



<http://dx.doi.org/10.11646/zootaxa.3811.1.4>

<http://zoobank.org/urn:lsid:zoobank.org:pub:F83059E6-560B-4E50-9A60-C7028E62BE9C>

## The strange case of *Laetesia raveni* n. sp., a green linyphiid spider from Eastern Australia with a preference for thorny plants (Araneae, Linyphiidae)

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### Abstract

*Laetesia raveni* n. sp. (Araneae, Linyphiidae), is described based on specimens collected in New South Wales and Queensland (Australia). This new linyphiid species is of bright green colour, and it seems to have a preference to build its webs almost exclusively on two plant species, namely *Calamus muelleri* Wendland (Arecaceae) and *Solanum inaequilaterum* Domin, (Solanaceae), both of them densely covered with thorns. The epigynal morphology of *Laetesia raveni* n. sp. varies intraspecifically. Live individuals and several of their dome-shaped sheet webs are illustrated.

**Key words:** Coloration, Genitalia, Natural History, Phylogeny, Spider–plant associations, Web architecture

### Introduction

With the exception of a few revisionary studies (e.g., van Helsdingen 1972) and a small number of isolated species descriptions embedded in non-revisionary works (e.g., Wunderlich 1976) the Australian linyphiid fauna remains largely undescribed. During the last two decades we have been able to study and collect linyphiids in several areas of Australia. Some of these species, such as *Australolinyphia remota* Wunderlich, 1976, have been included in our phylogenetic analyses (e.g., Arnedo *et al.* 2009). In this paper we describe a new species of *Laetesia* that we first collected more than a decade ago, although adult males were collected for the first time only in 2011. We believe that the most sound and efficient approach to taxonomy is the monographic one, in which a taxonomic treatment focuses on a lineage, produces parallel species descriptions of all the members of the clade and summarizes all relevant information within a phylogenetic context. Although in this paper we describe a single species of a genus that is largely unstudied in Australia, we think that this new species is notable on several counts and illustrates biological features that are highly unusual, if not unique, in linyphiid spiders. This new linyphiid species is of bright green colour, seems to build its sheet webs almost exclusively on two plant species and exhibits remarkable intraspecific epigynal variation. Most of the 24 known species of *Laetesia* have been described (or redescribed) recently and have been well illustrated, so despite the absence of a revisionary context we believe that these unusual features warrant the description of this new species. The *Laetesia* species described so far are mainly distributed in New Zealand (15 species) and Australia (seven species), but there are also species reported from Thailand (one species) and the Vanuatu (New Hebrides, one species). The Australian fauna includes three species from Western Australia, two from Southern Australia and two from New South Wales, and all of them are known from single or very few specimens. No *Laetesia* species has been recorded or described from Queensland, and the two species so far described from New South Wales are geographically far away from the known localities of the new species described here. *Laetesia werburdi* (Urquhart, 1890) is known after a single female collected in the Jenolan Caves of the Blue Mountains, west of Sydney. *Laetesia forsteri* Wunderlich, 1976 is also known after a single female, collected north of Sydney, in Ku-Ring-Gai Chase National Park.

## Material and Methods

Specimens were examined and illustrated using a Leica M205A stereoscopic microscope equipped with a Leica DFC425 camera and LAS software or with a camera lucida. Further details were studied using a Leica DMRM compound microscope with a camera lucida. Single images were combined with Helicon Focus (version 5.3; www.heliconsoft.com) software from Helicon Soft Ltd., to increase depth of field. Left structures are depicted. Most setae and macrosetae are not depicted in the final palp and epigynum drawings. All morphological measurements are in millimetres. Somatic morphological measurements were taken using the LAS Live Measurement module in the dissecting microscope. The position of the metatarsal trichobothrium is expressed as in Denis (1949). Female genitalia were excised using surgical blades or sharpened needles. Epigyna were transferred to methyl salicylate (Holm 1979) for examination under the microscope. Taxonomic descriptions follow the format of Hormiga (2002). Genitalic morphological terms follow Hormiga (2000). Webs were dusted with corn starch before being photographed. Museum depositories are abbreviated as follows: AMNH, American Museum of Natural History (New York); CAS, California Academy of Sciences (San Francisco); MCZ, Museum of Comparative Zoology, Harvard University (Cambridge); QM, Queensland Museum (Brisbane); ZMUC, Zoological Museum, University of Copenhagen (Copenhagen).

**Anatomical abbreviations used in figures.** CB, Cymbium; CD, Copulatory Duct; CL, Column; DSA, Distal tegular apophysis; E, Embolus; EM, Embolic Membrane; FD, Fertilization Duct; LC, Lamella Characteristica; P, Paracymbium; S, Spermathecae; SPT, Suprategulum; ST, Subtegulum; T, Tegulum; TA, Terminal apophysis.

## Taxonomy

### *Laetesia* Simon, 1908

Type species: *Laetesia mollita* Simon, 1908 (as per designation by Petrunkevitch, 1928)

**Composition.** 26 species, including the new species described here. *Laetesia* includes eight species from Australia, 15 from New Zealand, one species in Auckland Island, one species in Vanuatu (New Hebrides) and one species from Thailand.

### *Laetesia raveni* new species

Figs. 1–6

**Material examined.** *Holotype.* AUSTRALIA: Queensland, Lamington National Park, Binna Burra section, Border track, 28°12'14.6"S, 153°11'26.8"E, 24.iv.2011, 850 m a.s.l., general collection, day, rainforest, G. Hormiga & N. Scharff leg., 1M (QM). *Paratype.* AUSTRALIA: Same data, together with male holotype, 1F (QM).

