

The bee tribe Anthidiini in Singapore (Anthophila: Megachilidae: Anthidiini) with notes on the regional fauna

Eunice J. Y. Soh¹, Zestin W. W. Soh², Shao Xiong Chui¹ and John S. Ascher^{1*}

¹Department of Biological Sciences, National University of Singapore, 14 Science Drive 4, Singapore 117543, Republic of Singapore; Email: dbsajs@nus.edu.sg (*corresponding author)

²Department of Life Sciences, Imperial College London, South Kensington Campus, London SW7 2AZ, UK

Abstract. The bee tribe Anthidiini in Singapore consists of two genera, *Euaspis* and *Anthidiellum*, with the latter newly documented for the country. We detected adults of *Anthidiellum* (*Pycnanthidium*) *smithii smithii* (Ritsema, 1874) foraging on flowers at the Dairy Farm Nature Park near the Bukit Timah Nature Reserve—Singapore’s highest quality remnant forest patch—nesting in bamboo stem trap-nests. Identification of the *Anthidiellum* subspecies was confirmed through study of regional material including the type specimen of *Anthidium minutissimum* Bingham, 1903 (considered to be a junior synonym of *Anthidiellum smithii smithii*), in the Natural History London, which proved to be a male whereas the original description cited it as a female. Nesting materials and nest architecture of *Anthidiellum smithii smithii* are compared with those of two other Asian species within the subgenus *Pycnanthidium* and with the other comparably small-bodied Singapore cavity-renting Megachilinae, *Heriades* (*Michenerella*) *othonis* Friese (Osmiini, a new record for Singapore). *Euaspis*, a genus of cleptoparasitic bees, is represented in Singapore by *Euaspis polynesia* Vachal, 1903, a widespread Southeast Asian species, along with a second species, probably undescribed, discovered foraging on flowers of *Syzygium zeylanicum* at Kent Ridge Park. Diagnostic features of this bee are illustrated as are those of a *Euaspis* female from Laos that may or may not prove to be conspecific. These enigmatic *Euaspis* are compared to *Euaspis polynesia* and to *Euaspis aequicarinata* Pasteels, 1980, the latter newly recorded from Peninsular Malaysia based on a female specimen examined. Distributional records for all three species of Singapore Anthidiini are summarised and mapped. A total of 29 species (including morphospecies) of family Megachilidae are now recorded for Singapore, out of a total known fauna of ca. 102 named species and 25 additional morphospecies. The 29 megachilids comprise, in addition to the three Anthidiini species, 20 *Megachile* species reported in a previous paper, two species of *Lithurgus* (Lithurgini), three species of *Coelioxys* including an undescribed (*Torridapis*) (Megachilini, a new subgeneric record for Singapore), and one *Heriades* species. Notes on the regional anthidiine fauna include new generic and subgeneric records for Laos and Cambodia, reclassification of *Dianthidium selangorensis* Cockerell, 1927, as *Anthidiellum* (*Clypanthidium*) *selangorensis* (Cockerell, 1927), and a new record of *Anthidiellum* (*Ranthidiellum*) *ignotum* Engel from Phayao Province in Thailand.

Key words. *Anthidiellum*, *Euaspis*, tropical rainforest, bees, Asia, nest

INTRODUCTION

The 876 described species in the 40 genera of tribe Anthidiini (Megachilidae) are solitary bees that occur worldwide in habitats ranging from deserts to tropical rainforest. Litman et al. (2016) reviewed their phylogenetic systematics. In Southeast Asia, 33 described species in nine genera are known, most of which belong to the widespread genera *Anthidiellum* (14 described species), *Euaspis* (eight described species), and *Trachusa* (four described species) (these and other species totals are from Ascher & Pickering, 2015, and include information not yet published in print). Genus-group taxa represented in Southeast Asia by single species include the regional endemics *Apianthidium* and *Stelis* (*Malanthidium*), the Asian endemic *Bathanthidium* (*Manthidium*) from Burma, Laos, and China (not “northeastern India and Malaysia” contra Michener, 2007), and *Trachusoides*, a genus proposed for an Indian species, based on *T. elsieae* Griswold, 2015, described recently from Laos and which could be confused with unidentified *Trachusa* (*Paraanthidium*) of similar habitus recently detected in this country from Houaphanh Province (new information). *Eoanthidium*, *Pachyanthidium* (*Trichanthidium*), and *Pseudoanthidium* (*Pseudoanthidium*) are more widespread but still scarce in the region. The last-mentioned subgenus is newly confirmed for Cambodia based on males found in February 2016 below Bou Sra Waterfall in Mondulhiri Province (Ascher et al., 2016b). Although Southeast Asian Anthidiini are moderately rich in species and have largely been revised (Pasteels, 1972, 1980; Baker, 1995a), many regional species are rarely collected and several are known only from type material, some of which has been of uncertain status.

Of the 14 anthidiine species recorded from Peninsular Malaysia, only one, the widely-distributed cleptoparasite, *Euaspis polynesia* Vachal (Fig. 1B), has previously been recorded from Singapore based on a single collection from 1968 (Baker, 1995a). Eight of the 12 described species of *Euaspis* are recorded from Southeast Asia, making it the second most species-rich anthidiine genus in the region; all are known or suspected to be cleptoparasites of resin bees of the genus *Megachile* (*Callomegachile*) (Iwata, 1933, 1976; Baker, 1995a).

Anthidiellum is a genus of pollen-collecting solitary bees with 61 described species worldwide (in seven subgenera), most of which 50 species in six subgenera occur in the Old World (Ascher & Pickering, 2015). The 14 species of *Anthidiellum* known from Southeast Asia belong to four subgenera, all known from Peninsular Malaysia. All but two regional species were described prior to 1930. These described species have been placed in the subgenera *Ananthidiellum* (1 species), *Clypanthidium* (3), *Pycnanthidium* (4), and *Ranthidiellum* (4). Cockerell described two additional species in genus *Dianthidium* that surely cannot pertain to this exclusively New World genus and may instead be attributable to genus *Anthidiellum* as indicated below. *Dianthidium selangorensense* Cockerell, 1927, Peninsular Malaysia is transferred to *Anthidiellum* (*Clypanthidium*) (see species account below), whereas *Dianthidium riparium* Cockerell, 1929, from Nan Province, Thailand, is reportedly small in size (only 6.3 mm long) and has a sharp-edged scutellum, suggesting that it may be an *Anthidiellum* (*Pycnanthidium*). Pasteels (1972) revised the Indo-Malayan anthidiines, recognising only one species of *Pycnanthidium* from the Thai-Malay Peninsula and Sundaland, *Anthidiellum smithii* (Ritsema). Engel (2009) reviewed *Anthidiellum* (*Ranthidiellum*) in a paper, describing a new species from Thailand for which a new record is provided below along with some remarks on this subgenus.

Studies of well-documented species of *Anthidiellum*, such as *Anthidiellum* (*Loyolanthidium*) *notatum* (Latreille) sensu lato of North America and *Anthidiellum* (*Anthidiellum*) *strigatum* (Panzer) of Europe, suggest that they are strictly solitary (i.e., non-gregarious) bees that occur widely, but usually in small numbers (Michener, 2007). Like most members of the tribe Anthidiini, species of *Anthidiellum* (Hymenoptera: Anthophila: Megachilidae) typically have yellow integumental markings and have more sparsely-distributed setae when compared to other Megachilinae. Species of *Anthidiellum* tend to be relatively small, globular in body form, and possess strong carinae or lamellae, notably on the mesoscutellum.

In general, the tribes of Megachilinae are known to use a variety of materials, sometimes in combination, for nest linings with these traits are generally conserved within genera or species groups (Michener, 2007: 441). Anthidiines, in particular, are known to use a great assortment of materials for lining nests, including resin, plant fibres, leaf bits, pebbles, grass stem, pith bark, twigs, and even lizard dung (Krombein, 1967). Nearctic and Palearctic members of the genus *Anthidiellum* typically construct single cells made of resin in the open, affixed to plants or rocks (Michener, 2007).

