dunedin NZ) specimens from across the geographic range of *L. brouniana*, as well as from the type specimens of *L. rugosifrons* Bezzi (1923) [previously synonymised with *L. brouniana* by Pitkin 1996, see below]. Measurements were taken from composite automontage images obtained with a M205C Leica microscope and camera using the "Distance Line Tool" in the Leica Application Suite software (version 3.4.0). Maximum head width, and length and width of the thorax, scutellum and wings were measured dorsally. Thorax and scutellar widths were measured at the level of the supra-alar setae, and thoracic-scutellar area of contact respectively. Wing (Fig. 9) length was measured from the tip at R4+5 to the wing base; the width was from the upper edge of the wing, at the centre of h / Sc to just proximal to the tip of CuA_1. Discal medial cell length (interior width of the cell) was measured from the bm-cu crossvein through the anterior tip of the dm-cu

crossvein (see Fig. 9). Images used for measuring the frons included both the ocelli and the base of the antennae in the same picture. Frons length was measured from the anterior ocellus to the upper edge of the lunule, the upper frons width was measured proximal to the anterior ocellus, while the lower frons width was measured at the upper edge of the lunule; the length of the arista was also obtained from these images. Maximum lengths and widths were obtained from lateral images of the head, eye, and the third antennal segment (postpedicellus). The head length was measured through the centre of the eye from the ocelli to the lower edge of the subgena. Head and eye widths were measured just above the lunule. The lateral body (lunule to tip of last abdominal segment) and abdomen (edge of thorax to tip of last abdominal segment) lengths were measured through the specimen's midline with the "Segment Line Tool" in the Leica software to account for differential specimen curling. Excel (2003 version) was used to calculate averages, standard deviations and ranges, as well as for male and female comparisons (two-tailed t-tests) and eye to frons width ratios.

The abdomens of representative adult *L. brouniana* were photographed in situ to record their relative sizes and the locations of terminalia on the abdomen prior to dissection and automontage imaging. Terminalia were dissected in glycerine from abdomens of pinned specimens that had been cleared in 10% KOH overnight, and have been preserved in glycerol in capsules on the specimen pins. Terminology of the male and female terminalia follows McAlpine & Steyskal (1982) and White *et al.* (1999).

Larval instars were determined by comparing the relative size and external morphology of individual larvae within a sample. Automontage images of all larval instars were obtained using the Leica microscope. Some larval specimens were cleared in 10% KOH overnight prior to dissection of the mouthparts and posterior spiracles. The characters used for the description of the morphology of third instar larvae and pupae follows the recommendations of Ferrar (1979) and White & Elson-Harris (1992) and descriptive terminology follows Ferrar (1987). A series of south-eastern Australian larval specimens of *L. brouniana* (from the VAIC), that were collected incidentally over the last decade from fruit samples examined for the presence of Queensland Fruit Fly (*Bactrocera tryoni* Froggatt), were studied to determine fruit host preferences and seasonal abundance of *L. brouniana*. All of the larval samples examined for host plant use and number of samples collected per year always included some third instar specimens that matched the morphological description given below (i.e. with characteristic anterior spiracles and a lateral pigmented ring on the posterior spiracles). Excel (2003 version) was used for calculating correlations between time and the number of insect samples, number of tomato samples and number of *L. brouniana* collected.

Samples of *L. brouniana* (VAIC), that included both larvae and laboratory reared adults, were examined for molecular variation in the current study. Six larval specimens (Buronga, NSW; Swan Hill, Vic; Porepunkah, Vic; Ascot Vale, Vic; Flemington, Vic; Bairnsdale Vic) from across the south-eastern Australian range of *L. brouniana* were sequenced for the mitochondrial Cytochrome Oxidase I (COI) gene using standard protocols. Briefly, DNA was extracted from larval specimens using Qiagen Blood and Tissue kits and the PCR primers LCO and HCO (Folmer *et al.* 1994) were employed to amplify approximately 700 b.p. of COI. PCR conditions included using 1x BSA and 35 cycles of amplification with an annealing temperature of 45°C on an Eppendorf (Mastercycler epgradientS) PCR machine. DNA sequences were obtained commercially using an Abi sequencer through Macrogen Inc (Korea). MEGA version 4.0 (Tamura *et al.* 2007) was used to visualise, align, and examine differences between DNA sequences and to translate them into their predicted amino-acid sequences. DNA sequences have been submitted to GenBank (HQ261232–HQ261237) and also to the Bar Code of Life database (Project: AAPL, Australian Arthropod Pests – Lonchaeidae), together with diagnostic photographs of associated adults and larval instars. Measurements of maximum length and width of each larval instar were taken from these photographs, as above using the "Segment Line Tool" of the Leica software. These images show typical variation in larval morphology (e.g. variation in the degree of pigmentation of the lateral posterior spiracle ring). All other images (adults, pupae, eggs) presented in the figures below were also obtained using the Leica microscope and automontage software.

Results

Lamprolonchaea brouniana (Bezzi 1919)

Lonchaea splendida Broun 1904: 307. (Homonymous with *Lonchaea splendida* Loew 1873)
Lonchaea brouniana Bezzi, 1919: 246.
Lamprolonchaea rugosifrons Bezzi, 1923: 183. (Synonymised by Pitkin, 1996: 476)

Material examined. Type specimens: ♂, AUSTRALIA; Sydney, "K48703", 26 Dec 1920, *Lamprolonchaea rugosifrons* n.sp. mf ", "TYPE', specimen on minuten pin, here designated lectotype (AMS). ♀, Sydney 26 Dec 1920, SPHTM Coll, here designated paralectotype (AMS). ♀, Sydney, 30.x.1921, Health Dept, "*Lonchaea rugosifrons* Bezzi, here designated paralectotype (MVM).

Type (not previously designated) location Sydney, Broun (1904). Broun (1905) is a duplicate species description that includes a photographic plate; Broun (1905) notes that while being sent away for the preparation of this plate his specimens were damaged in transit. Bezzi (1919) was a nomenclatural note (see below) that did not add any associated type material for *L. brouniana*.

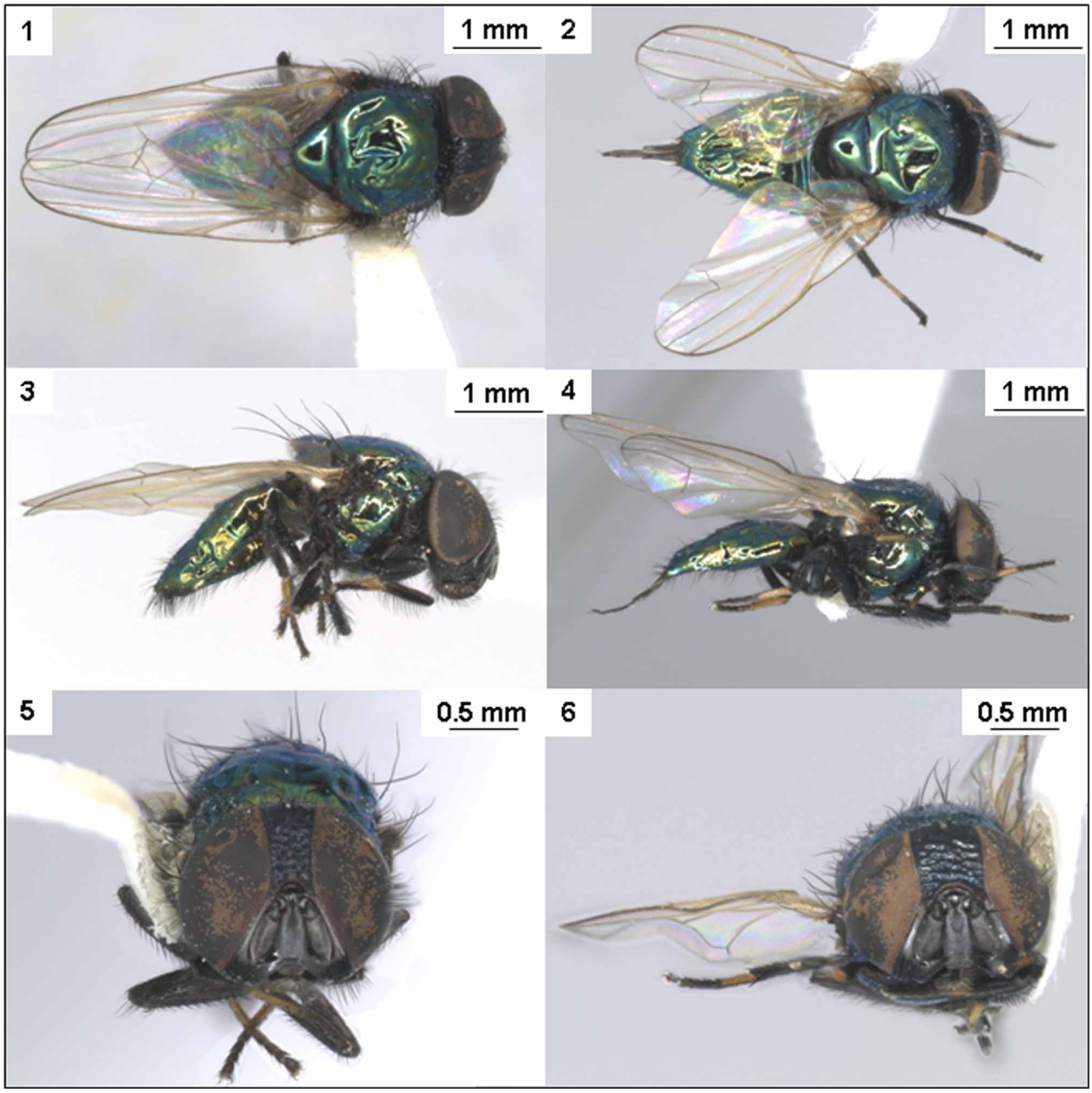
Other (adult) specimens: **AUSTRALIA; New South Wales:** ♀, Bilpin nr Kurrajong, 27 Oct 1980, NW Rodd, in AM; ♂, Wahroonga, Sydney, 20 Nov 1926, in AM; ♂, Yass, 14 Dec 1931, in AM; ♂, Northmead, 26.Jan.1963, DK McAlpine, in AM; ♂, same loc., 4 Feb 1963, N. Gregg, in AM; ♂, ♀,Bronte, near Sydney, 13 Nov 1960, DK McAlpine, in AM; ♀, Katoomba, 13.Nov 1958, "*Lamprolonchaea brouniana* Bezzi det. by JF McAlpine (AMS) . 2♀, Murray R 80 km W of Wentworth, 22.xi.1967, A. Neboiss (MVM). ♀, Brewarrina WWF, "*Lamprolonchaea brouniana* JF McAlpine 1960, in MV. 3♂, 3♀, NSW, Feb.1966, bred from tomato (VAIC).

Northern Territory: 3♂,♀, Darwin, 22.ii.1984, S. Collins, ex peaches from Pickering Brook WA; 2♂, 4♀, Anula Supermarket, 11.ii. 1981, J. Freeman, ex nectarines; ♂, 3♀, Curtain Springs Roadhouse, 1.vi.1993, M. Barton, reared from *Solanum melongena*; 13♂, 4♀, Arid Gold Farm, Ti Tree, 29.i.2001, collected from CUE trap during an outbreak and eradication; ♂, Tennant Creek, 20.ii.1997, Mrs Hopf, ex *Citrus limon*; ♂, Alice Springs, 4.vii.1977, J. Bobb, bred from orange; 5♂, 9♀, Alice Springs, 5.xii.1978, F. McEllister, ex tomato; 4♂, 15 km N of Alice Springs, 18.iv.1982, emerged 24.v.1982, ex *Solanum* sp. (NTDR).