**Additional material examined.** AUSTRALIA: **New South Wales:** Dorrigo National Park, Dorrigo Rainforest Centre, along Wonga walk, 30°22' 3.5"S, 152°43'42.4"E, 19.iii.2010, 758 m a.s.l., general collection, night, rainforest, 9FF, 2Juv, G. Hormiga & N. Scharff leg. (CAS); Border Ranges National Park, Brindle Creek Road, 28°22'42.2"S, 153°04'09.4"E, 22–23.iii.2010, 713 m a.s.l., general collection, night, rainforest, 2FF, G. Hormiga & N. Scharff leg. (GWU, MCZ). **Queensland:** Lamington National Park, Binna Burra section, 28°12'11"S, 153°11'20"E, 18.iv.2002, 910 m a.s.l., general collecting, day, rainforest, 2FF, G. Hormiga, M. Kuntner & F. Alvarez leg. (AMNH); Lamington National Park, Binna Burra section, Border track, 28°12'14.6"S, 153°11'26.8"E, 24.iv.2011, 850 m a.s.l., general collection, day, rainforest, 11FF, 1M, G. Hormiga & N. Scharff leg. (ZMUC); Lamington National Park, Binna Burra section, Border track, 28°12'14.6"S, 153°11'27.1"E, 24.iv.2011, 847 m a.s.l., general collection, day, rainforest, 14FF, 1M, 2Juv, G. Hormiga & N. Scharff leg. (QM, MCZ, CAS); Lamington National Park, Green Mountains, Border track, 28°14'04.2"S, 153°8'31.1"E, 22.iv.2011, 896 m a.s.l., general collecting, night, rainforest, 2FF, G. Hormiga & N. Scharff leg. (MCZ).

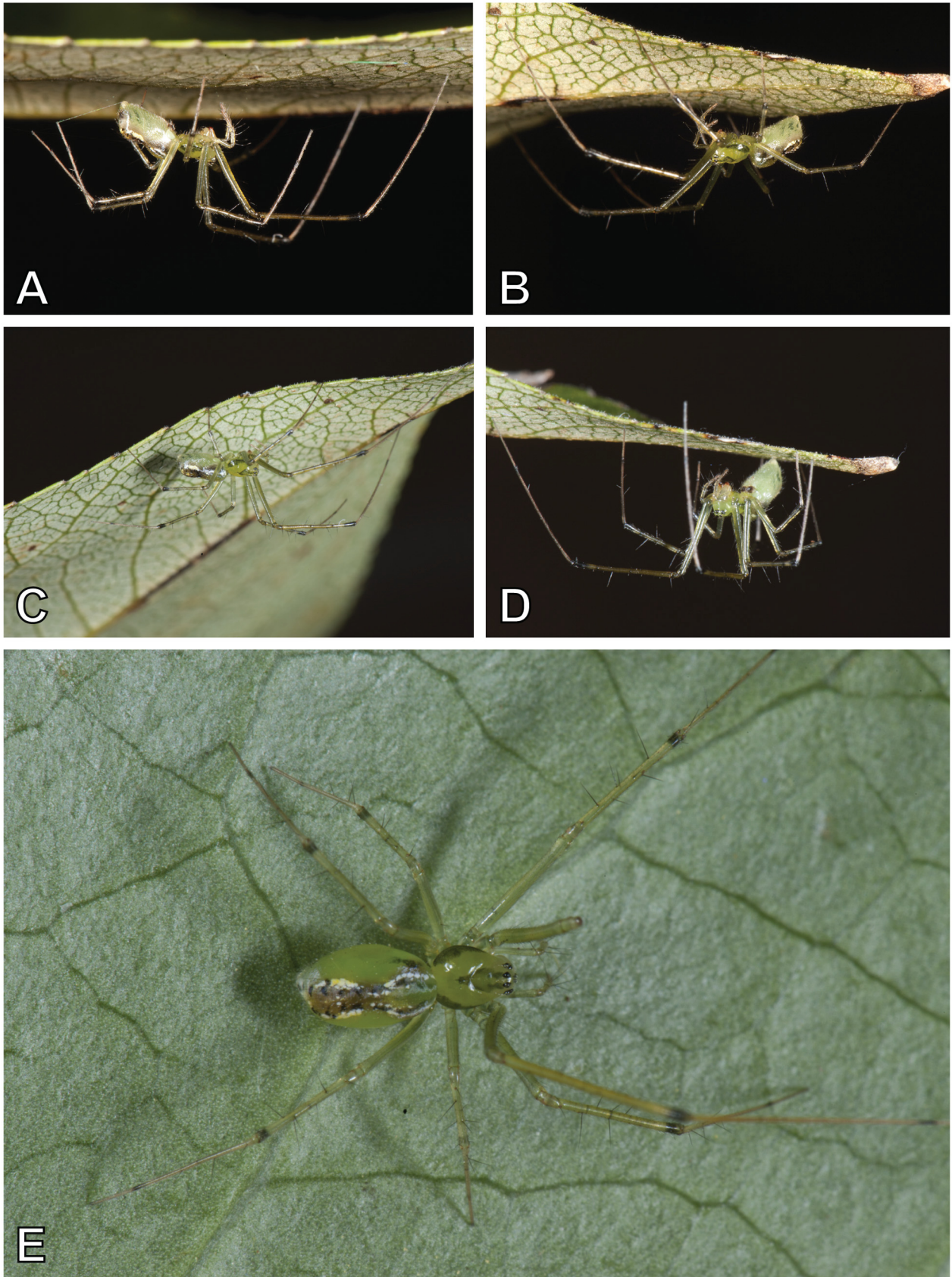
**Etymology.** The species epithet is a patronym in honour of our colleague Dr. Robert Raven, of the Queensland Museum (Brisbane), who over the years has offered us unconditional help and support for our research on Australian spiders.

**Diagnosis.** Males of *Laetesia raveni* n. sp. can be differentiated from other species described in this genus by their long, setiform and highly sclerotized apophysis of the lamella characteristica. Females are separated by the broad dorsal plate of the epigynum and by the two small digitiform lobes on the ventral plate (although there is intraspecific variation in the size of these lobes, and in some specimens the lobes are hardly visible or even absent). The bright green colour of *Laetesia raveni* n. sp. might be diagnostic as to our knowledge no other linyphiid species has been reported to be green, although the green coloration fades quickly in ethanol.