Here we update the Anthidiini species in Singapore, permitting the first assessment of overall megachilid diversity in the country, and report noteworthy records of the tribe from the region. Firstly, we document the first Singapore record of the pollen-collecting anthidiine genus *Anthidiellum* based on a population of *Anthidiellum* (*Pycnanthidium*) *smithii smithii* (Ritsema) (Fig. 1A) discovered in 2014 at the Dairy Farm Nature Park near the Bukit Timah Nature Reserve—Singapore's highest quality remnant forest, and report observations of bamboo trap-nests occupied by this species. In addition, we document two species of *Eusapis* in Singapore, reporting new records for the known species *Eusapis polynesia* and recording a second enigmatic species represented by two males collected in 2015 at Kent Ridge Park. The identity of this second *Eusapis* species remains uncertain, and it will likely prove to be undescribed, i.e. a species new to science. Notes on the regional anthidiine fauna include new generic and subgeneric records for Laos and Cambodia, reclassification of *Dianthidium selangorensense* Cockerell, 1927, as *Anthidiellum* (*Clypanthidium*) *selangorensense* (Cockerell, 1927), and a new record of *Anthidiellum* (*Ranthidiellum*) *ignotum* Engel from Phayao Province in Thailand.

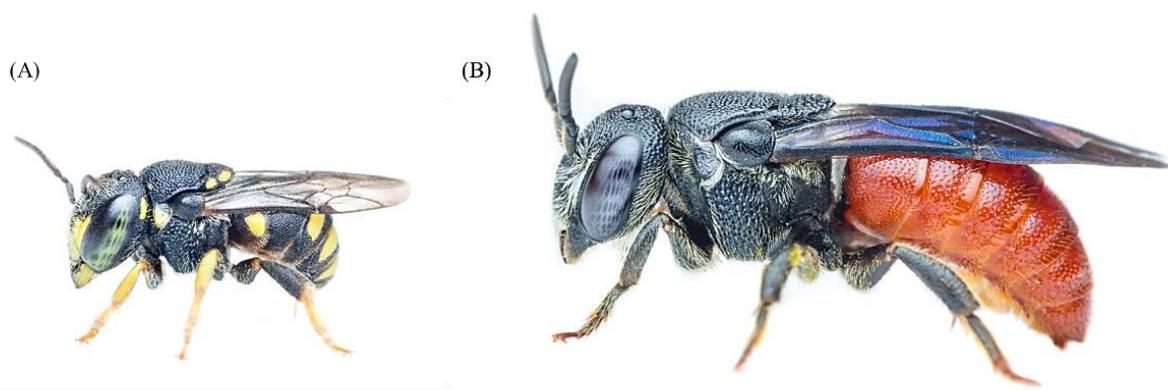


Fig. 1. Representative Anthidiini of Singapore. Profile habitus of live (a) *Anthidiellum* (*Pycnanthidium*) *smithii smithii* (Ritsema) male and (b) *Eusapis polynesia* Vachal female. Scale bar = 2mm. (Photographs by: Z. W. W. Soh).

TAXONOMY AND OBSERVATIONS

Anthidiellum (Clypanthidium) selangorensis (Cockerell, 1927), new combination

Dianthidium selangorensis Cockerell, 1927: 532. [Female holotype from the Malay Peninsula, Selangor Province, Bukit Kutu [site of the former colonial station also known as Treacher's Hill], 3500 ft. deposited in the Natural History Museum, London (NHML) (examined and imaged by Zestin Soh, but images not presented here) was collected by H. M. Pendlebury on 18 April 1924.]

Global distribution. Malaysia: Selangor

Remarks. The author of this species noted that it, “appears to be closely related to *Anthidium bimaculatum*, Friese” (a species of subgenus *Clypanthidium*). The female type examined is newly placed in subgenus *Clypanthidium* based on presence of subgeneric characters mentioned by Michener (2007) but with one discrepancy noted that should be investigated in a revisionary study. Michener observed that in species of this subgenus, “The body may be black with yellow marks only on T5 (female), as in *Anthidiellum (C.) bimaculatum* (Friese).” By contrast, in *Anthidiellum (Clypanthidium) selangorensis* the yellow marks are only on T6 (not T5). Although subgenus *Clypanthidium* has previously been reported only from Peninsular Malaysia (Michener, 2007), it is now known to occur in Yunnan, China (Niu et al., 2016), and the newly placed Chinese species along with two others have been found in Laos (new information). The newly recognised material from Laos includes the previously unknown male of this enigmatic subgenus, which should facilitate its generic placement (see Michener, 2007).

Anthidiellum (Pycnanthidium) smithii smithii (Ritsema, 1874)

(Figs. 1A, 2)

Anthidiellum smithii Ritsema, 1874: 111 [Male holotype from Ambarawa in Java deposited in the Naturalis Biodiversity Center (former Rijksmuseum van Natuurlijke Historie) in Leiden, Netherlands, was collected by Dr. Ludeking.]

Anthidium minutissimum Bingham, 1903: App. [Male (not female) “type” from Biserat in “Jalor” in Siam (now Yala Province, Thailand) deposited in the Natural History Museum, London (NHML) (examined and imaged by Zestin Soh, but images not presented here)]

Anthidium javanicum Friese, 1909: 257 [Two male syntypes from the botanical garden in Buitenzorg (now Bogor) in Java, collected by Schmiedeknecht.]

Global distribution. Indonesia: Bangka, East Kalimantan (Borneo), Java, Sumba; Malaysia: Negeri Sembilan, Penang; Philippines: Palawan; Singapore (new record); Thailand: Chaiyaphum, Chiang Mai (Tadauchi & Tasen, 2009), Chonburi (new record). An additional subspecies *Anthidiellum (Pycnanthidium) smithii ochropus* Pasteels (1972: 93) was described from Ambon in the Maluku Islands of Indonesia. *Anthidiellum (Pycnanthidium) carinatum* (Wu, 1962), with a type locality of southern Yunnan (Xishuangbanna), is similar (Niu et al., 2016). Another similar form, undocumented in the literature, from Laos has much reduced yellow maculations (see below).

Materials examined. Singapore material: SINGAPORE: Dairy Farm Nature Park, 1 female and 1 male (National University of Singapore Insect Diversity Laboratory Insect Collection (IDL)), E. J. Y. Soh, 10 June 2014, ex. *Bidens pilosa*, scrubby area [male—Total Length (TL): 4.16mm, Intertegular Distance (ID): 1.43mm]; 1 male (IDL DF11Jun2014-026), coll. J. S. Ascher & E. J. Y. Soh, 11 June 2015, ex. *Bidens pilosa* [imaged at high resolution: see Fig. 2]; 2 males (IDL DFB-024 & DFB-030), coll. E. J. Y. Soh, 19 June 2014, ex. *Bidens pilosa*, at scrubby area [male—TL: 4.45mm, ID: 1.50mm]; 1 male (IDL), 11 June 2014, coll. E. J. Y. Soh; outside Bukit Timah Nature Reserve at Bukit Drive: 1 male and 1 female (IDL), 1 July 2014, coll. E. J. Y. Soh, ex. *Muntingia calabura* [female—TL: 3.52mm, ID: 1.19mm]; 1 male (IDL), 28 July 2014, coll. Z. W. W. Soh & E. J. Y. Soh, ex. *Muntingia calabura* [live bee imaged, see Fig. 1A]; Other non-Singapore material: MALAYSIA: Negeri Sembilan: 1 female (Forest Research Institute of Malaysia (FRIM)), Pasoh Research Centre, coll. Bud, Inoka, 11 August 2003. THAILAND: Chonburi Province: 1 male (personal collection of Maximilian Schwarz), Pattaya, coll. W. Schecht, May 1989, det. to species by S. Risch, 2008; Yala Province: 1 male (not female) holotype from “Biserat, Jalor” of *Anthidium minutissimum* Bingham (NHML HYM 17a. 1875), 18 September 1901 (as cited by Bingham, 1906), coll. “Annadale & Robinson, 1903” (label on specimen; evidently the year does not refer to the collecting event); Nan Province: 1 male (Oberösterreichisches Landesmuseum, Linz (OLML)), Mae Charim National Park entrance, 10 May 2012, coll. “E. und [&] J. Hüttinger”; Mae Hong Son Province: 2 males (OLML), “Soppong env., 600m”, 28 May 1999, coll. M. Riha