Queensland: 2♂, Dalby, 20 Feb 1935, bred from tomatoes, "*Lamprolonchaea brouniana* Bezzi det. by JF McAlpine 1960. 2♂, 2♀, Esdivold, "24", Bancroft, bred from tomatoes, SPHTM Coll (AMS).

Victoria: ♂, 2♀, Warburton, F.E. Wilson, 13 Jan 1924; SPHTM Coll (AMS). ♂, 3♀, Preston; ♂, Eltham, 8.xii.1918, CE Cole; ♀, Croydon, 13.ii.08; ♂, Melbourne, 15.i.28, GF Hill; 3♀, Nunawading, 9.i.1968, Neboiss, "*Lamprolonchaea* sp det. DK McAlpine 1979" ♂, Mt Albert, 15.iii.47, R.T.; 3♂, 5♀, 1 puparium, Windsor, out of tomato, T.K., 02.08; ♂, ♀, Melton, 27.i.1957, A. Neboiss; ♂, Kerang, 11.v.1946, RE Trebilock, ♂, same except, 26.v.1946, 3♀, same except, 24.xi.1946; ♂, 1(headless), Ardmona, 1.xi.1928, GF Hill, "*Lamprolonchaea brouniana* det. J.F. McAlpine 1960"; ♀, Grampians, 12.94; ♂, ♀, Little Desert, 12.xi.1958, FE Wilson; ♀, 17 km SE Merrijig Howqua River, 1.xii.1971, Neboiss; ♂,♀,20 km NNE Horsham, 29.x.1982, KL Walker, on Eucalyptus; 2♀, 40 km NW Donald, 29.x.1982, KLWalker, on Eucalyptus; ♂, ♀, 38 km N Birchip, 29.x.1982, KLWalker, on Eucalytpus; ♂, ♀, 46 km N Ouyen, 30.x.1982, KLWalker; 2♀, Cape Otway, 29.xi.1966, A. Neboiss; 2♀, Glenelg R, 6 km NNE Nelson, 25.xi.1966, A. Neboiss (MVM).3 ♀, Victoria, oranges, reared Dunedin, "X no. 6", 20.i.1922; ♂, same locality, reared Wellington, 22.i.1922; 2♂, same locality, reared Dunedin, i.1922, one labelled "*Lonchaea splendida*; all Coll. Miller (NZAC). ♀, Tatura, 14 15.iii.1991, on Japanese millet, M.Malipatil and K.L. Dunn; ♂, 1 missing head, Kyabram, in tomatoes, emerged 10.iv.1907; 2♂, 2♀, 4 pupae, Ararat, H.W.Davey; ♂, 2 pupae, Geelong, H.W.Davey; 2♂, 4♀, Port Melbourne, Feb.1950, V.Sloane; 2♀, Werribee, xi.1940, HA. Barnham; 3♂, 3♀, several larvae, several pupae, Yarrawonga, 13.ii.2009, S. Lewis, ex domestic tomatoes; ♂, 6♀, 7 pupae, several larvae, Thornbury, 20.ii.2002, C.Pollard, ex tomato fruit; ♀,1pupa, Cobram, Dec 1997, ex *Citrus sinensis* fruit; ♂, Cobram East, 23.i.2001, M.Malipatil, on peach leaves; ♂, Knoxfield, Dec.2002, B.Henderson, in glasshouse; ♀, also larvae and puparia, Barham, 18 Dec 2010, A. Anderson, ex avocado fruit reared 4 Jan 2010; 3♂, also larvae and puparia, Flemington, 6 Jan 2010, D. Mansell, ex tomato fruit reared 22 Jan 2010; ♂, also larvae, Echuca, 12

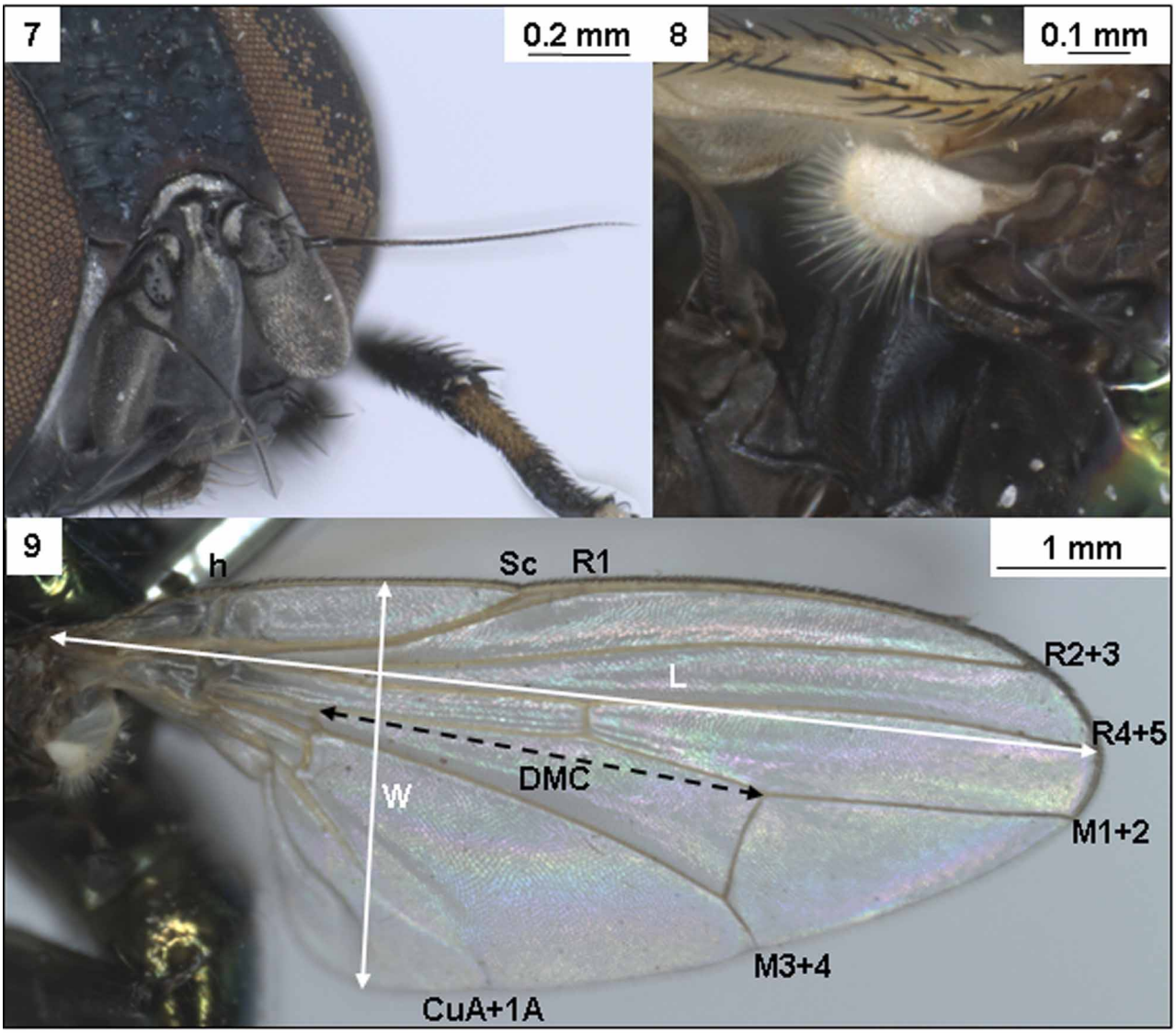
Mar 2004, K. Ockerby, ex eggplant fruit reared; 5♂, 1 ♀, also larvae and puparia, Heywood, 15 Jan 2010, W. Stevens, ex tomato fruit reared 31 Jan 2010; 2♀, also larvae and puparia, Ascot Vale, 8 Jan 2010, N. Gerad, ex tomato fruit reared 30 Jan 2010; 2♂, ♀, also larvae and puparia, Sale, 18 Jan 2010, J. McBay, ex tomato fruit reared 9 Feb 2010 (VAIC).



FIGURES 1–6. *L. brouniana* adults – 1, 3, 5) male, Thornbury, Vic; 2, 4, 6) female,Yarrawonga, Vic. 1–2) habitus, dorsal views; 3–4) habitus, lateral views; 5–6) head, frontal views.

Western Australia: ♂,♀, Bunbury, 17.ii.1954, A.Neboiss (MVM). 2♂, Bunbury, 1 20 Oct 1955, A. Snell; ♂, Cape district, 28 km S of Bunbury, 7 Jan 1957, A. Snell; ♂, 18 km E of Wicherina, 25.ix.1964, G.L. Bush; ♀, 18 km W of Eucla, 13.ix.1964, G.L. Bush; all "*Lamprolonchaea brouniana* Bezzi det. by JF McAlpine (AMS). ♂, ♀, Fremantle, 11.i.1954, KR Norris, "*Lamprolonchaea brouniana* det. JF McAlpine 1960"; ♀, Capel, 7.i.1957, Snell; ♂, Beelerup, 25.ii.1958, Snell (MVM). 4♂, 2♀, Carnarvon, -.x.1955, ex capsicums; 2♂, Dalkeith, Perth, ex tomato fruit reared 16.ii.1989, J. Bradshaw; 2♀, Geraldton, 14 Oct 1947, F. Ryan; 2♂, 2♀, Kununurra, ex overripe rockmelon collected maggots 7.vi.1990, flies emerged 19.vi.1990, G.R. Strickland;

30♂, 4♀, Lake Bryde, 16.xii.1974, K.T. Richards; 2m 7♀, Middle Swan, 15.vi.1972, ex Sodam Apple, D.L. Hardey; 2♂ 2♀, Narrogin, March 1979, ex Tomatoes; ♀, Nedlands, 15.4.46 FE, reared in lab from Apple of Sodom; ♀, North Gingin, 17.ix.1969, K.T. Richards; ♂, Perth, bred in insectory from Walnuts, 22-4-55, E. Elkington; 4♂, 4♀, Swan River, March, L.J. Newman; ♂, Wanneroo, May 1955, bred from tomatoes in lab, Mrs Edwards; 4♂ 4♀, Wanneroo, ex cowdung, 15.iii.1997, D.F. Cook, "*Lamprolonchaea brouniana* Bezzi det. D.K. MacAlpine"(DAFWA).



FIGURES 7–9. *L. brouniana* adults – 7, 8) female, Yarrawonga, Vic; 7) antennae enlarged; 8) right wing base with calypter enlarged. 9) male, Northmead, NSW, right wing. *Abbreviations:* DMC, discal medial cell length; L, length; W, width.