**Description.** *Male holotype* (from Lamington National Park, Binna Burra Section, 24.iv.2011): Total length 3.40. Cephalothorax 1.60 long, 1.24 wide. Sternum 0.78 long, 0.79 wide, shield-shaped. Abdomen 2.00 long, 0.95 wide. Colour (preserved specimen): Cephalothorax, legs and abdomen yellowish white. Carapace with broad blackish margin, also surrounding cephalon. Black rings around eyes. Fovea with black Y-shaped marking. Abdomen with irregular black and white dorsal markings (Figs. 1A–E). Legs with distinct black annulations distally on tibiae and metatarsi (Fig. 1E). AME diameter 0.09. Clypeus height 4 times AME diameter. Cephalon with long strong setae in ocular area (Fig. 4C). Chelicerae with 4 prolateral teeth, the second distal-most with dorso-ventral fork. Chelicerae without stridulating file. Retrolateral teeth not visible on type specimen, but a subadult male from Dorrigo National Park had 3 on the right chelicera and 4 on the left. Femur I 2.84 long, 1.78 times length of cephalothorax. All femora with long strong setae ventrally and shorter strong proximal setae dorsally. Ventral setae several times longer than diameter of femora. Leg formula 1243. Trichobothrium metatarsus I = 0.18. Pedipalp (Figs. 2, 3A): Tibia unmodified, with a long dorsal macroseta and one dorsal and two retrolateral trichobothria. Cymbium dorsally widest at the basal third, gradually tapering towards a blunt apex. Alveolus occupying the basal half of cymbium. Tarsal organ apicoventral. Paracymbium intersegmental, U-shaped, with broad base, tapering distally into a pointed apex. Tegular division with a pointed caudal apophysis (which in mesoventral view sits over the base of the suprategulum; Fig. 3A) and an anteriorly projected apical lobe with a sack-like membranous process that is more sclerotized in its acutely pointed apex (Figs. 2B and 3A, left pointing arrow). Suprategulum projected into a long distal suprategular apophysis (DSA), with a slightly bifurcating pointed apex (Figs. 2B–C). Column in caudal position on the tegular division, bearing a long, membranous embolic membrane that in mesal view runs parallel to the DSA and the embolus (Figs. 2B–C). Lamella characteristica massive, about the same length of cymbium, highly sclerotized and with two apical processes: a conspicuous setiform sclerotized apophysis and two processes with highly serrated margins (one membranous, the other sclerotized; Fig. 2C, left pointing arrow). Embolus arm-shaped, running parallel to the DSA and embolic membrane (Fig. 2C). Radix a slight engrossment of the embolus base, concealed under the lamella characteristica. A slightly sclerotized sclerite, with a linguiform process, sits anterior to the embolus base (possibly a homolog of the terminal apophysis; Fig. 2C). Spermduct with a kinked diameter constriction on dorsal tegular region (in mesoventral view the narrowing of the duct can be seen under the column; Fig. 3A).

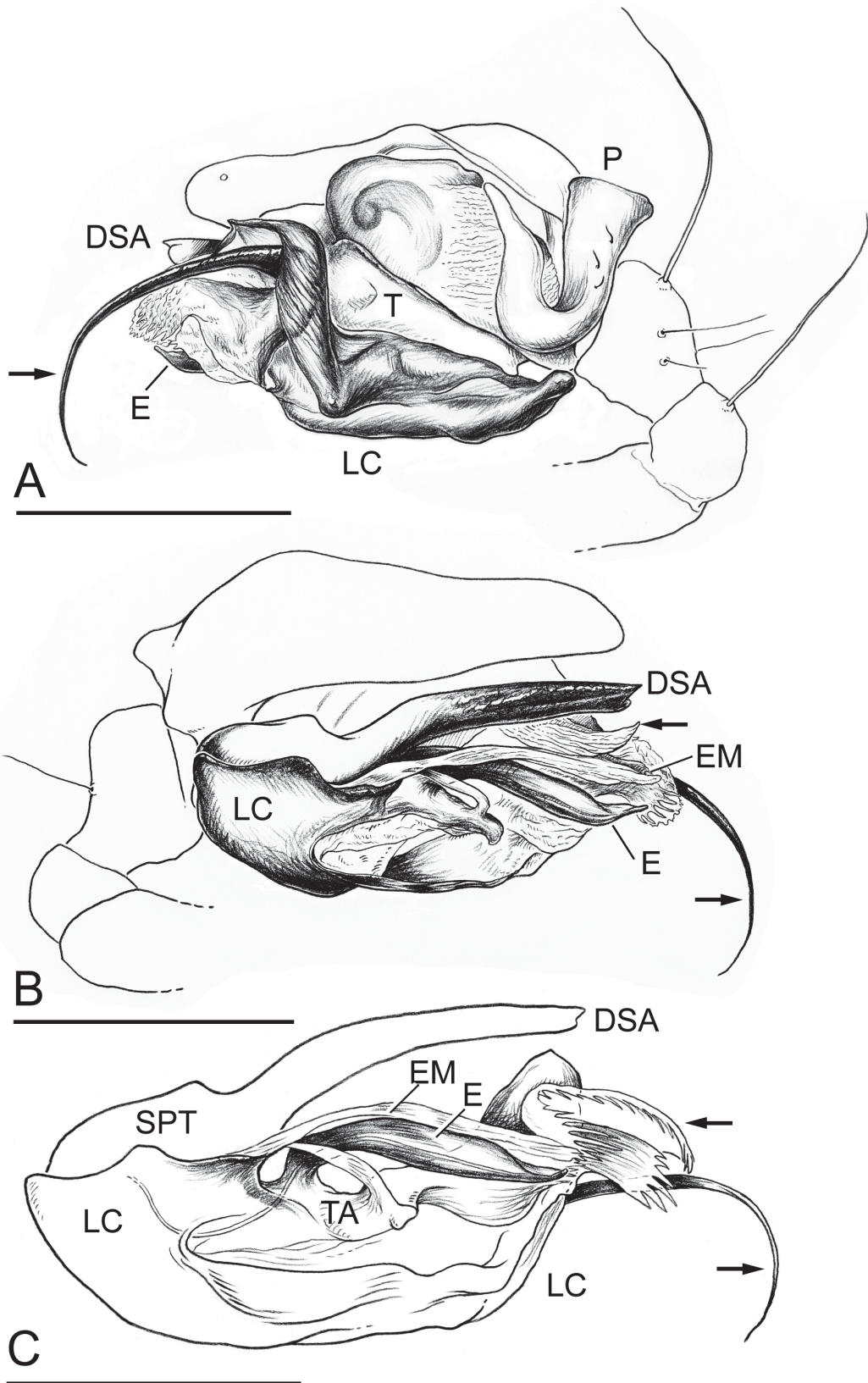
*Female paratype* (together with holotype): Total length 5.27. Cephalothorax 1.98 long, 1.44 wide. Sternum 1.04 long, 0.98 wide, shield-shaped. Abdomen 3.32 long, 1.79 wide. Colour (preserved specimen): As male holotype. AME diameter 0.08. Clypeus height 0.42, 5.25 times AME diameter. Chelicerae with 3 prolateral and 4 retrolateral teeth. Chelicerae without stridulating file. Femur I 3.59 long, 1.81 times length of cephalothorax. All femora with long strong setae ventrally and shorter strong proximal setae dorsally. Ventral setae several times longer than diameter of femora. Leg formula 1243. Pedipalp long and slender (1.4 times the length of cephalothorax) and provided with long spines on tibia and tarsus. Trichobothrium metatarsus I = 0.17. Epigynum (Figs. 3B–D, 4A–B): Epigynal region bulging in lateral view. Dorsal plate broad, with a sclerotized basal stalk on midventral surface, projected into a long scape bearing an apicoventral socket with darker pigmentation. Posterior margin of ventral plate (VP) cleaved, forming two semicircular lobes. Atrium flanked by two small digitiform processes on VP, caudally oriented. Copulatory openings in mid epigynal region, at the base of the dorsal plate (DP) stalk, in atrium (under VP). Copulatory ducts (CD) make long loops towards the lateral margins. Spermathecae darkly pigmented, curved as an extension of CD, visible by transparency through the epigynal cuticle on both sides of the VP lobes. Fertilization duct located dorsally at the DP margin, caudolaterally oriented (Fig. 3C), then curving anteriorly. Tracheae (Binna Burra, 2010 specimens) can be seen in life specimens by transparency through the abdominal cuticle. The tracheal trunks are very superficial, consisting of two simple, unbranched pairs (haplotracheate system). Lateral pair seen as thin white lines running anteriorly from atrium and then dorsally on abdomen; median pair can be seen too, not as superficial as lateral.



