

## *Megachile* leaf-cutter and resin bees of Singapore (Hymenoptera: Apoidea: Megachilidae)

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**Abstract.** This paper treats the twenty species and morphospecies of leaf-cutter and resin bees of the genus *Megachile* sensu lato known from Singapore. All five species recorded by historical workers prior to 1930 and another collected in 1961 were recorded during 2012–2014 along with 10 *Megachile* species newly detected in Singapore. Three of the most common species in recent surveys of urban Singapore, the resin bees *Megachile* (*Callomegachile*) *umbripennis* and *M. (C.) disjuncta*, and the leaf-cutter bee *M. (Eutricharaea)* sp. 1 were first detected in the country in 1974, 2010, and 1986 respectively suggesting that these they may be adventive from elsewhere in Asia rather than truly native. The following 11 *Megachile* are newly recorded for Singapore or were first recorded in 2013 under a different name in a study of flower-visiting insects: *Megachile* (*Aethomegachile*) *borneana*, *M. (A.)* nr. *borneana*, *M. (A.)* sp. (*fusciventris* group), *M. (Alococanthedon)* *indonesica*, *M. (Callomegachile)* *ornata*, *M. (C.) stulta*, *M. (C.)* sp. 1 (nr. *stulta*), *M. (C.)* sp. (*biroi* group), *M. (Chelostomoda)* *moera*, *M. (Eutricharaea)* sp. 1, *M. (Paracella)* *tricincta*. Data on occurrence within Singapore including locality, collection event, and floral host are summarised based on all available historical and recent specimens. Global distribution (including some new country and primary subdivision records), maps of Singaporean distribution, measurements, and images are provided for the named species, and new life history information about habitat associations, nesting, and floral associations are presented concisely.

**Key words.** Southeast Asia, taxonomy, pollinator declines, global distribution, floral associations, habitat, nesting

### INTRODUCTION

*Megachile* Latreille, 1802 sensu lato (Megachilidae: Megachilini) is one of the three hyperdiverse bee genera, with more than 1525 described, valid species worldwide (Ascher & Pickering, 2015) placed in more than 50 subgenera (Michener, 2007). Currently more than 150 Southeast Asian species of *Megachile* in a dozen subgenera are recognised as valid (Ascher & Pickering, 2015), but the taxonomy and distribution of these species requires much additional study, and many names now treated as valid will prove to be junior synonyms (S. Risch, unpublished). Striking mimicry among *Megachile* species has contributed to description of composite type series and routine confusion between structurally dissimilar species such as *M. conjuncta* and *M. disjuncta*.

*Megachile* species are solitary and many are highly seasonal, with short flight seasons tracking the bloom of their preferred host plants. Many *Megachile*, especially larger species, visit

Fabales (Fabaceae and Polygalaceae) with papilionaceous flowers that require a large bee to force its way between closed petals (Momose et al., 1996, Corlett, 2004, and refs. therein). In Sarawak rainforests, mass emergence, nest construction, and foraging of *Megachile* occur during May to July in years with general flowering events of host plants (Momose & Karim, 2005). At Serdang in Selangor, Malaysia, Pagden (1934) found females of four *Megachile* species to be the most common bee visitors apart from *Apis dorsata* to the legume *Tephrosia sinapou* (Buc'hoz) A. Chev. (as *T. toxicaria*). Southeast Asian *Megachile*, especially smaller species, also regularly visit Asteraceae and Lamiaceae (Corlett, 2004; and refs. therein).

Most *Megachile* nest opportunistically in a variety of pre-existing cavities which they line with external materials such as resin or neatly cut and folded leaves, and these are potentially manageable through deployment of trap-nests. Others, such as species of subgenus *Creightonella* instead excavate burrows in soil which they line with folded leaves (Michener, 2007). The present study summarises current knowledge of the Singaporean *Megachile* fauna, based on a review of historical and recent specimens, as a first step towards characterising the regional fauna, and to facilitate taxonomic, life history, and molecular diagnostic studies now in progress.

Of three recent studies of bees from Singapore, one conducted in forests (Liow, 2001) found eusocial corbiculate Apidae to be the most abundant bee group and recorded few other

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solitary bees and no species of family Megachilidae. By contrast, Chong (2010) and Soh & Ngiam (2013), recorded numerous and diverse solitary bees including, in the latter study, 10 leaf-cutter and resin bee species in genus *Megachile* sensu lato. The few previous reports of *Megachile* from Singapore (e.g., Smith, 1853, 1857; Cockerell, 1918; Dover, 1929) included an erroneous record of *M. erythropoda* Cameron (1901) based on misinterpretation of its type locality, which is correctly Singora (=Singgora), the Malay name for Songkhla, a city and province in southern peninsular Thailand bordering Malaysia. This report aims to summarise updated information about *Megachile* in Singapore.

## MATERIAL AND METHODS

Accounts for described species include the original combination, author and date, and page number of heading of original description followed by a summary of global distribution by country and primary division or islands as recorded in the Discover Life Bee Species Guide and World Checklist (Ascher & Pickering, 2015). Type localities and repositories are cited, with details provided for those species described from Singapore. New records for Singapore are noted, and details and sources are cited for selected new and noteworthy records.