Diagnosis. Adult fly moderately large (relative to other *Lamprolonchaea*), approximately 3.5–4.5 mm body length, bright metallic golden-green in colour, with black head, a shiny-black frons entirely covered with large irregular coarse pits (rugose), dusky grey antennal postpedicellus, white calypters, clear iridescent wings, legs with femora ventrally fringed with long black setae and yellowish basal tarsal segments

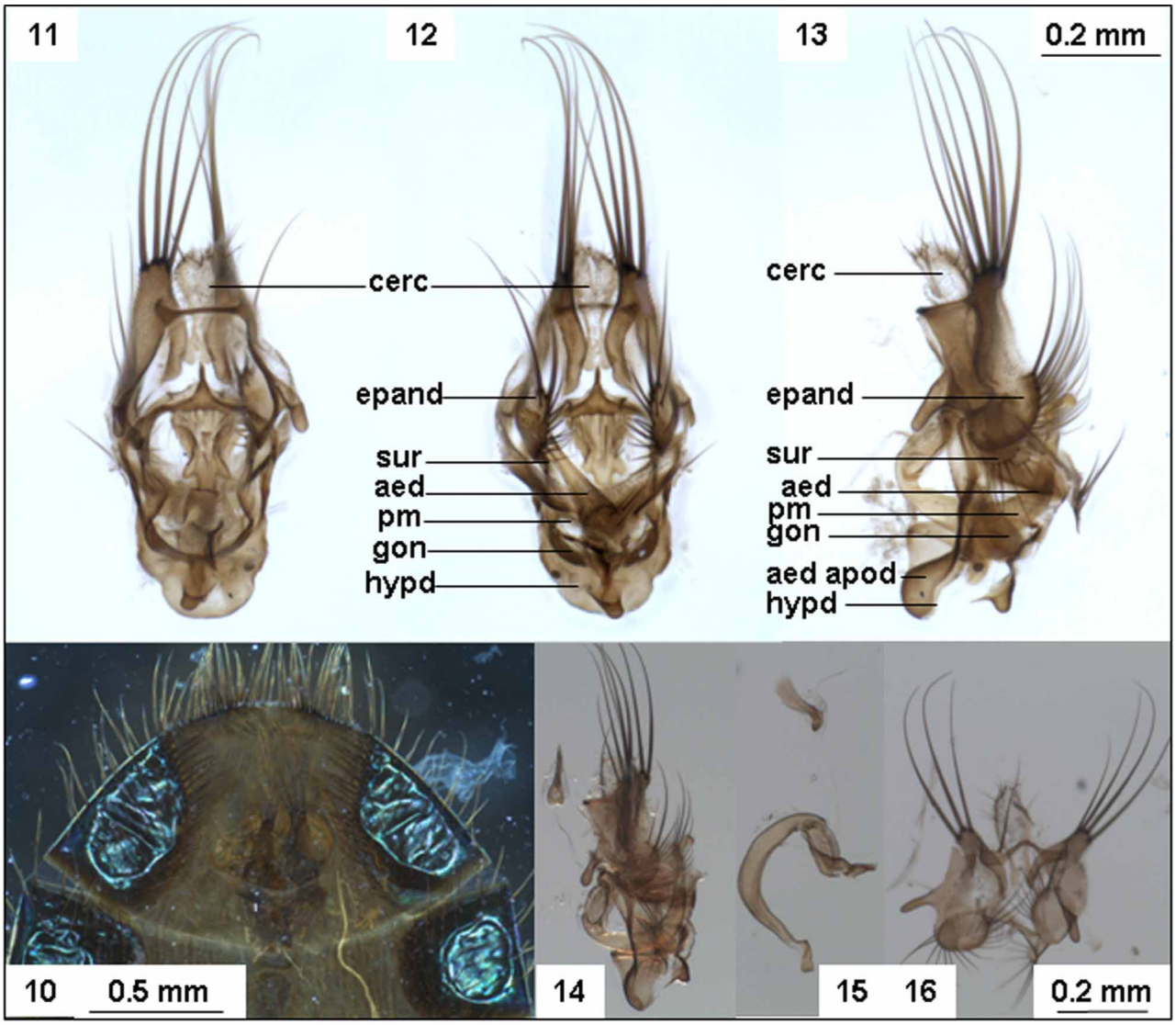
Description. Adults (Figs. 1–19)

Males. General body colour bright metallic golden-green except head which is black (Figs. 1, 3, 5).

Head: Eyes chocolate-brown coloured, large rounded externally and oval in shape (Fig. 3, 5). In live specimens the eyes are reddish-brown. Frons narrow, widening at top (Fig. 5), lower frons width 0.5 of one eye, upper frons width 0.6 of one eye, shiny black with greenish or bluish reflections, covered with large

irregular and indistinct pits on almost entire surface giving a rugose appearance. Ocelli small, forming three points of a triangle. Strong setae present along margin of genal plate, fine subequal setula on frons up to orbital setae. Head setae previously illustrated in Colless & McAlpine (1991); outer vertical setae 2/3 length of inner vertical setae, ocellar setae proclinate, subequal to inner vertical setae, orbital setae subequal to outer vertical setae. Postocular setae ½ (inner) to ¼ (outer) length of outer vertical setae. Lunule bare, black or reddish-brown and silver dusted, as is face and parafacials. The antennal postpedicellus dusky grey and three times as long as wide, arista often pale at base black at tip, entirely bare. Short robust oral setulae along subgenal margin. (Figs. 1, 3, 5).

Thorax: Thorax dorsally only slightly longer than broad, narrowed at rear with a strong groove between the mesonotum and scutellum, entirely shining, and devoid of dust (Figs. 1, 3). Scutellum, on margin, with 2, one apical and one subbasal, pairs of long setae (lateral setular) and 1–4 short lateral scutellar setulae (often broken off). Thoracic sclerites shining metallic-green with no dust, and numerous fine setula and long robust setae: single stigmatal seta, two posterior and two or more anterodorsal mesoplural setae, single humeral seta and single anterior and posterior notoplural seta, four strong postsupra-alar setae.



FIGURES 10–16. *L. brouniana* adult male terminalia, – 10-16) Thornbury, Vic; 10) Last abdominal segments, ventral view; 11) terminalia, dorsal view; 12) terminalia, ventral view; 13) terminalia, lateral view. 14) terminalia with accessory ejaculatory apodeme attached; 15) phallus and ejaculatory apodeme, dissected; 16) cerci and associated structures, dissected. *Abbreviations:* aed, aedeagus; aed apod, aedeagal apodeme; cerc, cercus; epand, epandrium; gon, gonopod; hypd, hypandrium; pm, paramere; sur, surstylus.

Legs black, basal tarsomeres yellow except at apices, other tarsomeres black and cordiform, femora ventrally fringed with long, dense black setae. Pretarsus and claws black, ariolum white with paired lobes that are often extended (Figs. 3, 5).

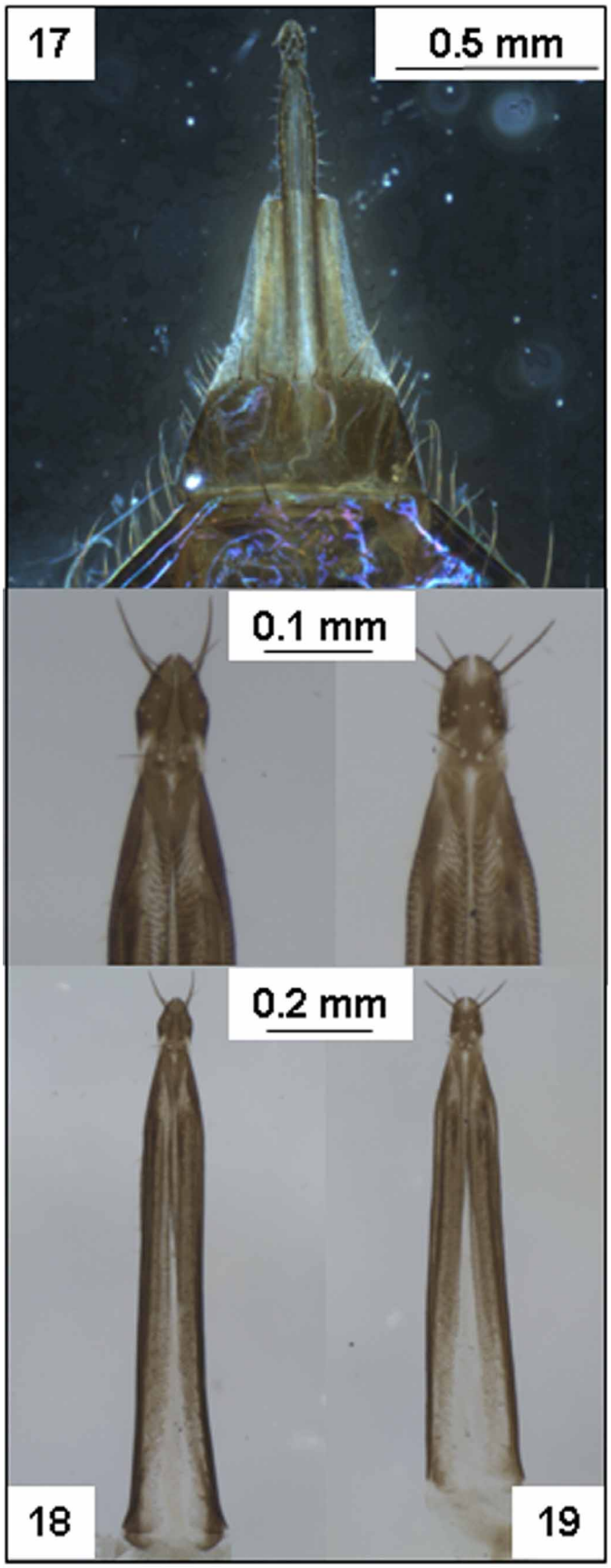
Wings ~3.5 mm long, clear and iridescent, with a distinct whitish tint, anterior margin of costa covered with dense dark spinules which gradually become shorter and thinner from base to apex of wing, all veins pale yellowish. The pattern of veins was previously illustrated in Colless & McAlpine (1991). Calypters whitish and white fringed, halteres black, transversely knobbed at the tips, their stalks rather long and slender (Figs. 3, 8).

Abdomen: Abdominal tergites glistening and coloured like mesonotum, with golden and coppery reflections, 5 visible tergites, with strong closely placed, almost divided into two tufts, black setulae at end of tergite 5, the latter about as long as combined length of tergites 3 and 4 (Fig. 3).

Terminalia: Short, projecting forward internally to about half length of abdomen, tips of setae on epandrium extending posteriorly to tip of abdomen (Fig. 10). In dissected terminalia (Fig. 11–16), cerci soft and flaplike, covered with fine setulae and spinules particularly on apical margin; epandrium large, posteriorly produced to a semi-circular, lobe with several strong setulae on posterior margin, apically produced to a small lobe with rounded margin and armed with 3 or 4 strong setae 1 ½ x longer than epandrium itself, and 2/3 length of remainder of terminalia, antero-laterally produced to a narrow pointed process. Surstyli smaller than epandrium, semi-circular and bearing a marginal fringe of strong setae. Phallus short and simple, in lateral view C-shaped with a characteristically angled and slightly thickened apex (Fig. 15). Ejaculatory apodeme narrow platelike, slightly broadened towards apex (Figs. 14–15)

TABLE 1. Specimen measurements of *L. brouniana*. Details of each measurement are described in the text. T-test probability values for differences between males and females of $P < 0.10$ are included. *Abbreviations:* **L,** Length; **W,** Width; **DMC,** Discal Medial Cell; **SD,** Standard Deviation; **n / s,** non-significant.