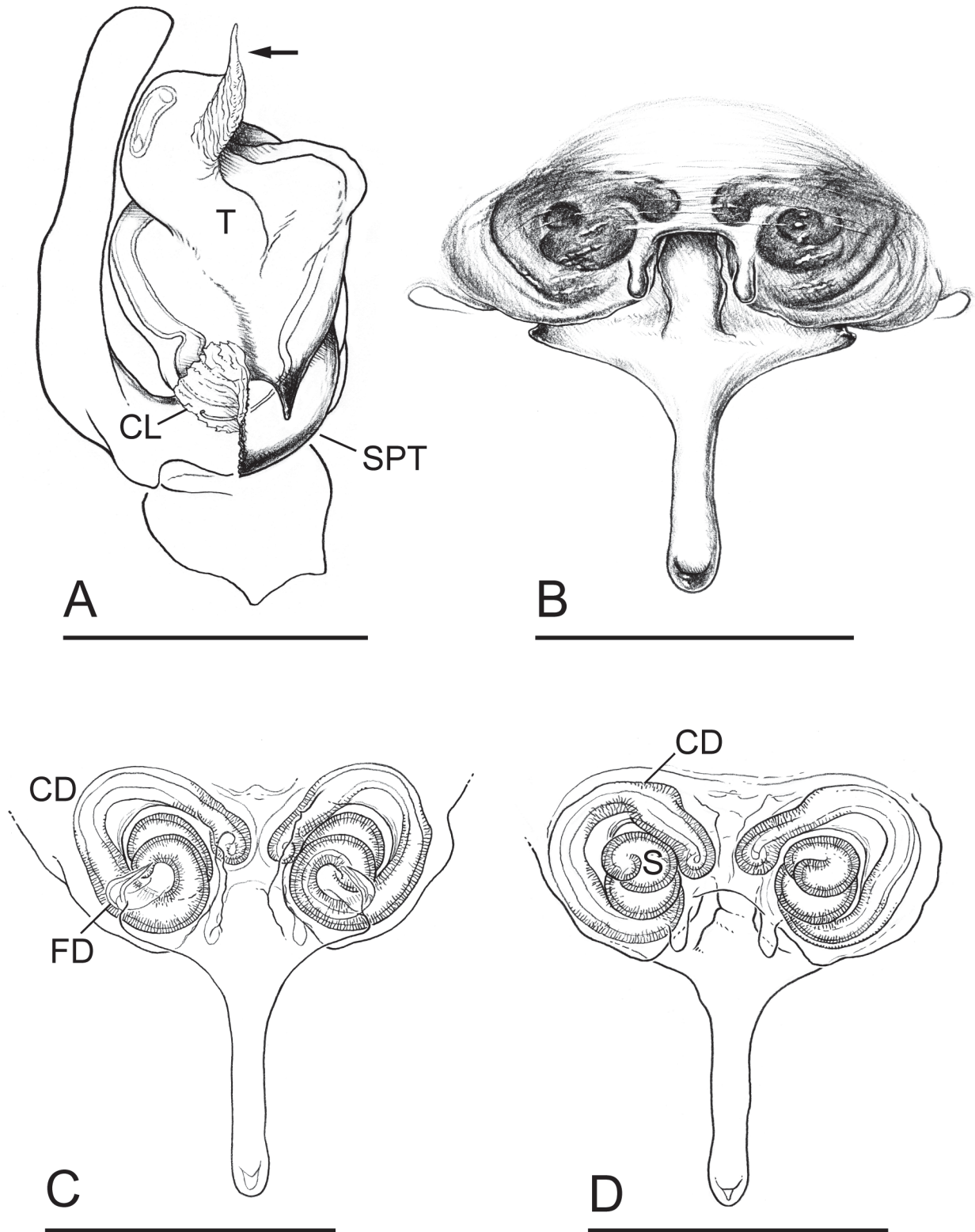


**FIGURE 1.** *Laetesia raveni* n. sp., female Dorrigo National Park, NSW (photographed on a different plant species than where it was collected). Photo voucher numbers as follows (all 10.iii.2010). A, NS3136. B, NS3142. C, GH2927. D, GH2981. E, GH2950.