References. Krombein (1951) described the subgenus *Pycnanthidium* and provided diagnoses of *Anthidium minutissimum*, a junior synonym of *Anthidiellum smithii*, and compared it to other *Pycnanthidium* (*Anthidiellum turneri*, *Anthidiellum solomonis*). The revision of Indo-malayan anthidiines by Pasteels (1972) provided line drawings of *Anthidiellum smithii smithii*, redescribed it, and synonymised the names *Anthidium javanicum* and *Anthidium minutissimum*. Griswold (2001) described *Anthidiellum krombeini*, noting its close taxonomic affinity to *Anthidiellum smithii*, with the former differing in “coarse punctuation of frons, scutum and terga and the shiny posterior face of the

propodeum”, the absence of a central sternal comb on the fifth sternum, and shape of the profemur and protibia. Tadauchi & Tasei (2009) recorded *Anthidiellum smithii* from Thailand for the first time from natural forests, and provided a monochrome image of its dorsal habitus.

Host plants. Males and female *Anthidiellum smithii smithii* were observed foraging on *Bidens pilosa* (Asteraceae) and *Muntingia calabura* (Muntingiaceae) in the mornings (~1030 hours) and afternoons (~1400 hours) at the Dairy Farm Nature Park and Bukit Timah Nature Reserve, respectively, from June–July 2014. Two females were collecting pollen from each of the aforementioned plants and carrying an orange pollen load in their ventral scopa (both plants have orange pollen). *Anthidiellum smithii smithii* has been recorded visiting flowers of *Microcos tomentosa* (Malvaceae) in Java (Pasteels, 1972).

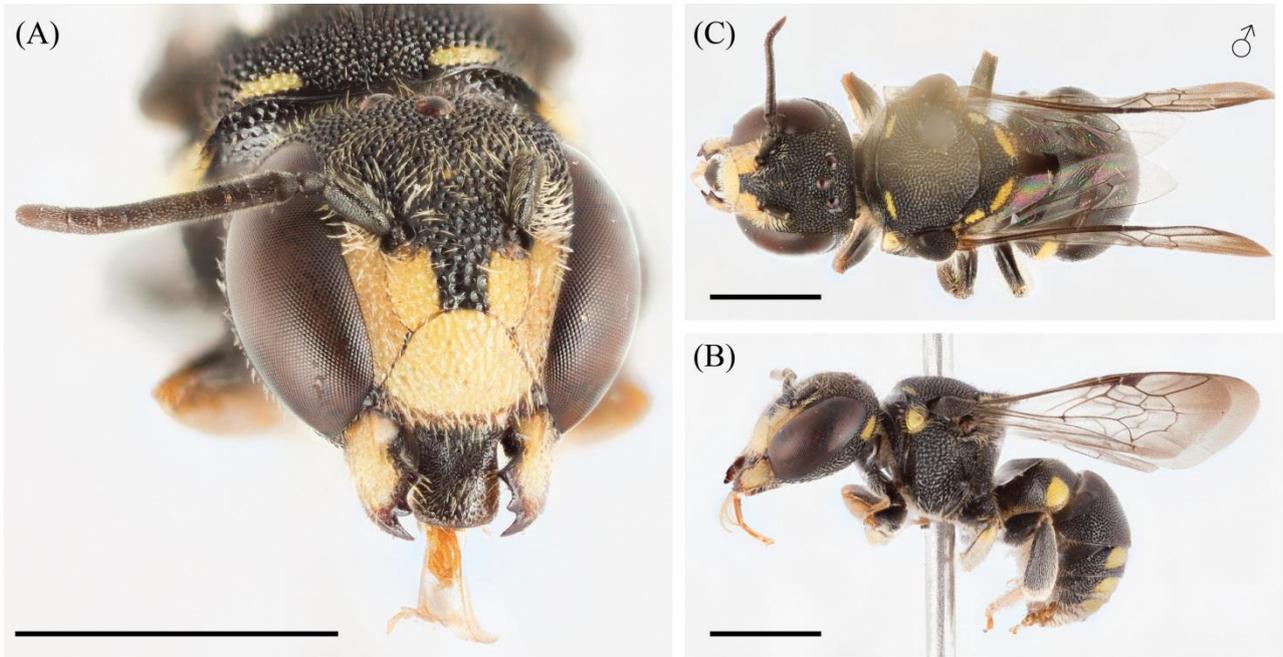


Fig. 2. *Anthidiellum smithii smithii* male. (A) head, (B) dorsal, (C) profile habitus. Scale bar = 1 mm. (Photographs by: E. J. Y. Soh).



Fig. 3. Open, scrubby habitat adjacent to the forest where *Anthidiellum (Pycnanthidium) smithii smithii* was found foraging on *Bidens pilosa* at the Dairy Farm Nature Park, Singapore. (Photograph by: E. J. Y. Soh).

Remarks. Although Bingham (1903) described *Anthidium minutissimum* based on a putative female, his description clearly refers to a male as it mentions yellow mandibles, a character found only in that sex. Although Pasteels (1972) correctly indicated the type to be a male, it had been labeled in the Natural History Museum collection as a female.

Singapore specimens of *Anthidiellum smithii* (Fig. 2) are somewhat darker than the male (not female) type of *Anthidium minutissimum* Bingham, 1903, with reduced markings on the head, scutum, scutellum, and third metasomal tergum (T3), and darker tegulae, and much darker than the non-type male examined from Pattaya, Thailand. Whereas, the male from Pattaya has a large maculation on the frons in the shape of an inverted teardrop, Singapore males have this spot greatly reduced to a dot (two individuals) or entirely lacking (five individuals). The specimen from Pattaya has the supraclypeal area entirely yellow below the level of the antennal sockets, but the Singapore males have this area black medially to the epistomal sulcus. In the Singapore exemplars and in the male (not female) *Anthidium minutissimum* type, paired yellow maculations on T3 are widely separated medially whereas the individual from Pattaya has a continuous band across T3. The newly determined male specimen from Nan, Thailand, is darker in colouration, similar to the specimens from Singapore, but the two specimens from Mae Hong Son, Thailand, are intermediate between the type and Singapore specimens. These and other more or less continuous differences in coloration between populations suggest that further taxonomic study may be needed, but Pasteels (1972) noted colour variation in this subspecies, and for now we apply the name available for the well-known regional subspecies of *Pycnanthidium* to the Singapore specimens pending revisionary study of the subgenus. A female *Anthidiellum* (*Pycnanthidium*) from Houaphanh Province in eastern Laos is darker in colour than any definitively identified *Anthidiellum smithii*, e.g., it has entirely black, unmaculated mid and hind legs. Discovery of the male of this form and use of molecular diagnostics should clarify the relationship of this and other undocumented forms to typical *Anthidiellum smithii*.

Nest architecture. Two nests of *Anthidiellum smithii smithii* were recovered from a trap-nest at the Dairy Farm Nature Park at the garden near the Wallace Education Centre (1°21'32.9472"N, 103°52'19.0416"E). One trap-nest unit was made of approximately nine bundled bamboo internodes with raffia string. The first was recovered on 11 June 2014 and the second on 28 July 2014. Both nests were from separate bamboo internodes but the same trap-nest placement (height: 45 cm, direction: south-facing at 106°, on a tree). The surrounding habitat is a human-managed garden at the edge to secondary forest (Dairy Farm Nature Park), in proximity to remnant coastal hill dipterocarp primary rainforest at Bukit Timah Nature Reserve (Yee et al., 2011).