	Lectotype Male	Paralectotype Female	Male Average (± SD)	Male Range	Female Average (± SD)	Female Range	T-test
Body L (lateral)	4.17	3.63	4.07 ± 0.23	3.68–4.31	3.74 ± 0.25	3.44–4.06	<0.04
Head L (lateral)	1.27	1.06	1.22 ± 0.10	1.02–1.30	1.14 ± 0.07	1.06–1.25	n / s
Head W (lateral)	0.69	0.56	0.66 ± 0.08	0.59–0.77	0.63 ± 0.04	0.56–0.67	n / s
Head W (dorsal)	1.51	1.37	1.45 ± 0.09	1.28–1.57	1.42 ± 0.09	1.30–1.55	n / s
Eye L (lateral)	1.14	0.95	1.10 ± 0.09	0.93–1.18	1.00 ± 0.06	0.94–1.09	<0.05
Eye W (lateral)	0.66	0.51	0.61 ± 0.10	0.47–0.75	0.58 ± 0.04	0.51–0.64	n / s
Frons L	0.48	0.43	0.51 ± 0.06	0.42–0.59	0.45 ± 0.04	0.41–0.50	<0.07
Frons W Lower	0.31	0.45	0.30 ± 0.02	0.27–0.33	0.45 ± 0.03	0.40–0.48	<0.01
Frons W Upper	0.38	0.47	0.38 ± 0.02	0.34–0.40	0.48 ± 0.04	0.42–0.53	<0.01
Antenna L (postpedicellus)	0.31	0.33	0.32 ± 0.02	0.28–0.34	0.33 ± 0.02	0.30 – 0.37	n / s
Antenna W (postpedicellus)	0.13	0.11	0.11 ± 0.01	0.10–0.12	0.12 ± 0.01	0.11–0.13	n / s
Arista L	0.68	0.59	0.59 ± 0.05	0.51–0.65	0.59 ± 0.04	0.53–0.65	n / s
Thorax L (dorsal)	1.32	1.13	1.24 ± 0.14	0.99–1.36	1.18 ± 0.06	1.10–1.26	n / s
Thorax W (dorsal)	1.32	1.11	1.24 ± 0.13	1.02–1.40	1.22 ± 0.10	1.11–1.34	n / s
Scutellum L	0.47	0.41	0.45 ± 0.02	0.42–0.48	0.43 ± 0.04	0.36–0.47	n / s
Scutellum W	0.67	0.59	0.67 ± 0.07	0.60–0.79	0.62 ± 0.06	0.54–0.69	n / s
Scutellar seta L	0.60	0.62	0.64 ± 0.07	0.56–0.75	0.56 ± 0.04	0.50–0.62	<0.07
Wing L	3.61	3.19	3.50 ± 0.22	3.16–3.76	3.42 ± 0.33	3.04–3.81	n / s
Wing W	1.33	1.24	1.38 ± 0.11	1.20–1.52	1.29 ± 0.13	1.17–1.53	n / s
Wing DMC L	1.54	1.44	1.51 ± 0.12	1.30–1.64	1.52 ± 0.10	1.40–1.66	n / s
Abdomen L (lateral)	2.03	1.63	1.85 ± 0.16	1.69–2.12	1.67 ± 0.13	1.48–1.84	<0.06



FIGURES 17–19. *L. brouniana* adult female terminalia – 17) Thornbury, Vic; 18) Nunawading, Vic; 19) Bunbury, WA. 17) last abdominal tergites, ventral view; 18–19) aculeus, complete dorsal view, and enlarged.

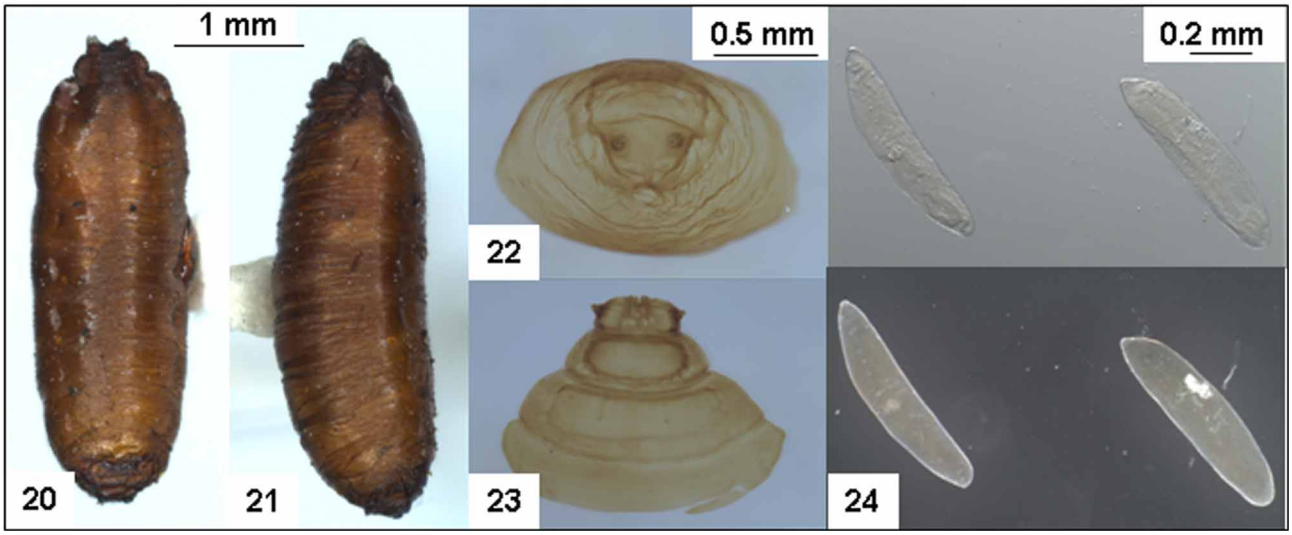
Females. Generally as in male (Figs. 2, 4, 6) except: slightly shorter body, abdomen, eye, and scutellar setae (Table 1); frons much wider and more parallel sided (Fig. 6), lower frons width 0.8 of one eye, upper frons width 0.8; of one eye; femoral fringe slightly less prominent and the tarsomeres are paler in colour, with both the basal plus the second tarsomere often yellow; abdomen with 6 visible tergites, sixth tergite about as long as fifth (Fig. 4), with no paired tuft of setulae at apex.

Aculeus relatively short (~1.0 mm), broad (~0.2 mm), and black, shaft slender (Figs. 17–19); basal segment has one row of submarginal sparse short setulae on both dorsal and ventral surfaces, central membrane spiculose in middle 1/3 area (as in Fig. 52 of McAlpine & Steyskal 1982), gradually widening slightly from base to apex; apical segment ends in bluntly rounded apex, about 1 ½ as long as broad, subbasal dorsal setae (one pair) about ½ as long as apical segment, and as long as apical pair, two longest preapical ventral setulae about as long as the segment, Note, apical setulae number variable and often rubbed off (Figs. 17–19).

Pupae (Figs. 20–23)

Material examined: AUSTRALIA;**Victoria:** Ararat, 4 specimens; Ascot Vale, 2 specimens; Cobram, 1 specimen; Flemington, 3 specimens; Geelong, 2 specimens; Heywood, 6 specimens; Knoxfield, 1 specimen; Sale, 3 specimens; Thornbury, 8 specimens; Yarrawonga, 15 specimens (VAIC).

Approximately 4 mm long and 1 mm wide (Fig. 20–21) barrel-shaped, with former larval segments marked by slight indentations, surface covered in transverse wrinkles, anterior end slightly compressed dorso-laterally, with a short lateral ridge on either side, and anterior spiracles represented by two small knobs on either side of "head" area (Fig. 23). The posterior spiracles represented by a pair of knobs, each with 3 narrow slits similar to in larvae (Fig. 22). In the laboratory at Knoxfield DPI, pupal stadium lasted for 11 to 14 days at 25ºC (mean =12 days, n =5 clutches, total 17 pupae).

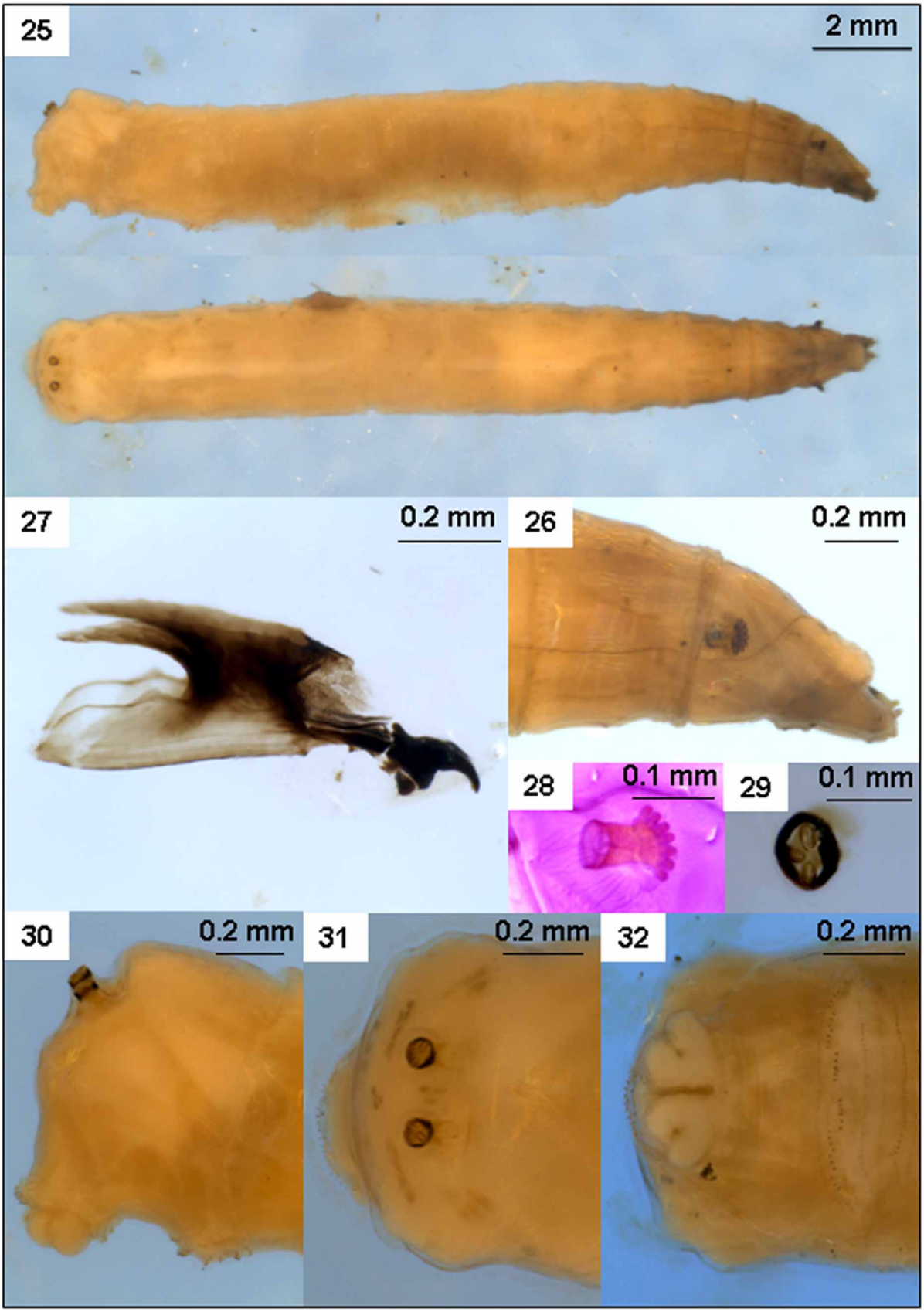


FIGURES 20–24. *L. brouniana* – 20–23) Thornbury, Vic: 20) puparium, dorsal view; 21) puparium, lateral view; 22) puparium, posterior spiracles; 23) puparium, anterior spiracles. 24) eggs, Bunbury, WA.