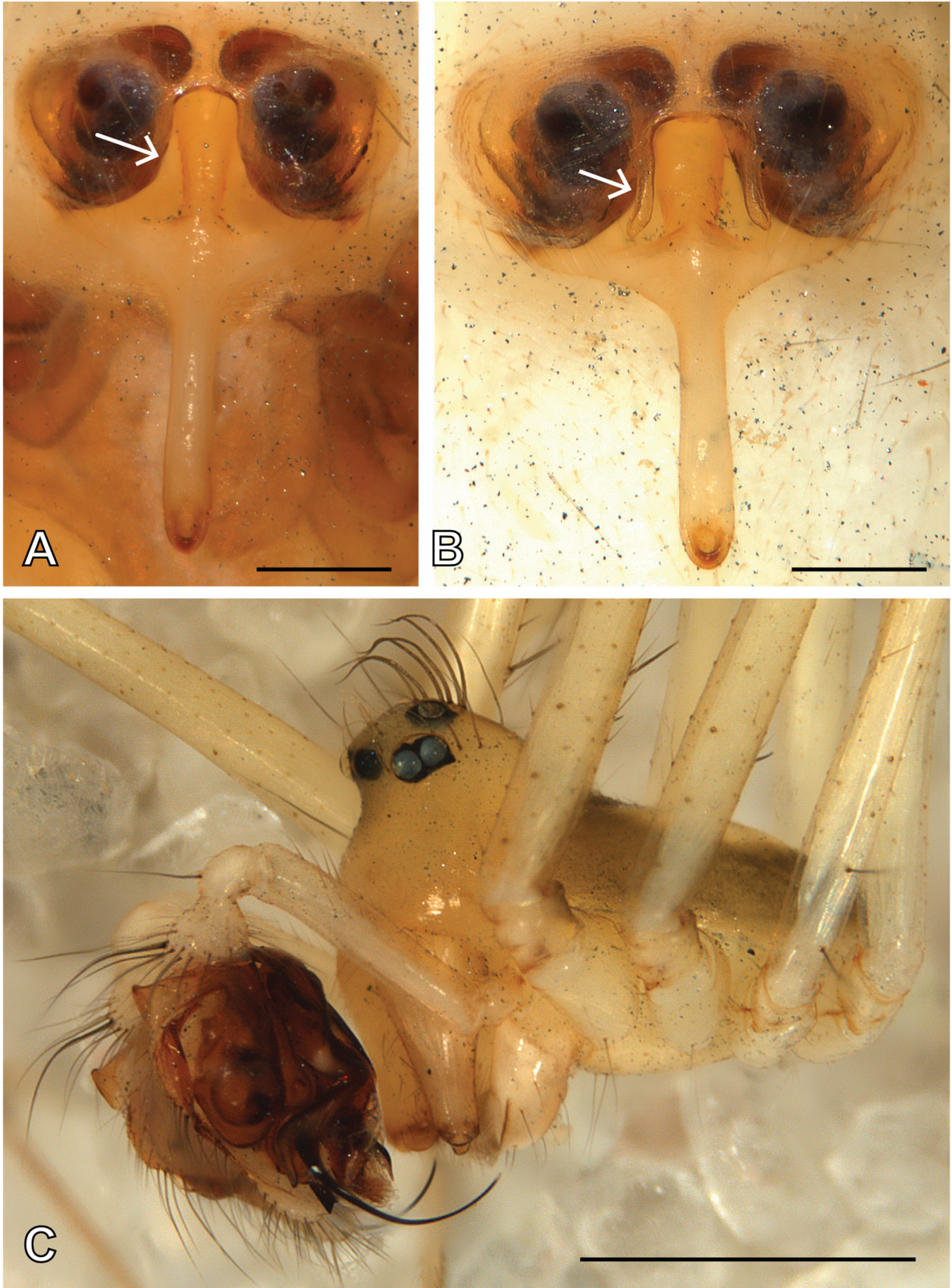


**FIGURE 2.** *Laetesia raveni* n. sp., pedipalp of male from Lamington National Park (Binna Burra), Queensland. A, Ectal (right pointing arrow, setiform process of lamella characteristic, also in B and C). B, Mesal (left pointing arrow, membranous tegular process). C, Suprategulum and embolic division, ventral (left pointing arrow, membranous and sclerotized processes of lamella characteristic). Scale bars, 0.5 mm.