Both nests were split open longitudinally and photographed. Only the bionomics of the first nest were recorded (internal diameter: 3.3 mm; length: 23 cm; Fig. 4A) and described with terminology according to Krombein (1967). The first nest was plugged with resin. This was followed by a partition made up of a complex of resin and a whitish substance 5.5 mm from the entrance, followed by another similar partition 17.5 mm from the entrance. These constituted two vestibular cells. The whitish substance and resin were interspersed as particles throughout the nest after the second partition, for 34 mm, before the pollen-provisioning cells (Fig. 4A). We were unable to identify the whitish substance but suspect that it could be plant gum as it was organic and not mineral in nature (Fig. 4 inset).

Immediately after the vestibular cells, there were four provisioning cells, each with pollen (Fig. 4B), and were not flushed to the closed end of the internode. The pollen within the cells was solid and compacted. These were in total 19 mm long, with individual cells 6–6.5 mm in horizontal length, similar to cell lengths recorded for consubgenera *Anthidiellum butarsis* Griswold (~7.14 mm) and *Anthidiellum krombeini* Griswold (~6 mm) (Krombein & Norden, 2001). Partitions between the four cells were of the whitish gummy substance and coated internally with resin (Fig. 4B). Provisioned cells in linear series were placed obliquely to each other. None of the larvae successfully pupated when reared ex-situ in the laboratory but the first nest could be attributed to *Anthidiellum smithii smithii* upon discovery of the dead female in the second dissected nest (vide infra). It could not have been constructed by *Heriades* (*Michenerella*) *othonis* Friese (Megachilinae: Osmiini) (new record for Singapore, recorded as *Heriades* (*Michenerella*) sp. 1 by Soh and Ngiam, 2013), the only other comparably small-bodied megachilid recorded in the Dairy Farm Nature Park (records from IDL), as there are prominent differences in nest bionomics between the two species (see Table 1). Firstly, the provisioned cells of nests of *Heriades* species were less compact than the cells of *Anthidiellum smithii smithii*. Secondly, cell walls were obliquely parallel in the nest of *Anthidiellum smithii smithii* but not in that of *Heriades* species. Thirdly, *Heriades* species only used resin for its nest partitions whereas *Anthidiellum smithii smithii* used resin and the unknown whitish substance. Fourthly, the cell walls of *Heriades* species were not coated internally with resin as were the cell walls of the *Anthidiellum smithii smithii* nest.

Bionomic details of the second nest of *Anthidiellum smithii smithii* (internal diameter: 4.4 mm; length: 23.1 cm) were not recorded as this nest was not completed. Rather, a wasp had superseded it and provisioned the single cell with spider prey (Fig. 5). The wasp's identity could not be determined as the individuals had already emerged and neither were the spider leg remains identified owing to lack of expertise. A dead female of *Anthidiellum smithii smithii* was found in its nest, presumably unable to exit when emerging due to the preliminary (basal) plug of the wasp nest. The female was desiccated and brittle when found.



Fig. 4. Nest of *Anthidiellum smithii smithii* in a bamboo culm, where the closing plug is to the right end of the diagram. A, The entire nest with four provisioned cells, clustered and two vestibular cells, (inset) close-up of closing plug, comprising of the whitish substance and resin. B, close-up of the clustered cells. Triangles with the black fill demarcate the start of each of the four cells respectively, and triangles otherwise so refer to the end of the cell. C, Nest of *Heriades (Michenerella) othonis* from Pasir Ris Park (collected on 30 April 2014) with cells spaced out, and cell partitions made exclusively of resin. *Heriades othonis* had successfully emerged as adults. Similarly, the closing plug is to the right of the diagram. Scale bars = 10 mm. (Photograph by: E. J. Y. Soh).



Fig. 5. Cells of undetermined spider-hunting wasp which superseded the *Anthidiellum smithii smithii* nest (not shown) in the bamboo internode. Foreground: ruler with 1mm markings. (Photograph by: E. J. Y. Soh).

Remarks. No candidate cleptoparasites exist but elsewhere the genus *Anthidiellum* is known to be parasitized by the genus *Stelis* (Megachilidae: Anthidiini) that primarily has a Holarctic distribution (Michener, 2007). The hosts of *Stelis (Malanthidium)*, endemic to the Malay Peninsula, are unknown but are unlikely to include *Anthidiellum smithii smithii* owing to a larger body size of the former (ca. 8–11 mm long).

***Anthidiellum (Ranthidiellum) ignotum* Engel, 2009**

Anthidiellum (Ranthidium) ignotum Engel, 2009: 30 [Female holotype from Sakaerat Environmental Research Area, about 40 km S of Nakhon Ratchasima in Nakhon Ratchasima Province, northeastern Thailand deposited in the Snow Entomology Museum Collection in Lawrence, Kansas, was obtained by an unknown collector on 10 July 1985.]

Global distribution. Thailand: Nakhon Ratchasima, Phayao (new record)

Materials examined. THAILAND: Phayao Province: 1 female (Natapot Warrit collection, Chulalongkorn University, Bangkok Thailand), Meuang District, Tumbon Maeka, Phayao University, 1 June 2012, coll. W. Suwannarak.

Remarks. Both known specimens were collected in the summer. A male *Anthidiellum (Ranthidiellum)* recorded in February 2016 from Seima Protection Forest in Mondulkiri Province in eastern Cambodia that mimics larger-bodied syntopic Meliponini such as *Tetrigona apicalis* (Smith, 1857) does not seem to match the known species but these all have female holotypes, complicating comparisons. Revisionary study of this subgenus with critical assessment of colour variability is required, and this should include reassessment of a Malaysian specimen from Johor illustrated by Engel (2009) as *Anthidiellum (Ranthidiellum) rufomaculatum* (Cameron, 1902) that appears to differ considerably in colour pattern from the type of that species.

***Euaspsis polynesia* Vachal, 1903**

(Fig. 1, Fig. 6)

Stelis abdominalis Smith, 1858: 7 [Male holotype in Oxford University Museum collected in Sulawesi (as Celebes), most likely from the Makassar vicinity by A. R. Wallace (Baker, 1995b).]

Euaspsis polyesia [!] Vachal, 1903a: 97, replacement name for *Stelis abdominalis* Smith. [Misspelling interpreted as a printer's error (Baker, 1995a).]

Euaspsis polynesia Vachal, 1903b: 173, justified emendation

Euaspsis smithi Friese, 1904:137, unnecessary replacement name

Parevaspsis impressus Viereck, 1924: 745 [Cited combination miscited by Baker (1995a), as *Parevaspsis impressa*; male holotype and female allotype are in the United States National Museum, collected from Surigao, Mindanao collected by C. F. Baker.]

Euaspsis basalis chinensis Cockerell, 1930: 50 [Female "type" and male "cotype" in the NHML collected in Foochow District, China, were collected by Kellogg.]

Global distribution. China: Anhui, Fujian, Guangdong, Gansu, Hebei, Hunan, Jiangsu, Jiangxi, Shandong, Xizang, Yunnan, Zhejiang; Hong Kong; Indonesia: Ambon, Bali, Bangka Island, Buru, Engano Island, Java, Kai Islands [probably; see Vachal (1903a), and Baker (1995a)], Sebesi Island, Sumatra, Sulawesi; Japan: Okinawa Prefecture; Laos; Philippines: Mindanao, Luzon; Myanmar; Nepal; Taiwan; Peninsular Malaysia: Kedah, Kelantan, Melaka, Penang, Perak, Selangor; Singapore; Thailand: Chiang Mai, Loei, Pattani, Satun, Surat Thani (Koh Samui Island, new record); Vietnam: Hoa Binh