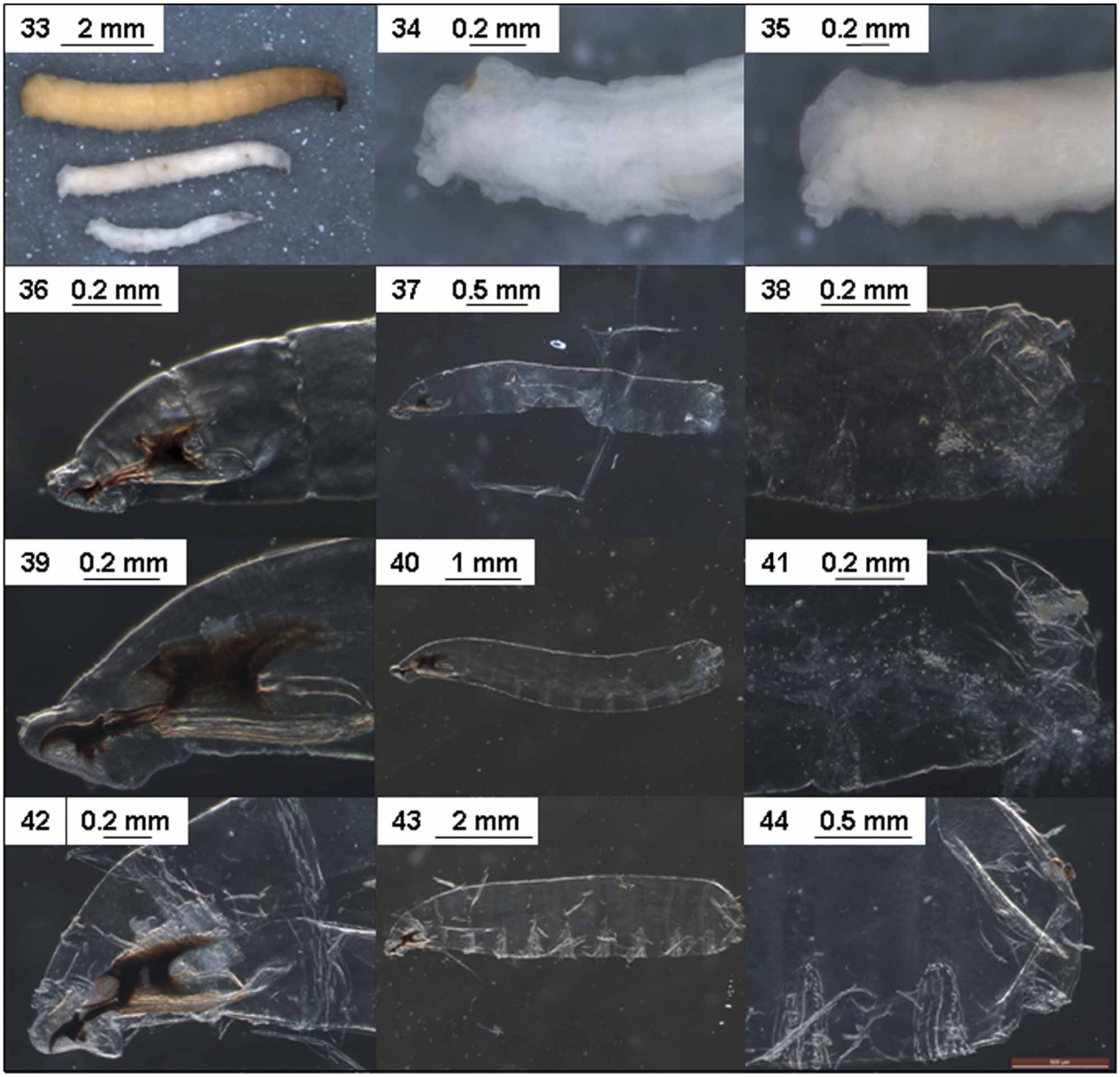
Larvae (Figs. 25–44)

Material examined: AUSTRALIA; New South Wales: ***Avocado:*** Barham, 18 Dec 2009; ***Capsicum:*** Barooga, 17 Mar 2008; Tocumwal, 6 Mar 2007; ***Citrus:*** Tocumwal, 17 Feb 2009; 27 Nov 2008; 1 Dec 2008; 1 Nov 2008; 2 Dec 2008; ***Stone Fruit:*** Tocumwal, 17 Feb 2009; 4 Feb 2009; 3 Feb 2009; 28 Feb 2007; ***Tomato:*** 32 km from Swan Hill, 18 Jan 2006; Barooga, 10 Apr 2008; Tocumwal, 2 Feb 2009; 14 Feb 2008; 18 Dec 2002; 14 Mar 2007; ***unknown host:*** Rock Valley, 28 Dec 1950.

Victoria: ***Apricot:*** Wangaratta, 20 Jan 2009; ***Avocado:*** Nichols Point, 10 Feb 2005; ***Capsicum:*** Chiltern, 30 Mar 2007; Rutherglen, 20 Feb 2007; Wahgunyah, 28 Mar 2007; ***Citrus:*** Moonee Ponds, 10 Nov 2008; ***Eggplant:*** Ascot Vale, 8 Apr 2008; Echuca, 12 Mar 2004; Eldorado, 28 Apr 2008; Myrrhee, 17 Mar 2008;



FIGURES 25–32. *L. brouniana*, Third instar larva, Echuca, Vic – 25) Lateral and dorsal views of whole larva; 26) anterior, lateral view ; 27) mouthparts dissected; 28) anterior spiracle (acid-fuchsin stained); 29) posterior spiracle; 30) posterior, lateral view; 31) posterior, dorsal view; 32) posterior, ventral view showing anal plate.



FIGURES 33–44. *L. brouniana* larvae, Porepunkah, Vic, 36–44) after clearing in KOH – 33) 1st, 2nd and 3rd instars; 34) 1st instar posterior, lateral view; 35) 2nd instar posterior, lateral view; 36) 1st instar anterior, lateral view; 37) 1st instar, lateral view; 38) 1st instar posterior, lateral view; 39) 2nd instar anterior, lateral view; 40) 2nd instar, lateral view; 41) 2nd instar posterior, lateral view; 42) 3rd instar anterior, lateral view; 43) 3rd instar, lateral view; 44) 3rd instar posterior, lateral view.

Rutherglen, 29 Mar 2007; Waaia, 4 May 2005; ***Grapefruit:*** Euroa, 15 Apr 2008; Rutherglen, 18 Dec 2007; Yarrawonga, 13 Jan 2009; ***Lemon:*** Moonee Ponds, 18 Nov 2008; Wangaratta, 21 Jan 2009; ***Mandarin:*** Springhurst, 3 Dec 2008; ***Nectarine:*** Wangaratta, 11 Feb 2009; ***Orange:*** Boorhaman, 3 Dec 2008; Wangaratta, 17 Feb 2008; ***Peach:*** Eldorado, 18 Jan 2006; Kyneton, Dec 1999; Mildura, 31 Mar 2009; Narre Warren, 15 Jan 2001; Wangaratta, 8 Feb 2008; Warracknabeal, 22 Feb 2008; ***Peach or Tomato:*** Bendigo, 5 Jan 2001; ***Stone Fruit:*** Baddaginnie, 31 Mar 2008; Benalla, Feb 2002; Shepparton, 2 Mar 2006; Waaia, 4 May 2005; ***Tomato:*** Airport West, 20 Mar 2008; Ascot Vale, 16 Apr 2008; 5 Mar 2009; Barwidgee, 4 Feb 2009; Beechworth, 2 Mar 2009; 27 Feb 2009; 2 Apr 2008; Benalla, 2 Dec 2008; 19 Feb 2007; 3 Apr 2007; 4 Apr 2007; 4 Apr 2007; 4 Apr 2007; 5 Apr 2007; Bendigo, 9 Feb 2009; Boho, 11 Mar 2009; Bunbartha, 1 Apr 2004; Bundalong, 20 Mar 2009; Castlemaine, 30 Jan 2001; Chiltern, 30 Mar 2007; 30 Mar 2007; Dereel, 3 Mar 2001; Devenish, 20 Mar 2008; Echuca, 21 Jan 2009; 14 Feb 2005; Eltham, 28 Mar 2008; 31 Jan 2000; 12

Feb 1999; Essendon, 27 Mar 2008; Euroa, 11 Apr 2008; 10 Apr 2008; 15 Apr 2008; Flemington, 9 Feb 2009; Footscray, 11 Mar 2008; Gapsted, 21 Feb 1940; Glenrowan, 10 Feb 2009; Kensington, 16 Feb 2008; Kerang, Jan 1999; Koonoomoo, 16 Feb 2007; Kotupna, 13 Feb 2006; Lower Templestowe, 21 Feb 2008; Lurg Upper Greta, 6 Mar 2009; Maffra, 3 Feb 2004; Melbourne, Jan 2001; Mildura, 30 Nov 1999; Moama, 8 Mar 2009; Moonee Ponds, 25 Mar 2008; Moorabbin, 22 Jan 2001; Myrtleford, 14 Mar 2008; Narre Warren, 5 Feb 2009; Oxley, 18 Apr 2008; Oxley, 21 Apr 2008; Parkville, 25 Jan 2001; Paynesville, 6 Feb 2008; Pyramid Hill, 21 Jan 2005; Raywood, 7 Mar 2006; Rushworth, 20 Mar 2008; Rutherglen, 20 Feb 2007; 29 Mar 2007; 5 Apr 2007; 29 Mar 2007; 29 Mar 2007; 20 Feb 2007; 29 Mar 2007; 27 Mar 2007; 18 Feb 2005; Sale, 2 Feb 2005; Scoresby, 2 Feb 2005; Shepparton, Jan 2000; South Yarra, 5 Feb 2008; Springhurst, 1 May 2008; Swan Hill, Mar 2002; Tatura, Jan 2001; 28 Mar 2006; 30 Mar 2006; Thornbury, 20 Feb 2002; Toolamba, 7 Jan 2004; Wahgunyah, 27 Mar 2007; 27 Mar 2007; Wandin East, 2 Mar 2004; Wangandary, 13 Jan 2009; Wangaratta, 23 Jun 2004; 13 Apr 2007; 12 Apr 2007; 12 Apr 2007; 12 Apr 2007; 19 Apr 2007;18 Feb 2008; 18 Feb 2008; 18 Feb 2008; 22 Jan 2009; 29 Feb 2009; 21 Dec 2009; 20 Jan 2009; Yackandandah, 17 Mar 2008; Yarrawonga, 13 Feb 2009; 17 Feb 2009; Jan 2009; 20 Feb 2009; ***Vegetable:*** Plenty, 29 Jan 2003. ***Unkown host:*** Bayswater, 12 Feb 2009; Kerang, 21 Jan 2004; Kyabram, 10 Apr 1907; (VAIC).

Third instar. ***Body:*** Body strongly tapering anteriorly, average length 7.1 mm ± 0.3 (SD), average width 1.0 mm ± 0.2 (SD) (Figs. 25–33, 43). Fresh specimens mostly white or creamy white in colour, except posterior spiracles and mouth hooks and associated internal structures contrastingly dark; often darken once preserved in ethanol.