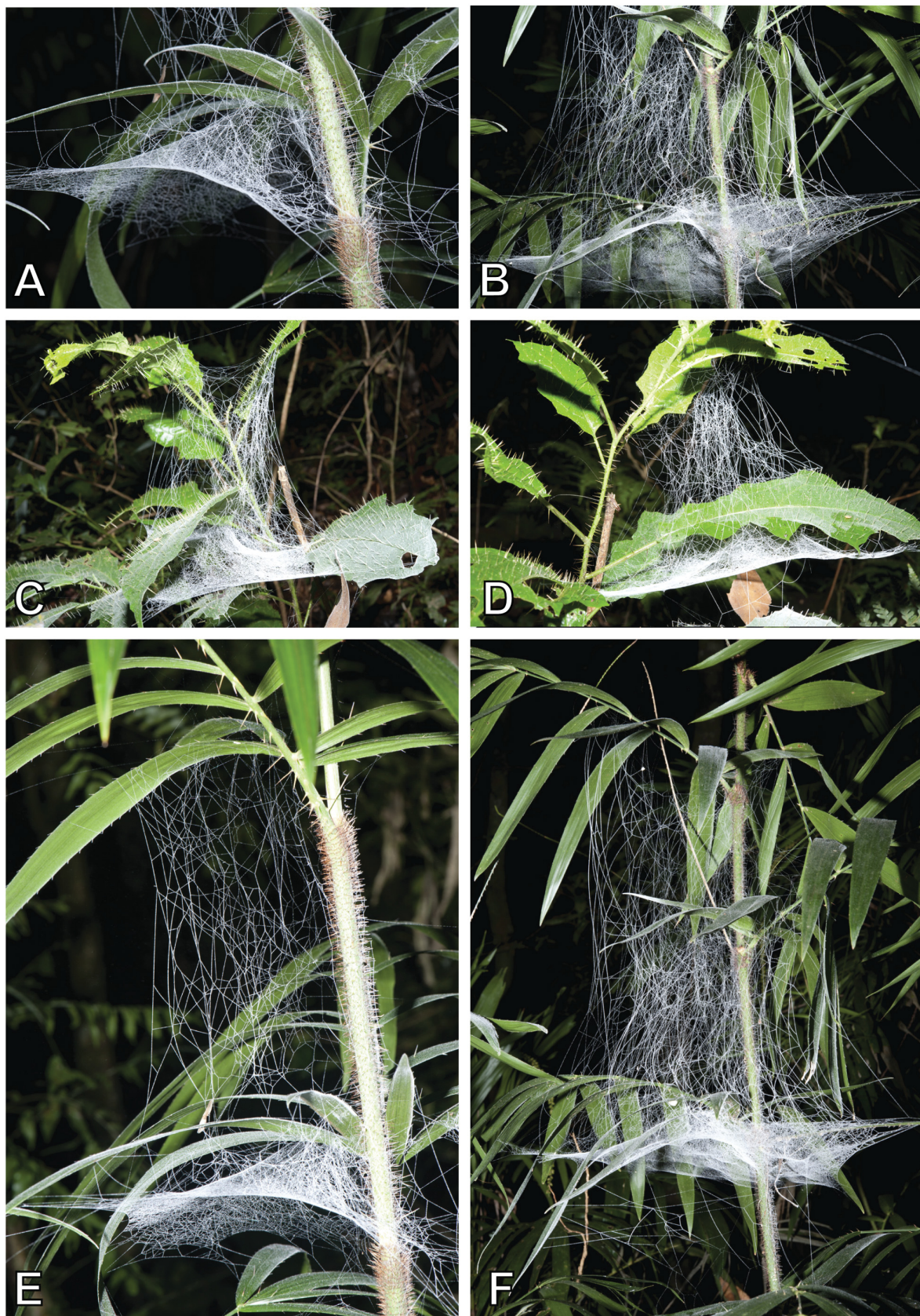
**FIGURE 3.** *Laetesia raveni* n. sp. A, Tegular division (suprategulum and embolic division dissected out, see Fig. 2C) of male from Lamington National Park (Binna Burra), Queensland (left pointing arrow, membranous tegular process). B–D, Epigynum of specimen from Dorrigo National Park, NSW. D, ventral. C, Dorsal, cleared. D, Ventral, cleared. Scale bars, 0.5 mm.





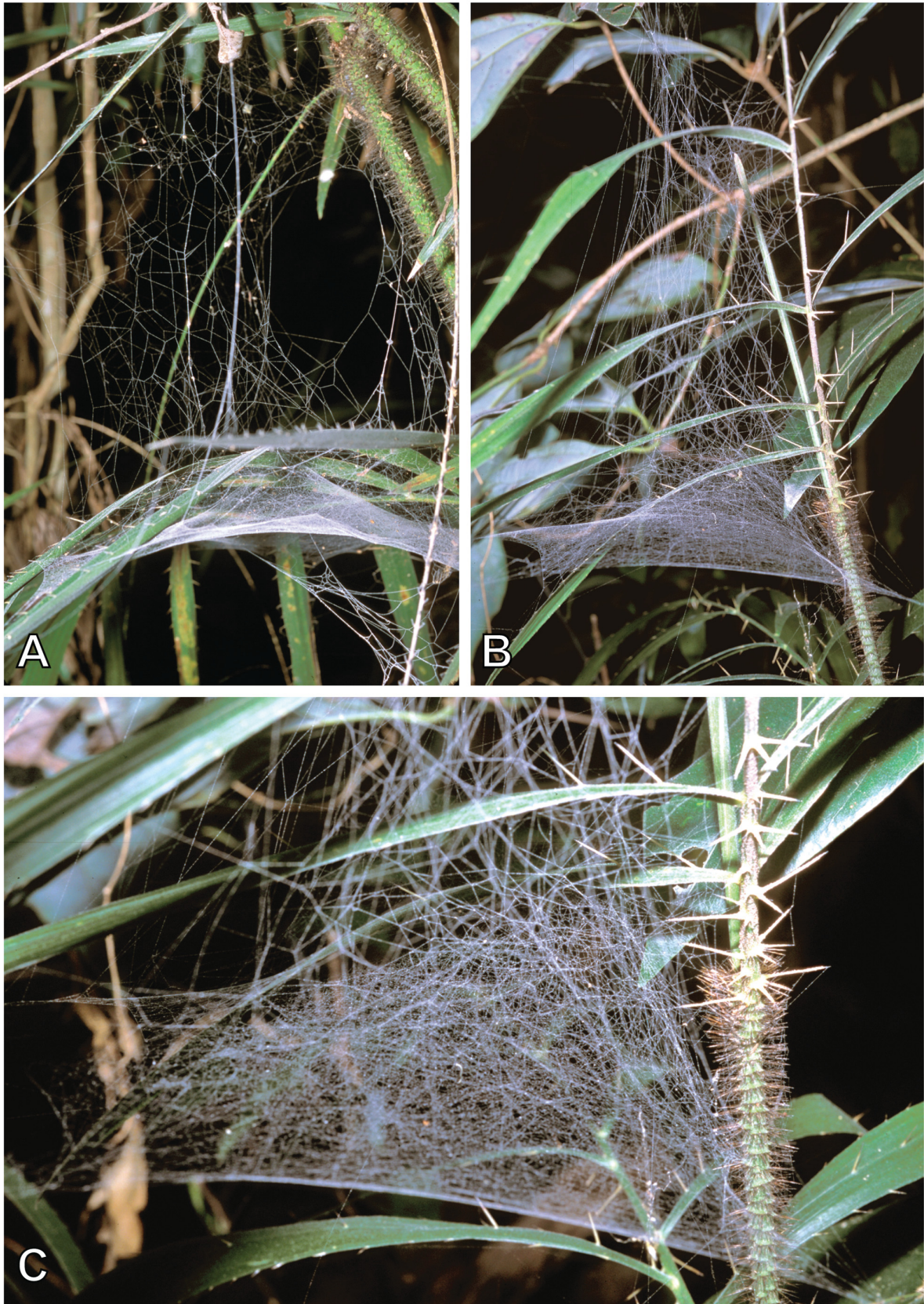
**FIGURE 4.** *Laetesia raveni* n. sp. A, Epigynum, from Dorrigo National Park, NSW. B, Epigynum, from Lamington National Park (Binna Burra). C, Prosoma of male from Lamington National Park (Binna Burra), Queensland, lateral. Arrows denote epigynal digitiform processes (B) and absence of (A). Scale bars, A, B, 0.2 mm; C, 1.0 mm.