Material examined. SINGAPORE: 1 male (Lee Kong Chian Natural History Museum Zoological Reference Collection (ZRC) JXQL0152), Pulau Ubin of Sungei Puaku mangrove, coll. John X. Q. Lee, 18 May 2012, ex. *Cordia cylindristachya*; 1 female (IDL), NUS, University Hall, coll. J. S. Ascher, 15 August 2013, ex. *Premna foetida*; 1 male (IDL Batch04-007), outside Bukit Timah Nature Reserve, at Bukit Drive, coll. Z. W. W. Soh & E. J. Y. Soh, 28 July 2014, ex. *Muntingia calabura*; 1 female and 1 male (IDL), Ang Mo Kio Town Garden West, coll. Z. W. W. Soh et al., 22 August 2014, ex. *Grammatophyllum speciosum* [female: TL—12.01 mm, IT—2.17 mm, live bee imaged: see Fig. 1B and imaged at high resolution: see Fig. 6A; male: TL—7.63 mm, IT—1.44 mm, imaged at high resolution: see Fig. 6B, C]; 1 female (IDL), Chinese Garden, coll. J. J. L. Lai, 14 October 2015, ex. *Antigonon leptopus*; 1 female (IDL), Jurong Estate, coll. J. J. L. Lai, 16 November 2015, ex. *Averrhoa carambola* [this locality, not mapped, is just west of Chinese Garden]; MALAYSIA: Selangor: 1 female (University of Malaya, Museum of Zoology Insect Collection (UMKL)), Petaling Jaya, coll. Kunauathy, 27 March 1974; 1 female (UMKL), coll. KSG, 20 February 1987; 1 female (UMKL), coll. Abd. Rashid, August 1973; Kedah: 1 male (UMKL), S. G. Way, coll. N. H., 21 October 1982; THAILAND: Surat Thani: 1 female (personal collection of Maximilian Schwarz), Koh Samui Island, env. SE, coll. J. Halada, M. Fabianová, February 2015

References. Revision of global *Euaspsis* by Pasteels (1980). Review of Asian species of *Euaspsis* by Baker (1995a). Baker (1995a) clarified the taxonomy, nomenclature, and distribution of this species, which had been complicated by homonymy, incorrect original spelling of Vachal's replacement name, publication of an unnecessary replacement name by Friese, and Pasteels' (1980) having overlooked both the paper of Viereck (1924) and the validity of the justified emendation of Vachal (1903b).

Host plants. Observed visiting flowers of *Premna serratifolia* (Lamiaceae); *Muntingia calabura* (Muntingiaceae), starfruit *Averrhoa carambola* (Oxalidaceae), and Tiger Orchid *Grammatophyllum speciosum* (Orchidaceae). The latter attracted many *Megachile* during a mass bloom during 2014 in Singapore (Soh et al., in prep.). As cleptoparasites, *Euaspiis* species do not collect pollen to provision their nests but are known to visit flowers such as *Antigonon* (Polygonaceae) for nectar (Baker, 1995a).

Remarks. The only published record from Singapore was that of a female collected from “Postal District 10” within the Ardmore, Bukit Timah, Holland Road and Tanglin districts (Urban Redevelopment Authority, 2015) on 20 July 1968 by C. G. Roche (personal collection at Maidstone; Baker, 1995a).

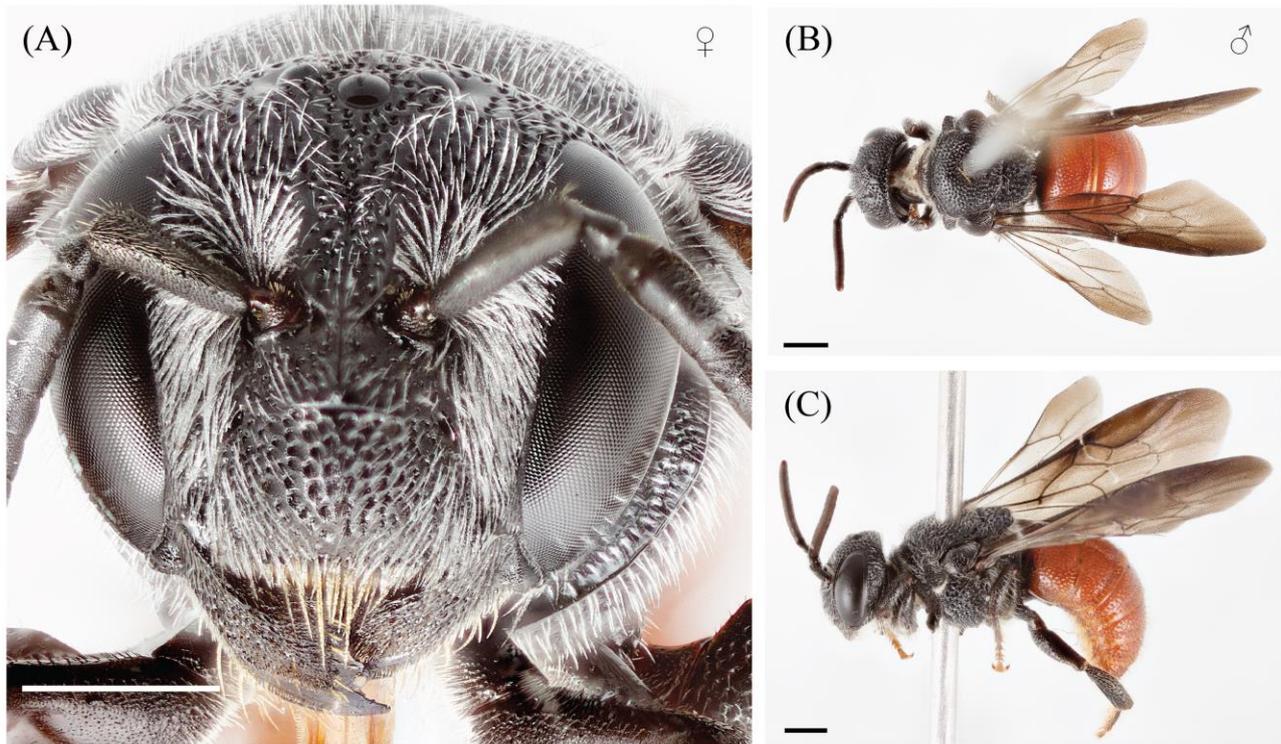


Fig. 6. *Euaspiis polynesia*. A, Head of female. B, dorsal and C, profile habitus of the male. See Baker (1995a) for illustrations of the diagnostic sternal character. Scale bars = 1 mm. (Images by: E. J. Y. Soh).

***Euaspiis* sp. nov.?**
(Fig. 7, Fig. 8)

Global distribution. Singapore (new record or probable male, described for the first time)

Diagnosis. Morphological terminology adopted is based on Michener (2007). This species is similar in size and habitus to *Euaspiis polynesia* which is found in Singapore, and tends to be relatively small, but readily distinguished by its 7th tergum (T7) (Fig. 8D) lacking the acute lateral spines of the “lobe” found in *Euaspiis polynesia* and thus resembling that of *Euaspiis trilobata* Pasteels, 1980. In comparison to *Euaspiis polynesia* and also *Euaspiis trilobata* of the Lesser Sundas (not expected to occur in Singapore) the Singapore male differs based on the 6th sternum (S6). The S6 has a narrow, glabrous [asetose] triangular groove only at the apex in *Euaspiis polynesia* and has a groove with a median projection (spine) in *Euaspiis trilobata*, but is a broader groove extending further basad and lacking an apical projection in the new species (Fig. 8C). As with females of *Euaspiis aequicarinata*, males of this species have conspicuous pale margins to the mesoscutellum that are lacking in *Euaspiis polynesia*, and the coarse punctures of the mesoscutellum are more closely spaced so that shining interspaces are lacking or very narrow (Fig. 8A, B); broader in *Euaspiis polynesia*. As compared with the male of *E. aequicarinata* (not recorded from Singapore) the new species lacks the medial spine on S5, and lacks a strong medial projection of S6 separated by emarginations from smaller lateral projections. The male of the probable new species has the integument of the apical terga somewhat blackened (but still red) as opposed to more uniformly and purely red in *Euaspiis polynesia* (both species have small black spots at the base of first tergum). The male genitalia (Fig. 8Fig. 7E) was not studied in detail but seems to resemble that of *Euaspiis polynesia*.