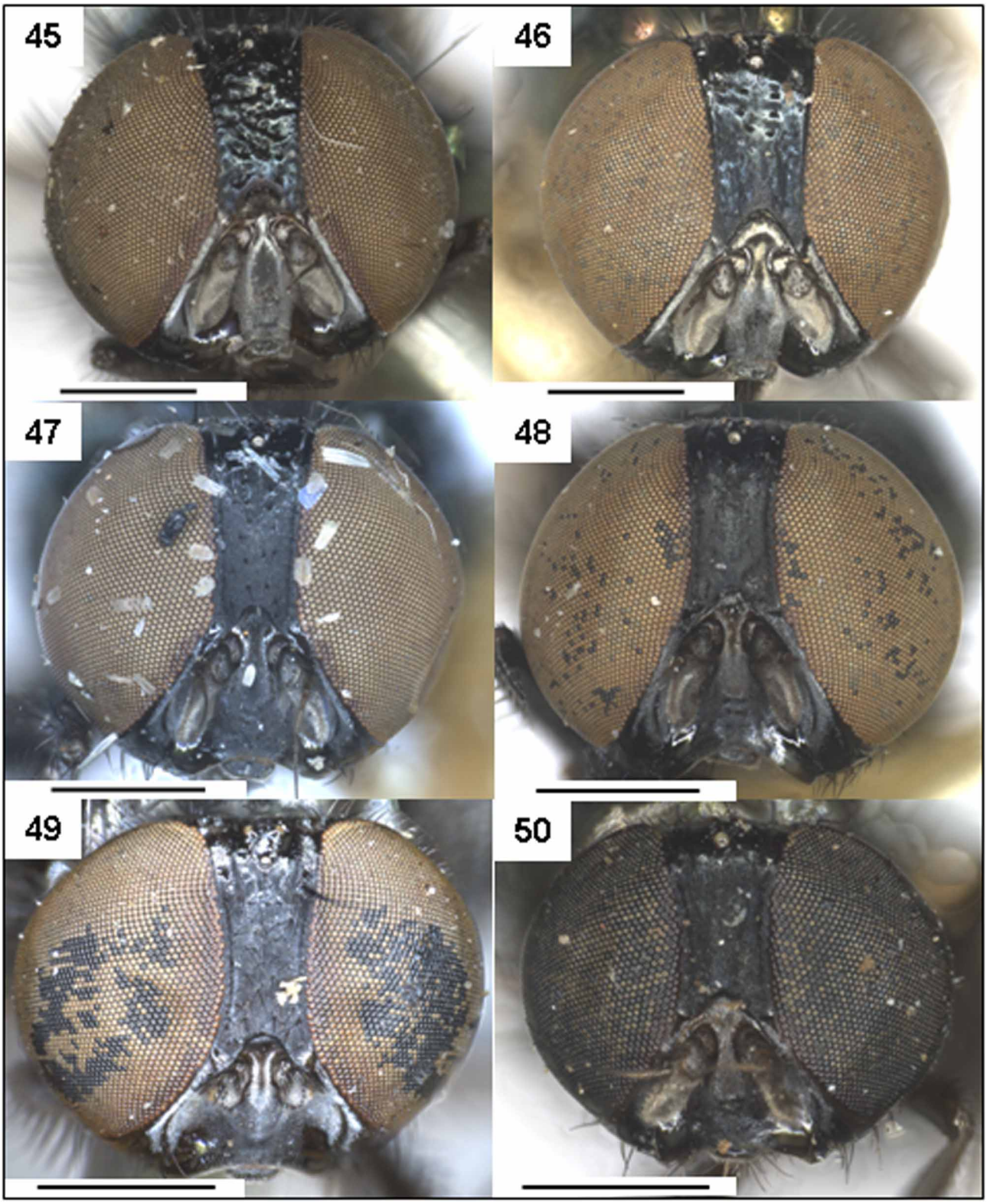
Head: Cephlopharangeal skeleton as in Fig. 27, with a pair of symmetrical stout sickle shaped mouthhooks without preapical teeth, but with a pair of distinct dental sclerites, labial and hypopharyngeal sclerites present, parastomal bars very narrow, posterolateral apodeme generally large, dorsal arch and cornu well developed and sclerotized, ventral cornu weakly sclerotized, fine ventral pharyngeal ridges present along lower margin of ventral cornu (Figs. 27, 42).

Thoracic and abdominal segments: Ventral locomotory welts of spines indistinct on thoracic segments, but distinctly present on abdominal segments, welts approximately 1/3 width of the body (laterally) becoming slightly more conspicuous from anterior to posterior segments (Figs. 25, 43). Each abdominal "proleg" elliptical in outline with gradually rounded ends, margined with a continuous row of very fine spicules (Figs. 32, 44). Each abdominal proleg, particularly the posterior ones, with five transverse parallel rows of locomotory spicules (Figs. 32, 44)—the most anterior row with relatively large spicules forming a broken line, followed by two continuous lines of fine spicules, the fourth line containing the largest spicules arranged in raised linear-clumps of 3–6 broad teeth, followed by a shorter fifth continuous row of fine spicules. *Anterior spiracles:* hand-like, with five to seven lobular papillae projecting from a stalk (Figs. 25–26, 28). *Posterior spiracles:* mounted above centre of the depressed posterior spiracular disk (Figs. 25, 30), characteristically projected on very short tubular horn-like projections (Figs. 30–31), in lateral view appears as a narrow pigmented band, sometimes with a clear layer above (Fig. 30), with three spiracle-slits roughly at right-angles to each other, in older specimens there are often sclerotized tubercules present laterally adjacent to the posterior spiracles (Fig. 30). *Anal area:* spines present around anal plate, with teeth on posterior of the last locomotory welt and behind anal lobes more strongly developed (Figs. 30, 32, 44). When extended anal lobese can be raised from the body (Fig. 30). Anal lobes large and heart-shaped (Fig. 32).

Second instar. Average body length 5.5 mm ± 0.4 (SD), width 0.8 mm ± 0.1 (SD). Generally as in third instar, except: ventral locomotory welts indistinct; anal lobes less developed; anterior spiracle with longer lobular papillae; posterior spiracles higher on posterior with the pigmentation around them reduced or entirely absent, spiracular slits more conspicuous, and horn projections reduced (Figs. 33, 35, 39–41).

First instar. Average body length 3.9 mm ± 0.4 (SD), width 0.5 mm ± 0.2 (SD). Generally as in second instar, posterior horn projections reduced further and posterior spiracles higher on posterior (Figs. 33–34, 36–38).

Eggs (Fig. 24). Generally, Ferrar (1987) reports that lance flies have typical muscine eggs, white in colour with the anterior end being relatively sharply pointed. Eggs dissected from the abdomen of a specimen collected from Bunbury WA (from the MVM collection) agree with this description, and were approximately 0.75 x 0.15 mm in size (Fig. 24).



FIGURES 45–50. Adult male frons. 45) *L. brouniana*, NSW (Sydney, lectotype, AMS K48703); 46) *L. brouniana* NSW (Northmead, AMS K272866, det. D.K. McAlpine); 47) *L. fulgida*, WA (Bunbury, paratype, AMS K68374, det. J.F. McAlpine); 48) *L. metatarsata*, NSW (Iluka Clarence River, AMS K232435, det. I. MacGowan); 49) *L. smaragdi* (=*L. aurea*), Qld (Mosman, AMS K272837); 50) *L. smaragdi* (=*L. aurea*), Qld (Eidsvold, AMS K272832, mentioned in Bezzi 1923). Scale bar represents 0.5 mm.

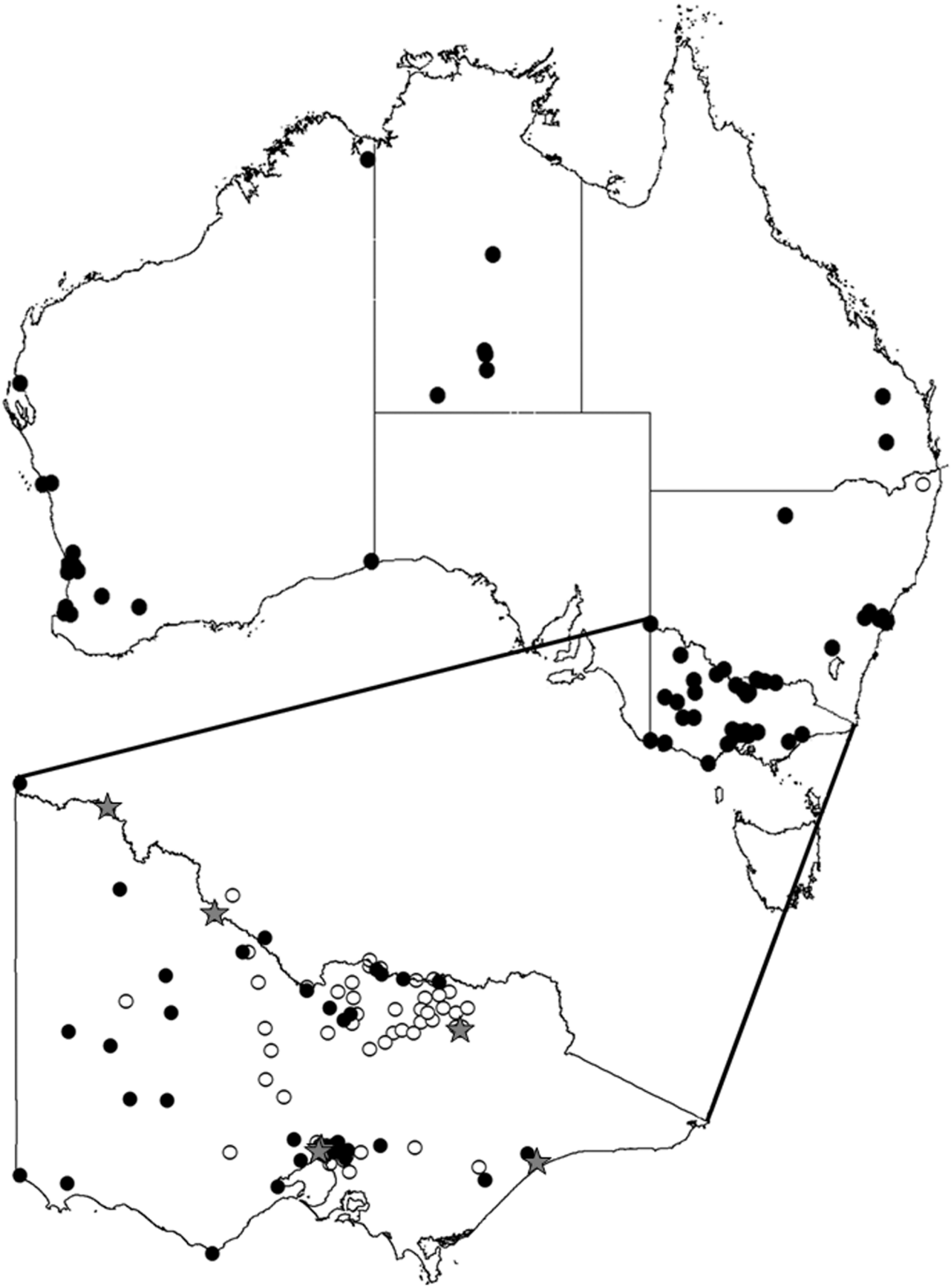


FIGURE 51. Distribution of *L. brouniana.* Based upon adult specimens examined in the current study – adults (black circles); larval samples (white circles). Larval specimens from which COI sequences were obtained from are indicated by grey stars.

Comments. Synonymies of *L. brouniana.* Broun (1904) originally described this species of lance fly from NSW material as *Lonchaea splendida*. However, this name was a homonym of *Lonchaea splendida* Loew [now regarded as a junior synonym of the cosmopolitan *Lamprolonchaea smaragdi* (Walker)]. Hence, Bezzi (1919) proposed the new name *Lonchaea brouniana* (in honour of Broun) as a replacement name. Subsequently, Bezzi (1923) described *L. rugosifrons* as a new species, noting that *L. brouniana* was likely to be synonymous with *L. aurea* Macquart, and followed by Malloch (1928) who did not include *L. brouniana* in his key to Australian species. However, Bezzi (1923) erroneously noted that *L. brouniana* differed from *L. rugosifrons* in not (1) possessing a pitted frons and (2) being much smaller in size. In Broun (1904, 1905) the body length of *L. brouniana* is given as 1 ¾ lines (=3.7 mm) and the frons is noted to be "rugosely punctured", both of which could equally apply to *L. rugosifrons*. Pitkin (1996) formally synonymised *L. rugosifrons* Bezzi with *L. brouniana* (Bezzi), which is supported by evidence from our study (see below)**.**

Morphological variation within *L. brouniana* adults. All adult specimens examined here exhibited pitting of the frons, however there was variation in the degree of pitting and colour of specimens from different localities which may represent currently unrecognised taxonomic diversity: *(1)* The two female specimens from Glenelg River Victoria are slightly coppery in body colour . In one female specimen from Glenelg River basal segment of tarsi except apices are less conspicuously yellow; *(2)* The two male adult specimens from Northmead (NSW) exhibit variation in punctation of frons – one specimen has frons evenly pitted and rugose, the other has frons with only a few widely spaced distinct punctures below ocelli (Fig. 46); *(3)* Two specimens from Bunbury were particularly small (e.g. body length of male =3.4 mm, female =3.0 mm), outside the size range of other specimens examined (Table 1), the female exhibited slight variation in the morphology of the ovipositor, being stockier and more parallel sided at the tip (Fig. 19); *(4)* Also, a number of specimens from the Pilbara and Kimberley regions of WA examined in the current study had paler tarsi and weakly pitted frons, further work is required to clarify their taxonomic status, hence these specimens have not been included in the above description or on the distribution map above; *(5)* A series of specimens collected from Wanneroo WA that were raised from larvae exhibited blue rather than green body colour, otherwise morphologically they match *L. brouniana* (including male and female genitalia); and *(6)* Among the specimens examined there were minor variations in number of setae and colour of calypters, wings, antennae and the lunules.