**FIGURE 5.** Webs of *Laetesia raveni* n. sp., from Dorrigo National Park, NSW. Webs in A, E, B, F are on *Calamus muelleri* (Arecaceae); webs in C, D on *Solanum inaequilaterum* (Solanaceae). Photo voucher numbers as follows (A, E, 18.iii.2010, rest 19.iii.2010). A, GH2804. B, GH2828 (detail of F). C, GH2834. D, GH2838. E, GH 2808 (detail of A). F, GH 2824 (notice eggsac under second leaflet to the left of stem).





**FIGURE 6.** Webs of *Laetesia raveni* n. sp., from Lamington National Park (Binna Burra), Queensland, on *Calamus muelleri* (Areaceae). Photo voucher numbers as follows (A–C, 18.iv.2002). A, GH020418\_R05\_33. B, GH020418\_R06\_05. C, GH020418\_R06\_07 (detail of B).



**Life coloration.** Female (Figs. 1A–E): Carapace green, margins dark green (wider marks in posterior half), cephalic region darker, Y-shaped, extending into fovea. Black rings around eyes. Sternum uniformly green. All leg segments translucent light green; leg tibiae and metatarsi darker, more brownish, distally suffused with dark/blackish pigment. Abdomen bright green, with a longitudinal median band, brown and black with a few yellow marks, delineated by white guanine spots. Ventrally uniformly green, with dark brown spots in front of epigastric furrow (copulatory ducts and spermatheca). Males ( $n = 3$ ) of similar colour, green tint not as bright as in females.

**Variation.** Colour (in preserved specimens): Blackish markings on carapace vary from a faint band along carapace margin to almost total coverage in certain individuals. Dorsal abdominal markings may be more or less pronounced and some female individuals are a little darker, overall. Epigynum: Lateral digitiform processes on VP vary in length, even in specimens from same locality, and can be absent. Measurements: Male total length ranges from 3.37 to 3.40 ( $n = 2$ ). Female total length varies from 3.36 to 5.27 ( $n = 20$ ). Male cephalothorax ranges from 1.57 to 1.60 ( $n = 3$ ). Female cephalothorax length ranges from 1.31 to 1.98 ( $n = 20$ ).

**Phylogenetic placement.** No explicitly phylogenetic (i.e., synapomorphy based) circumscription exists for the genus *Laetesia*. Simon (1908) originally described *Laetesia* to group two new species from Western Australia. Van Helsdingen (1972) provided the first modern definition of the genus, based on overall similarity. Millidge (1988) similarly defined the genus upon further study of the New Zealand fauna. The morphology of *Laetesia raveni* **n. sp.** suggests that it is congeneric with *L. mollita*, the type species. We hypothesize here two potential synapomorphies of *Laetesia*: the distally forked distal supratégular apophysis and the long, straight and narrow embolic membrane, both traits being shared by all the *Laetesia* species illustrated by van Helsdingen (1972) and Millidge (1988). Other distinctive characters of *Laetesia* may be symplesiomorphic, e.g., the presence of two latero-ventral scapes or processes in *Laetesia* species is also shared by several *Dunedinia* species (e.g., *D. denticulata* Millidge 1988: fig. 203). The membranous and apically pointed tegular process of some *Laetesia* species (e.g., *Laetesia raveni* **n. sp.**, Fig. 3A, left pointing arrow; *L. aucklandensis* (Forster), Millidge 1988: fig. 146) is also found in some *Laperousea* (e.g., *Laperousea cupidinea* (Simon), van Helsdingen 1972: fig. 5) and *Diploplecta* species (e.g., *D. communis* Millidge 1988: fig. 221).

**Distribution.** Eastern Australia. Known from Dorrigo National Park and Border Ranges National Park in north eastern New South Wales and Lamington National Park in south eastern Queensland.

**Natural history.** *Laetesia raveni* **n. sp.** builds dome-shaped sheet webs on vegetation (Figs. 5, 6). The spider sits upside-down under the apex of the dome, under a leaf that is usually positioned at the centre of the sheet. All webs have relatively dense upper scaffolding, although the density of silk lines in this mesh is variable. An eggsac, presumably of this species, was observed attached under a leaflet at edge of web (photos GH2823–2828/19.iii.2010; Fig. 5B, F). When disturbed, the spider flattens the body against the leaf surface. In two webs we have observed early instars with the adult female. Except in two cases, the webs of all the 48 specimens of *Laetesia raveni* **n. sp.** that we have collected were built exclusively on two plant species (both of them distinctively thorny): wait-a-while vines, also commonly known as southern lawyer cane (*Calamus muelleri* Wendland, Araceae; Figs. 5A–B, E–F, 6) or on Gin's Whiskers (*Solanum inaequilaterum* Domin, Solanaceae; Figs. 5C–D). Most webs were found in the first plant species. Only in two instances, in Binna Burra (Lamington National Park), were their webs built on other plant species, and in these two latter cases these plants were adjacent (in physical contact) to one of these two aforementioned species.