Material examined. SINGAPORE: Kent Ridge Park: 1 male (IDL), coll. N. A. Mohd Adom, 20 October 2015; 1 male (IDL), coll. S. X. Chui, F. A. Tjong, 23 October 2015, ex. *Syzygium zeylanicum* [male: TL—8.64 mm, IT—2.08 mm]

Host plants. *Syzygium zeylanicum* (Myrtaceae)

Remarks. The male specimens from Singapore do not match any species treated by Pasteels (1972) or Baker (1995a), so are presumably a new species. In addition to these Singapore males, we also examined a female specimen (Fig. 8A, C) from Laos of uncertain identity in the personal collection of Maximilian Schwarz likely pertaining to this or another new species. [Note added in proof: this may prove to be a small individual of *Euaspsis strandi* Meyer, 1921] This bee, from Houaphan Province, Mount Phu Pane, ca. 1,500 m, coll. S. Jakl, 10–22 May 2011, closely resembles Singapore males in coloration, including the yellow-margined scutellum (Fig. 8A) and, as with the Singapore males, the sternum of the Laotian female is simple, with S6 (Fig. 8C) lacking the median carina found in other species such as *Euaspsis polynesia* and lacking the transverse carina of *Euaspsis aequicarinata*. Collection of the opposite sexes of the putative new male from Singapore and the putative new female from Laos will be desirable after which their taxonomic status can be better assessed in revisionary study and one or more new species described as necessary.

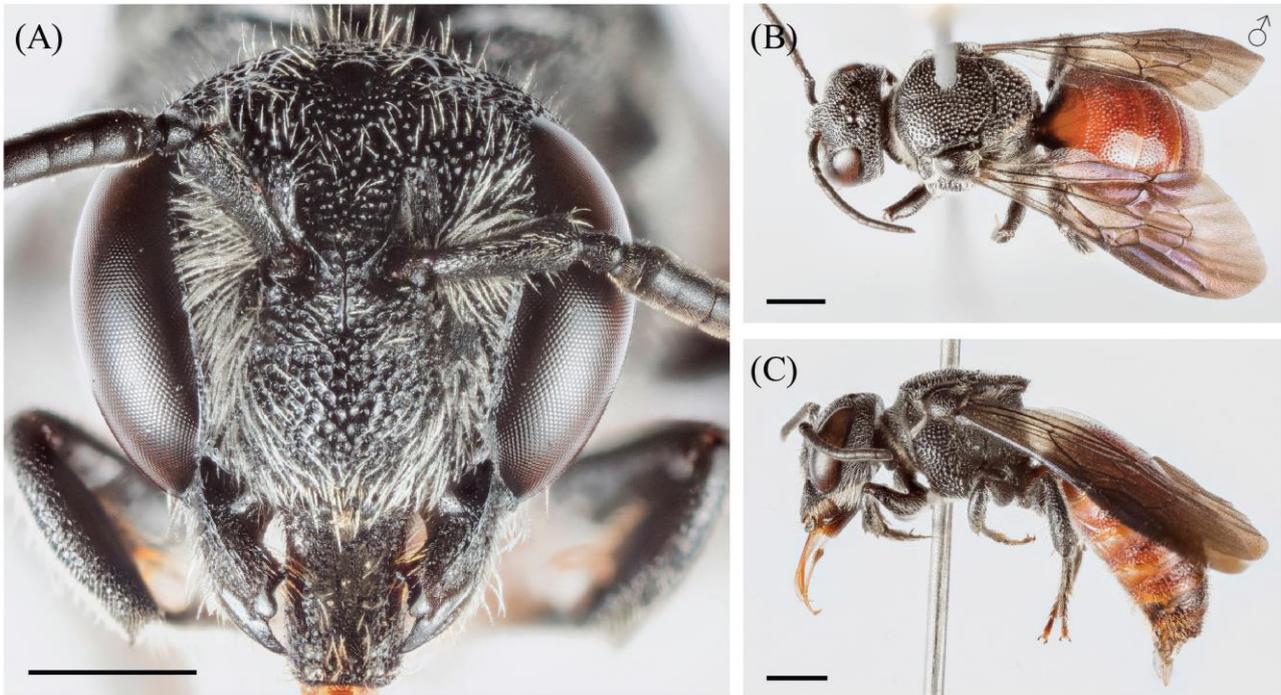


Fig. 7. *Euaspsis* nov. sp.? A, head; B, dorsal; and C, profile habitus of male. Scale bars = 1 mm. (Images by: S. X. Chui).

Euaspsis aequicarinata Pasteels, 1980

Euaspsis aequicarinata Pasteels, 1980: 78 [Female holotype in NHML from “Sabah, Kalabakan, collected 3–11 April 1973, by K. M. Guichard.]

Global distribution. China: Yunnan; Indonesia: Java; Laos: Vientiane; Malaysia: Negeri Sembilan (new record), Sarawak; Thailand: Nakhon Ratchasima, Surat Thani; Vietnam: Hoa Binh

Material examined. MALAYSIA: Negeri Sembilan: 1 female (FRIM), Pasoh Research Centre, coll. Inoka, Yang, Ema, 3 August 2003.

References. The male described as *Euaspsis aequicarinata* by Pasteels from Surat Thani Province, Thailand was only doubtfully associated with the female, based on the similarity in clypeal sculpture, as the allotype was unique and collected far from any females (those not reported from Thailand).

Remarks. As the distribution of *Euaspsis* species in the region is incompletely documented, we take this opportunity to record a female *Euaspsis aequicarinata* Pasteels, 1980 present in Negeri Sembilan state in Peninsular Malaysia, a new record for the country. The species was described based on a female holotype from Sabah, Borneo (the correct type locality as noted by Baker, 1995a, misattributed by Pasteels to “Arabie”) and is newly recorded here from Peninsular Malaysia based on a female specimen examined. Baker (1995a) did not include this species in his key to male *Euaspsis* suggesting that he was also uncertain about the status of its putative male.