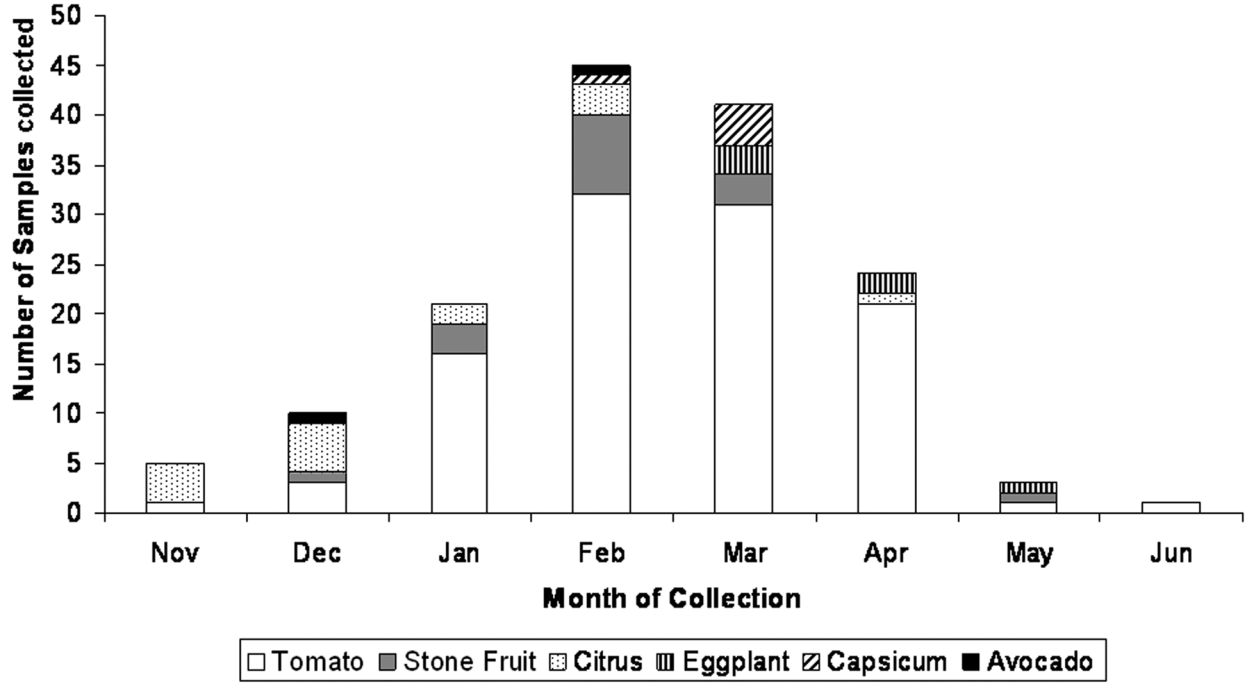
Molecular variation. The six DNA sequences obtained from the (COI) DNA barcoding region (with the primer sequences removed) were 658 b.p. in length, with 1–3 single base differences (0.2–0.5 %) in pairwise sequence comparisons. The predicted amino acid sequence contained no substitutions (0% variation) and no putative stop codons. These sequences have been submitted to GenBank (HQ261232–HQ261237) and the Bar Code of Life (BOLD Project: AAPL) databases.

Distribution (Fig. 51). This species appears to be restricted to Australia, and has been most commonly collected from the temperate south. It was previously recorded from south-eastern Australia (Sydney and Como, NSW; Mt Gambier, South Australia; Linga, north-western Victoria. (Broun 1904, 1905; Bezzi 1923; Malloch 1928). In the current study adult specimens have been examined from south-eastern Queensland, the Northern Territory and Western Australia, and additional localities from New South Wales and Victoria. Figure 51 shows the geographic distribution of *L. brouniana* specimens examined in the present study. The specimens examined in the present study were almost all collected from southerly non-tropical areas (with the exception of some adults reared from larvae at Kununurra WA, DAFWA collection), Fig. 51; a number of additional *L. brouniana* specimens from non-locally grown stone fruit were intercepted in Darwin (from the NTDR collection listed above) and are not included on Fig. 51. All of the northerly records may be introductions associated with horticulture.

References to *L. brouniana* being collected from Fiji (e.g. Bezzi 1919) is an historical error that has apparently occurred through confusion with a portion of the species description of *Dacus xanthodes* Broun, 1905 (from Suva, Fiji) which precedes the description of *L. splendida* (*=L. brouniana)* on the same page in Broun (1905), as previously noted by McAlpine (1960). An additional historical error that has occurred is that this species has become established in New Zealand. Broun (1904, 1905) notes that *L. brouniana* was bred from imported tomatoes in New Zealand, but does not state that the species was established there. Subsequent

references to *L. brouniana* being present in New Zealand by Froggatt (cited in French 1911) and Tillyard (1926) are apparently mistakenly based on Broun (1904, 1905). No species of Lonchaeidae are recorded from New Zealand (Ferrar 1987, T. Crosby, *pers comm*. Jan. 2010).

Host plants (Fig. 52). Generally *L. brouniana* appears to be capable of breeding in a wide variety of organic matter, but they appear to have a particular preference for *Lycopersicon* and *Solanum* plants (Solanaceae). Previously, Broun (1904, 1905), French (1911), and Tillyard (1926) recorded that Metallic-green tomato flies have been reported as major pests of tomato plants in NSW and Victoria (and mistakenly in New Zealand, see notes under Distribution above) and were also known from potato, eggplant, and other Solanaceae. Ferrar (1987) recorded them from tomato, wild tobacco, rotting potato stalks, cowdung, and even dead grasshoppers. They have also been noted to commonly breed in cow dung in southern NSW (Ferrar 1979), and Hughes & Woolcock (1976) include them in with other dung breeding flies. A series of adult specimens examined in the current study were raised from larvae collected from cow dung at Wanneroo (WA), while other individuals were raised from rockmelon and walnut fruit. However, in south-eastern Australia, larvae have been most commonly collected from tomato fruit (>70% of records, Fig. 52), they also regularly occur in other Solanaceae (capsicum and eggplant), Rosaceae (apricot, nectarine, peach), Rutaceae (grapefruit, lemon, mandarin, orange), and Lauraceae (avocado), during the warm summer (Dec–Feb) and autumn (Mar–May) months (Fig. 52).



FIGURES 52. Host Plant use. Samples in the VAIC collected from fruit and vegetables between 1999 and 2009.

Additional *Lamprolonchaea* species in Australia
(Figs. 45–50)

A number of other *Lamprolonchaea* species have been recorded from Australia (Pitkin 1996); all of these species differ from *L. brouniana* in possessing a smooth frons. Below we provide a key to known Australian *Lamprolonchaea* based upon published species descriptions:

Key to Australian *Lamprolonchaea* species

1 Frons shiny-black and covered in irregular punctures (rugose) (Figs. 45–46); body length 3.5–4.5 mm..... ..... *L. brouniana* Bezzi, 1919 (syn. *L. splendida* Broun & *L. rugosifrons* Bezzi)
- Frons dull or shiny-black, smooth without punctures; body length <3.5 mm..... 2
2 Body rich emerald-green colour; frons dull-black; calypters brown; wings dark brown, veins brown; legs brown, metatarsi pale-brown proximally ..... *L. badiceps* MacAlpine
- Body highly polished golden-green / bronzy-blue coloured; frons dull or shiny-black; calypters white / cream; wings clear, veins yellow; legs brown / black, metatarsi yellow proximally..... 3
3 Body golden-green; frons shiny-black (Fig. 47); phallus elongated G-shaped; (Western Australia)..... ..... *L. fulgida* McAlpine
- Body golden-green and bronzy-blue in colour; frons dull-black (Figs. 49–50); phallus simple C-shaped..... ..... *L. smaragdi* Walker (syn. *L. aurea* Maquart & *L. splendida* Loew)

Pitkin (1996) lists *L. badiceps* from Victoria and NSW without citing a source. No records of this species in Australia, or Australian specimens, were located in the current study. The original description of *L. badiceps* was based upon specimens from the Northern Marianas and Guam in the Pacific (McAlpine 1964a). *L. smaragdi* shares the common name metallic-green tomato fly, but does not appear to be common in Australia, with only two specimens examined in the current study that may have represented this species (Figs. 49–50). Pitkin lists *L. metatarsata* (Kertész) from New Guinea and the Pacific, and a single specimen previously identified as *L. metatarsata* from NSW was examined in the current study (Fig. 48). However, further clarification of the status *L. smaragdi, L. badiceps* and *L. metatarsata* in Australia will require further work.

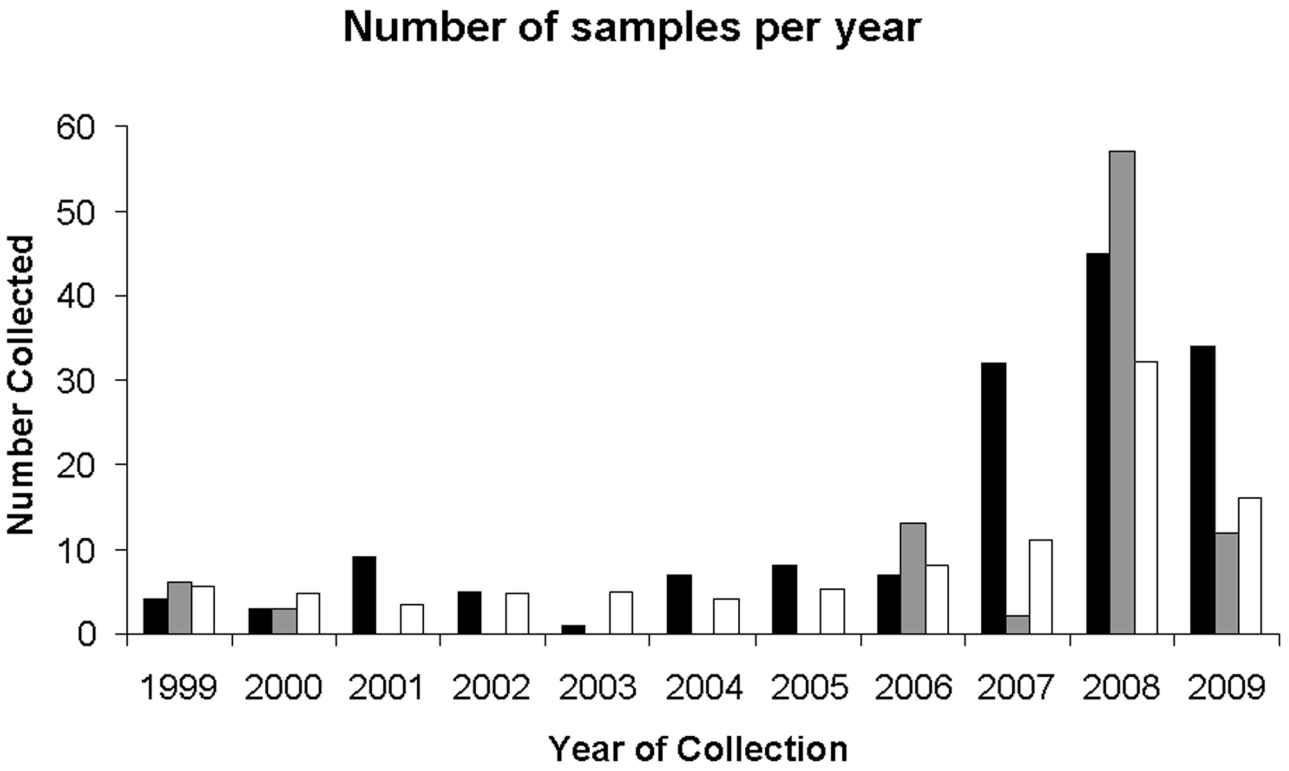


FIGURE 53. Number of *L. brouniana* (black) and tomato samples (grey) per year, as well as the proportion of total insect identifications (%) per year over this period (white) in the VAIC from fruit and vegetable samples collected between 1999 and 2009. Correlations between the number of *L. brouniana* identified, the number of tomato samples examined, and the proportion of total insect identifications compared with increasing time =0.79, 0.50, 0.68 respectively.