## Discussion

Green colouration. To our knowledge, no other linyphiid species, of the 4,461 species described so far (Platnick 2013), has been reported to be of green colour. Although in spiders green colour fades quickly in alcohol, the absence of any reports of green linyphiids is unlikely to represent an artifact because numerous species have been directly collected and photographed (especially in Europe, where the family is particularly diverse). This observation begs the question of why there are so few green linyphiids. Green pigments are sporadic in spiders (Oxford & Gillespie 1998). Within Orbiculariae (the orb-weaving spiders) green coloured species have been described at least in the families Araneidae, Tetragnathidae, Theridiidae, and Synotaxidae, but in none of these groups green species are particularly common. In some species, such as *Micrommata virescens* (Clerck, 1757) (Sparassidae) green colours are based on bilins, which consist on linear arrangements of pyrroles (Oxford & Gillespie 1998) but the biochemical basis for the coloration of most spider species remains unstudied. The fact that



all the specimens of *Laetesia raveni* **n. sp.** that we studied were green suggests that this colour is not physiologically induced, that is, that its green colouration is not the result of ingesting green-coloured prey or the result of reversible environmentally induced colour changes. For the most part, spider colouration is genetically determined and impervious to environmental influences. In the majority of cases studied spider colouration is involved in various forms of predator avoidance, including crypsis, mimicry, aposematism and thermoregulation (Oxford & Gillespie 1998). Our anecdotal observations on the natural history of *Laetesia raveni* **n. sp.** suggest that the green colouration of this species may enhance crypsis, as it rests under a leaf, protecting it from visually oriented predators, such as birds and some wasps.

Associations between spiders and plants. The plant species with *Laetesia raveni* **n. sp.** webs have in common an abundance of prickly thorns and are endemic to subtropical rainforests of north eastern New South Wales and south eastern Queensland. *Calamus muelleri* is a climbing palm with fronds up to one meter long and long tendrils with sharp curved hooks. The stems are densely covered with prickles; the leaflets, stalks and midribs have small prickles (Cronin 2009). *Solanum inaequilaterum* is a shrub that can grow up to two meters high, with leaves up to 15 cm long and prickles on leaves and stems that are particularly dense on the main stems (Bean 2012). We cannot explain the unusual behaviour of using almost exclusively two plant species to build their webs, but since both plants share an abundance of thorns this may suggest that these plants provide the spiders protection from certain predators. Associations between spiders and plants are unusual, but several studies have shown that spiders can indeed be associated with plant species (Romero 2006, Romero & Vasconcellos-Neto 2004, Vasconcellos-Neto *et al.* 2007). For instance, all species of the spider genus *Cupiennius* (Ctenidae) are associated with plants within the taxa Bromeliaceae and Musaceae (Barth *et al.* 1988), on which they spend most of their lives. The jumping spider *Pelegrina tillandsiae* (Salticidae) has only been recorded on Spanish moss (*Tillandsia usneoides*, Bromeliaceae) in south eastern USA (Romero 2006) and the crab spider *Synema obscuripes* Dahl, 1907 (Thomisidae) lives its entire life in the pitchers of the pitcher plant *Nepenthes madagascariensis* (Nepenthaceae) where it feeds on insects attracted to the pitchers and finds refuge in the digestive enzymes when disturbed (Rembold *et al.* 2012).

Genitalic intraspecific variation. The dominant paradigm in morphological spider taxonomy (at least for most groups of araneomorphs) relies heavily in assessing variation in genitalia to circumscribe species, which are a priori assumed to exhibit little intraspecific variation in their genitalia. Intraspecific variation in genitalic morphology (and behaviour) may affect the success of copulation, but their effects are almost completely unstudied (Eberhard & Huber 2010). However it is clear, and has been empirically demonstrated, that intraspecific variation exists in spiders (e.g., see Grasshoff 1968 for a study of genitalic variation in Araneidae). It may be that female genitalia are more variable intraspecifically than those of the males (Eberhard & Huber 2010 and references therein). Nonetheless, the degree and range of variation in the epigynal morphology of *Laetesia raveni* **n. sp.** is certainly unusual. There is a remarkable range of variation in the size and shape of the lateral epigynal processes, with some individuals lacking them altogether. We cannot discern any geographic pattern to this variation, as females collected in a single locality can exhibit the full spectrum of epigynal variation. The three adult males studied do not present any comparable degree of variation in their pedipalps. Given the existing taxonomic dogma, it is easy to imagine that a taxonomist facing only two female specimens in allopatry, one without and the other with the full lateral processes, would at least hesitate circumscribing these two females to a single species. More specimens and more localities are needed to better understand the epigynal variation of this species.

Our data on the natural history of *Laetesia raveni* **n. sp.** is largely anecdotal and were collected within a taxonomic context, not as a targeted study to document the biology of this species. More data are clearly needed to understand the ecology of this interesting species. For example, additional samples are needed to test the alleged preference of this spider for thorny plants. If individuals of this species were to be found building webs against backgrounds other than green leaves (e.g., brown dried leaves), the colouration of such individuals would be especially relevant to test any hypotheses that invoke selection by predators for maintenance of green colour.

## Acknowledgments

We thank our colleagues Robert Raven, Barbara Baehr, Michel Rix and the late Val Davies for advice and support during our field work in eastern Australia. Thiago Moreira helped obtaining some of the references. Peter van Helsdingen, Robert Raven, Geoff Oxford and Martín Ramírez provided helpful comments on an earlier version of this paper. This research was supported by US NSF grants DEB 1144492 and DEB 114417 (to GH and Gonzalo

Giribet), a Selective Excellence Grant from The George Washington University, and Carlsberg Foundation research grants 2010-0-0186 (to NS and GH) and 2009-01-0616 (to NS). GH's work at the University of Copenhagen (Zoological Museum) was supported by a scholarship from Danmarks Nationalbank. NS acknowledges the Danish National Research Foundation for support to the Center for Macroecology, Evolution and Climate. Funding for this research was also provided by grants from the Danish Agency for Science, Technology and Innovation (Project 272-08-0480 to NS).

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