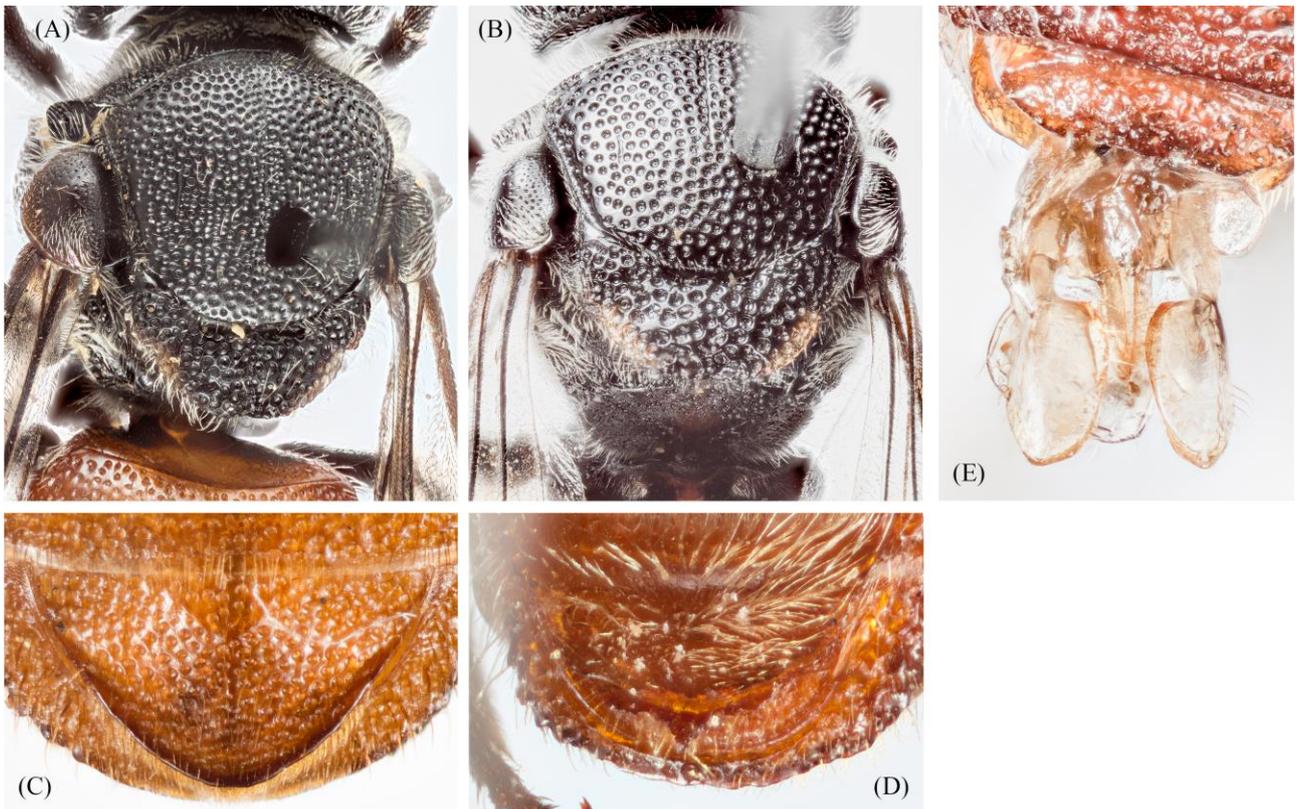


Fig. 8. Some diagnostic features of *Eusapis* nov. sp.? including: A, B, dorsal view of thorax; note coarsely punctate scutellum with pale lateral margins in both A, the Laotian female and B, Singapore male; C, sixth sternite (S6) in oblique ventral view; note lack of median carina; D, weakly trilobed seventh tergum (T7) in oblique ventral view; E, male genitalia in oblique dorsal view; Females: A, C; Males: B, D, E. (Images by S. X. Chui).

DISCUSSION

First record of *Anthidiellum* and diversity of Anthidiini in Singapore. This represents the first and only record of a pollen-collecting anthidiine for Singapore, bringing the number of species of the tribe Anthidiini in Singapore to three: *Anthidiellum (Pycnanthidium) smithii smithii*, *Eusapis polynesia*, and an unidentified *Eusapis* species that is likely undescribed, i.e., new to science. *Anthidiellum* was undetected in two prior bee studies (Liow, 2001; Soh & Ngiam, 2013), although the latter included surveys conducted in the same locality (DFNP). This bee may have been overlooked owing to its small body size and its limited flight period, as used to explain infrequent encounters with *Anthidiellum* in Thailand (Engel, 2009; see Table 1 in this paper for month of nest collection). The species occurs in or near forests in Singapore and can be considered native to the region, including Singapore, as it was recorded historically from both Peninsular Malaysia and several Indonesian islands.

Females of *Anthidiellum smithii smithii* were found collecting pollen from *Bidens pilosa* and *Muntingia calabura*, both of which are exotic in Singapore (Chong et al., 2009). In Australia, *Bidens pilosa* is found commonly growing at the edges of natural forests, as well as roadsides, parks and gardens, and both *Bidens pilosa* and *Muntingia calabura* are regarded as ‘environmental weeds’ (The University of Queensland, 2011). However, despite widespread distribution of host plants for *Anthidiellum smithii smithii* throughout Singapore, individuals have only been found near high-quality forests (Fig. 9) unlike several other pollen-generalist (polylectic) species of *Megachile* in Singapore (Ascher et al., 2016a), suggesting that the species may require such habitats for nesting. Tadauchi & Tasen (2009) also recorded *Anthidiellum smithii* from natural forests. Habitat fidelity to the primary or mature secondary forest could potentially be due to specificity in resin use, as with a confamilial bee, *Megachile pluto*, which collects resin of dipterocarp trees with antifungal properties, specifically to line its nest (Messer, 1984; 1985). Elucidation of the plants used as sources of the resin used for lining nests of *Anthidiellum smithii smithii* may shed light on its limited habitat occupancy.

Further investigation of this species at the collecting site in 2015 (Fig. 3) revealed that the original scrubby habitat was rehabilitated with tree plantings. While forest-dwelling wildlife may benefit from general reforestation, many bees are known to utilise (but not necessarily prefer) flowers of exotic plants owing to their sheer abundance (Williams et al., 2011). These exotic plants can be abundant in open, early-successional habitats as shown here in the habitat within the pollen-foraging range of *Anthidiellum smithii smithii*. However, whether the removal of these exotic plants (e.g., *Bidens pilosa*) significantly diminishes floral resources for such native bees and decreases the bee population is currently uncertain and could be investigated further with another trap-nesting study.

The cleptoparasitic *Euaspis polynesia* is widely distributed across Singapore, reflecting the widespread occurrence of its likely hosts among *Megachile* (*Callomegachile*), which are well known to inhabit managed greenery and urban areas in addition to secondary forests and forest edge (Fig. 8). In our recent studies we have encountered *Euaspis* as singleton visitors to nectar plants also visited, in most cases, by *Megachile* (*Callomegachile*). *Euaspis polynesia* is known as a cleptoparasite of *Megachile disjuncta* but must have other host species because its geographical range extends beyond that of *Megachile disjuncta*, and because *Euaspis polynesia* varies considerably in size (Baker, 1995a). In Singapore, *Megachile* (*Callomegachile*) *umbripennis* Smith is another candidate host of *Euaspis polynesia* based on size and co-occurrence. Although 20 species of *Megachile* have now been recorded from Singapore (Ascher et al., 2016a), only one associated species of cuckoo bees in the genus *Coelioxys*, tentatively identified as *Coelioxys confusa* Smith, 1875, has been recorded frequently in recent surveys. The leaf-cutter bee *Megachile* (*Aethomegachile*) *laticeps* Smith has been confirmed as a host of this species (Ascher et al., 2016a). Thus, species of *Euaspis* are the only known or suspected cleptoparasites of Singapore *Megachile* resin bees and should be confirmed by rearing of parasites from nests of *Megachile*. Megachilidae larvae found in *Megachile* (*Callomegachile*) resin bee nests should be identified critically as they potentially could be either of three megachilid genera. What appears to be an adult of an undescribed species of *Coelioxys* (*Torridapis*) aff. *fenestrata* Smith, has also been found recently in Singapore and may be associated with that host subgenus as *C. fenestrata* is well known to parasitize *Megachile* (*Callomegachile*) *sculpturalis* Smith in Japan (Nagase, 2006). In total, 29 megachilid species are now confirmed for Singapore including the three Anthidiini species treated in this paper (one apparently undescribed), the osmiine *Heriades othonis*, 20 *Megachile* species (five of which are unnamed morphospecies, see Ascher et al., 2016a), the three confirmed *Coelioxys* (one unidentified and one undescribed), and two *Lithurgus* morphospecies. One of the *Lithurgus* closely resembles *Lithurgus collaris* Smith and is associated with sea hibiscus, *Talipariti tiliaceum* (Malvaceae) on the shores of Singapore, whereas a similar but smaller species occurs at Gardens by the Bay and in other urban gardens. The 29 species of Megachilidae reported here comprise nearly one-quarter of the ca. 127 bee species and morphospecies now known to occur in Singapore, of which ca. 102 are named and the remaining 25 are unidentified and, in several cases, likely undescribed.

Notably, *Megachile disjuncta* and *Megachile umbripennis* are now also the two most common species of resin bees of the genus *Megachile* present in Singapore, despite having been first detected in the country relatively recently (1974 and 2010, respectively; Ascher et al., 2016a). Lack of historical records of these *Megachile* and of either *Euaspis* prior to 1968 may suggest that the presence of both host and cleptoparasite in Singapore may be relatively recent. Groom et al. (2014) showed through population genetics that megachilids, including *Megachile umbripennis*, established recently as exotics to the island of Fiji. Whereas the two *Callomegachile* are now very conspicuous in Singapore, the cleptoparasites are rare enough that either or both could have been overlooked by collectors. Molecular population genetics would be necessary to test the possibility of co-introductions of *Megachile* hosts and *Euaspis* cleptoparasites to Singapore. Globally, introductions of exotic cleptoparasitic bee species have not been reported in the literature but have occurred. *Coelioxys* (*Allocoelioxys*) *coturnix* Pérez, 1884["1883"], as determined by *Coelioxys* specialist Maximilian Schwarz based on his study of the first North American specimen detected (by JSA), is now known to be established in Maryland, Pennsylvania, and Virginia in the eastern United States as documented in various online sources including Bugguide (www.bugguide.net), Discover Life (www.discoverlife.org), and the Maryland Biodiversity Project (<http://www.marylandbiodiversity.com>).