Discussion

The current study has clarified some economically relevant aspects of the ecology and life history of the Australian metallic-green tomato fly, *L. brouniana*. These include geographic distribution, host plant use, timing of occurrence, and the length of pupal development time. *L. brouniana* appears to be a generalist species capable of breeding in wide variety of organic matter (fruit, vegetables, dung), and the fruit that it is most often found in is tomatoes. Some species of *Lamprolonchaea* and *Silba* Macquart have previously been reported as often being found as secondary pests in association with "true" tephritid fruit flies, where they are believed to utilise tephritid oviposition holes for depositing their own eggs (Ferrar 1987, White & Elson-Harris 1992, Pitkin 1996, MacGowan 2005a). Generally, it is believed that *L. brouniana* occurs in ripe or damaged fruit and is not a serious primary invader (e.g. McKeown 1945, Hely *et al.* 1982), however French (1911) noted that larvae regularly occurred in apparently undamaged tomato fruit. Some evidence for a primary pest role of *L. brouniana* is provided in the current study by an examination of database records for associations between lonchaeid specimens (mostly *L. brouniana*) with other insect larvae co-occurring in fruit samples in the VAIC. Sixty-three percent of these samples contained only lance flies (i.e. they were the primary invader), 22% also had scavenging insect species present (Drosophilidae and Nitidulidae), 7% Lepidoptera, and 8% of the samples contained other dipteran larvae (i.e. Muscoidea, Tephritidae and undetermined Diptera) of which less than 2% represented Queensland fruit fly larvae (*Bactrocera tryoni*), a serious primary pest of fruit that shares the same host fruit range. If *L. brouniana* were to become an even more serious pest in the future some potential natural biological control agents, such as parasitic wasp (previously tested by Hughes & Woolcock 1976), might prove useful.

It appears that *L. brouniana* might be increasing in the frequency in which it is intercepted in food produce samples, as despite similar techniques being applied over the last decade in the collection of VAIC larval samples there has been a marked increase in the number of *L. brouniana* samples being collected, with three to four times as many larval samples being collected over the last three years (Fig. 53). However, over this same time period the proportion of insect samples identified, and tomato samples examined, have also increased due to increased surveillance for Queensland Fruit Flies (see Fig. 53). Correlations between the number of tomatoes examined and number of *L. brouniana* samples identified, and between the number of tomato samples examined and proportion of total insect identifications were also both strong (0.72, 0.95 respectively). Therefore, although *L. brouniana* is now being collected from south-eastern Australia more often this may not actually reflect an increase in abundance in the field.

In the current study we have clarified the taxonomic confusion that existed between *L. brouniana* and other morphologically similar *Lamprolonchaea* species (e.g. *L. smaragdi*), as well as the systematics of *L. brouniana*, agreeing with Pitkin's (1996) synonymy of two previously described species (*splendida* Broun and *rugosifrons* Bezzi). We have assigned type material for *L. brouniana* which lacked any designated specimens. We have also characterised the COI gene and provided detailed morphological descriptions of *L. brouniana*, including all life stages, to improve future species diagnosis. Extralimital records of *L. brouniana* in Fiji and New Zealand appear to be historical errors and this species appears to be currently restricted to Australia, where it might well be endemic. This possibility is further supported by the presence of a number of morphologically distinctive specimens, all having similar genitalia and a pitted frons, that were examined in the current study and could represent closely related but currently unrecognised diversity in Australia. Additional future morphological, and molecular (if feasible), examinations of these specimens would be valuable in clarifying their taxonomic status.

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References

Bezzi, M. (1919) Two new Ethiopian Lonchaeidae, with notes on other species (Dipt.). *Bulletin of Entomological Research,* 9, 241–254.

Bezzi, M. (1923) On the Australian Lonchaeidae (Diptera). *The Australian Zoologist,* 3, 183–185.

Blacket, M.J., Kemper, C. & Brandle, R. (2008) Planigales (Marsupialia: Dasyuridae) of eastern Australia's interior: a comparison of morphology, distributions and habitat preferences, with particular emphasis on South Australia. *Australian Journal of Zoology,* 56**,** 195–205.

Broun, T. (1904) Description of *Lonchaea splendida*. *In: The twelfth report of the Department of Agriculture.* New Zealand Department of Agriculture, Wellington, pp 307–308.

Broun, T. (1905) Descriptions of three species of fruit flies. *Bulletin of New Zealand Department of Agriculture Division Biological Horticulture,* 4**,** 3–6.

Colless, D.H. & McAlpine, D.K. (1991) Diptera: Lonchaeidae. *In:* The Insects of Australia. A textbook for students and research workers. CSIRO, Melbourne University Press, Carlton, pp. 770 & 774.

Ferrar, P. (1979) The immature stages of dung-breeding Muscoid flies in Australia, with notes on the species, and keys to larvae and puparia. *Australian Journal of Zoology, Supplementary Series,* No. 73**,** 1–106.

Ferrar, P. (1987) Family: Lonchaeidae. *In: A guide to the breeding habits and immature stages of Diptera Cyclorrhapha.* Scandinavian Science Press, Copenhagen, Part1: pp205–214, Part 2: Figures 707–709.

Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrijenhoek, R.C. (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I form diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology,* 3**,** 294–299.

French, C. (1911) Metallic Tomato Fly (*Lonchaea splendida*). *In: A Handboook of the destructive insects of Victoria, Part V.* Victorian Department of Agriculture, Melbourne, pp 20–24.

Hely, P.C., Pasfield, G. & Gellatley, J.G. (1982) Metallic-green tomato fly *Lamprolonchaea brouniana. In: Insect Pests of fruit and vegetables in NSW.* Inkata Press, Melbourne, Sydney & London, pp. 294.

Hughes, R.D. & Woolcock, L.T. (1976) *Aphaereta aotea* sp. n. (Hymenoptera: Braconidae), an Alysiine parasite of dung breeding flies. *Journal of Australian Entomological Society,* 15**,** 191–196.

Loew, H. (1873) Beschreibungen europäischer Dipteran III. Band II (pt. 10 of MEIGEN'S System. Besschr. Der bek. Eur. Zweifl. Ins.). 8, 320 pp.

McKeown, K.C. (1945) Order Diptera – The flies. *In: Australian Insects: An Introductory Handbook.* 2nd Ed. Royal Zoological Society of New South Wales, Sydney, pp. 227–230.

Malloch, J.R. (1928) Notes on Australian Diptera, No xiv. *Proceedings of the Linnaean Society of New South Wales,* 53**,** 295–309.

MacGowan, I. (2004) A list of Lance flies from Taiwan with descriptions of new species (Diptera, Lonchaeidae). *Entomofauna,* 25**,** 321–332.

MacGowan, I. (2005a) New species of Lonchaeidae (Diptera : Shizophora) from central and southern Africa. *Zootaxa,* 967, 1–23.

MacGowan, I. (2005b) New species of Lonchaeidae (Diptera) from the Cameron Highlands, Malaysia. *Studia dipterologica,* 12**,** 179–192.

MacGowan, I. (2006) New species of Lonchaeidae (Diptera) from Nepal and Afganistan. *Studia dipterologica,* 12**,** 315–318.

MacGowan, I. (2007) New species of Lonchaeidae (Diptera : Schizophora) from Asia. *Zootaxa,* 1631**,** 1–32.

MacGowan, I. (2008a) The Loncheidae (Diptera) of Israel, with descriptions of three new species. *Israel Journal of Entomology,* 38, 61–92.

MacGowan, I. (2008b) A new species of Lonchaea Fallén (Diptera: Lonchaeidae) from Cáceres Province, Spain. *Boletin de la Asociacion Espanola de Entomologica,* 33, 59–62.

MacGowan, I. (2009) Two new species of Lonchaeidae (Diptera: Schizophora) from Greece. *Studia Dipterologica,* 14, 285–288.

McAlpine, J.F. (1960) Chapter XVI. Diptera (Brachycera): Lonchaeidae. In Hanstrom, B., Brink,P. & Rudebeck, G. (Eds.). South African animal life. Results of the Lund University Expedidtion 1950–1951. Volume 7. Almqvist and Wisell, Goteborg, Stockholm, Upsalla, pp. 327–376.

McAlpine, J.F. (1964) Descriptions of new Lonchaeidae (Diptera) I. *The Canadian Entomologist,* 96**,** 661–700.

McAlpine, J.F. (1975) Identities of Lance flies (Diptera: Lonchaeidae) described by De Meijere, with notes on related

species. *The Canadian Entomologist,* 107**,** 989–1007.
McAlpine, J.F. & Steyskal, G.C. (1982) A revision of *Neosilba* McAlpine with a key to the world genera of Lonchaeidae (Diptera). *The Canadian Entomologist,* 114**,** 105–137.
Pitkin, B.R. (1996) Family Lonchaiedae, *In:* Pitkin, B.R. (Ed), *Catalog of the Diptera of the Australasian and Oceanic regions*, Bishop Museum Press, Hawaii, pp. 476–478. Available from http://hbs.bishopmuseum.org/aocat/lonchaeidae.html (accessed January 2010).
Tamura, K., Dudley, J., Nei, M. & Kumar, S. (2007) MEGA4: Molecular Evolutionary Genetics Analysis (MEGA) software version 4.0. *Molecular Biology and Evolution,* 24**,**1596–1599. (Publication PDF at http://www.kumarlab.net/publications)
Tillyard, R.J. (1926) Diptera: Acalyptrata. *In: The insects of Australia and New Zealand*. Angus and Robertson, Sydney, pp. 371.
White, I.M. & Elson-Harris, M.M. (1992) Lonchaeidae & Key to fruit pest Tephritidae – Third instar larvae. *In: Fruit flies of economic significance: Their identification and bionomics.* Redwood Press Ltd, Melksham, UK, pp. 14, 112–113.
White, I.M., Headrick, D.H., Norrbom, A.L. & Carroll, L.E. (1999) Glossary. *In:* Aluja, M. and Norrbom, A.L. (Eds.). *Fruit flies (Tephritidae): Phylogeny and evolution of behaviour.* CRC Press, Boca Raton, pp. 881–924.