Nest of *Anthidiellum smithii smithii*. Construction by subgenus *Pycnanthidium* with resin nest cells in trap-nests as previously reported from Sri Lanka (Krombein & Norden, 2001), contrasts with construction of nest cells in the open by well-known Holarctic species of *Anthidiellum* (*Anthidiellum*) sensu stricto and *Anthidiellum* (*Loyalanthidium*), and in the soil by the Southeast Asian subgenus *Ranthidiellum* (Pasteels, 1972, 1977). Here, we report for the first time that *Anthidiellum smithii smithii* is a cavity-renting species, based on utilisation of bamboo nests with an internal diameter ranging between 3.3–4.4 mm.

Anthidiellum (*Pycnanthidium*) *smithii smithii* used nest partitions made of resin and an unknown whitish substance, whereas its consubgenera *Anthidiellum* (*Pycnanthidium*) *butarsis* Griswold, and *Anthidiellum* (*Pycnanthidium*) *krombeini* Griswold only used resin (Krombein & Norden, 2001). *Anthidiellum smithii smithii* and *A. krombeini* are both closely related and similar in size, whereas *Anthidiellum butarsis* is allied to *Anthidiellum ramakrishnae* (Griswold, 2001). All three species are cavity-renters. This suggests the nesting habits (as cavity-renters) are likely to be conserved within *Pycnanthidium* whereas materials used in nest construction may differ owing to resource availability (see Table 1 for comparison in greater detail). Elucidating and comparing nesting materials nesting habits of various species within *Anthidiellum* (*Pycnanthidium*) through a phylogeny may shed more light on trait evolution.

Supersedure of a nest is likely to be a common occurrence for trap-nesting Hymenoptera (Krombein, 1967), suggesting that suitable nest sites may be limited and that there is competition for these. This was observed here between *Anthidiellum smithii smithii* and a spider-hunting wasp, and between *Anthidiellum butarsis* and a mud-collecting hymenopteran in Krombein & Norden (2001). Thus, a plausible way to augment populations of cavity-renting bees and wasps, is for bamboo or wood trap-nests of suitable sizes, to accommodate various Hymenoptera, to be placed in suitable positions such as sheltered areas to encourage nesting; however, in Singapore and elsewhere in the tropics, measures

should be taken to prevent ant occupation (Soh, 2014). It will also be important to maintain floral and nesting resources within flight range of the bees and is correlated with the size of the bee (Gathmann & Tscharrtk, 2002).

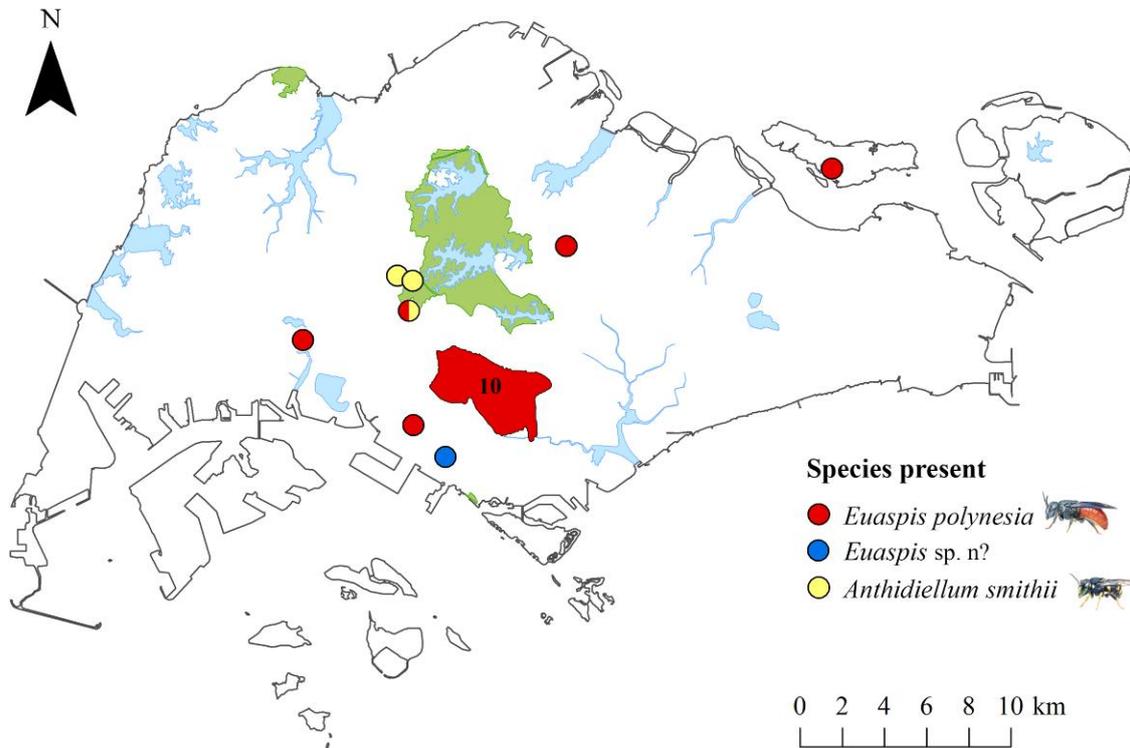


Fig. 9. Known distribution of *Euaspsis polynesia* (in red), *Euaspsis* sp. nov.? (in blue) and *Anthidiellum (Pycnanthidium) smithii smithii* (in yellow), represented by coloured circles, in Singapore. The earliest known *Euaspsis polynesia* record for Singapore, from 1968 in Postal District 10 is represented with a red polygon as its exact locality is ambiguous. The other more precise records are based on recent surveys from 2012–2015. Base map of Singapore by Teo Siyang and nature reserves (in green) from IUCN & UNEP-WCMC (2014).

Table 1. Comparison of nest bionomics between *Anthidiellum (Pycnanthidium) smithii smithii*, *Anthidiellum (Pycnanthidium) krombeini*, *Anthidiellum (Pycnanthidium) butarsis*, and *Heriades (Michenerella) othonis* Friese. Nest bionomic terminology is based on that of Krombein (1967).

	Tribe Anthidiini			Tribe Osmini
	<i>Anthidiellum (Pycnanthidium) smithii smithii</i> (Ritsema) (new observation)	<i>Anthidiellum (Pycnanthidium) krombeini</i> Griswold (Krombein & Norden, 2001)	<i>Anthidiellum (Pycnanthidium) butarsis</i> Griswold (Krombein & Norden, 2001)	<i>Heriades (Michenerella) othonis</i> Friese (new observation)
Trap-nest type (length)	Bamboo internodes (230 mm)	Wood pieces (165 mm)	Wood pieces (165 mm)	Bamboo internodes (208 mm)
Internal diameter of nest opening	3.3–4.4 mm	3 mm	3 mm	3.2 mm
Trap placement	On a tree	Unknown	On a tree	On a garden stake
Preliminary plug	Not observed	Resin and debris; resin only	Resin only	Resin only
Cell spacing	Clustered	Not able to infer	Clustered	Spaced out
Cell wall of provisioning cell	Coated internally with resin	Coated internally with resin	Coated internally with resin	Not coated
Cell partition*	Resin and whitish substance	Resin only	Resin only	Resin only

Presence of vestibular cell	Yes (2 cells; 12.5 mm and 34 mm), second with resin and whitish substance interspersed	Yes (1 cell; 7 mm), completely empty	Yes (1 cell; 37 mm), with drops of resin	No
Closing plug*	Resin and whitish substance	Resin only	Resin only	Resin only
Collection month	May–July	April	April (~two months from larvae to adult)	April
Maximum number of cells	Four	Four	Seven	Eight

*nest bionomics differing between *Anthidiellum smithii smithii* and *Anthidiellum krombeini*

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