Materials examined summarises label data for all available specimens from Singapore including historical material in the Lee Kong Chian Natural History Museum Zoological Reference Collection (ZRC) collected mainly by D. H. Murphy (mostly 1961–1962, 1974–1977) records from recent surveys from the 2012–2014 including the flower visitor survey by Soh & Ngiam (2013), recent bamboo trap-nesting study (March–August 2014), surveys of *Megachile* by netting at flowers (2013–2014) by Insect Diversity Laboratory (National University of Singapore) and John X. Q. Lee, surveys of pollinators of Tiger Orchids *Grammatophyllum speciosum* (ZWWS & colleagues, in prep.; August 2014), and malaise trap samples from the Mangrove Insect Project (Evolutionary Biology Laboratory, National University of Singapore) (2012–2014). The verbatim locality was recorded faithfully from each specimen label but in the case of ambiguity or usage of an old name, was amended and placed in square brackets after the verbatim locality (i.e., as specific locality). The specimen records are the basis for a distributional map provided for each non-singleton species. Coordinates for the maps were generated based on specimen labels or, for historical records lacking precise GPS data, by georeferencing localities using Google Earth and online gazetteers. Only current and original combinations are cited, not junior synonyms and other combinations.

References are provided to published records for Singapore. Remarks summarise new or noteworthy information about the species. Accounts for morphospecies include an additional minimal diagnosis. Photographs of live bees were taken in the studio by ZWWS and images of pinned bees were taken by EJYS with the Visionary Digital Passport System, unless otherwise stated.

Vouchers from Singaporean projects currently maintained separately from the ZRC are cited under the following collection initials: IDL – Insect Diversity Laboratory reference collection (National University Singapore), MIP – Mangrove Insect Project. Initials of major collectors associated with this museum are abbreviated as follows (in alphabetical order): DHM – D. H. Murphy, EJYS – Eunice J. Y. Soh, JXQL – John X. Q. Lee, JSA – J. S. Ascher, SR – Stephan Risch and ZWWS – Zestin W. W. Soh. Type repositories cited for regional *Megachile* are abbreviated as follows: National Museum of Natural History, Smithsonian – NMNH; The Natural History Museum, London, United Kingdom – NHML; Oxford University Museum of Natural History, Hope Entomological Collections – OUM; Museum für Naturkunde der Humboldt-Universität, Berlin – ZMHB; Zoological Museum of the University of Copenhagen – ZMUC. Singaporean material in NHML was studied by ZWWS and that in the NMNH by JSA. Specimens in the Forest Institute of Malaya (FRIM) and University of Malaya Museum of Zoology (UMKL) material are the basis for new state records for Peninsular Malaysia cited in the global distribution section. Total length (TL) and intertegular distance (IT) were measured with a reticle on Leica MZ16 stereomicroscope.

## TAXONOMY

### *Megachile* Latreille

*Megachile* (*Aethomegachile*) Engel & Baker

*Megachile* (*Aethomegachile*) *borneana* Cameron  
(Fig. 1A, 2A, C)

*Megachile borneana* Cameron, 1903: 174.

**Global distribution.** Malaysia: Sarawak [type female, Kuching, NHML 17a.2043; type specimen is broken (ZWWS)]; Singapore.

**Materials examined.** 1 male (IDL), Dairy Farm Nature Park, coll. ZWWS, 13 June 2012, ex. *Asystasia gangetica*; 1 male (IDL), Kent Ridge Park, coll. S. X. Chui, G. W. J. Low, 21 October 2015.

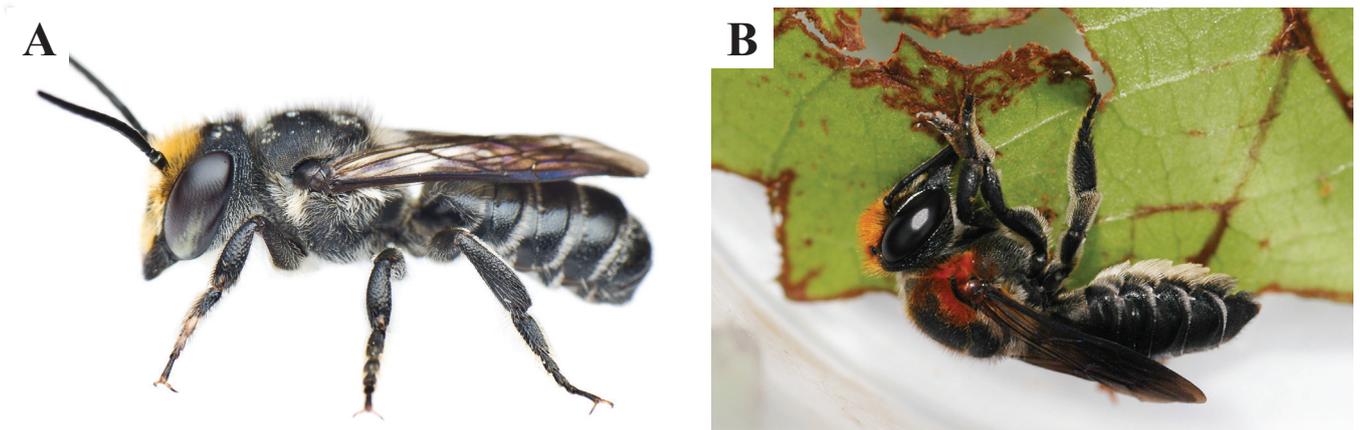


Fig. 1. *Megachile (Aethomegachile) borneana* male (A) and possible *M. (Aethomegachile) nr. borneana* female (B) (Photograph by: Cheong L. F [B]).

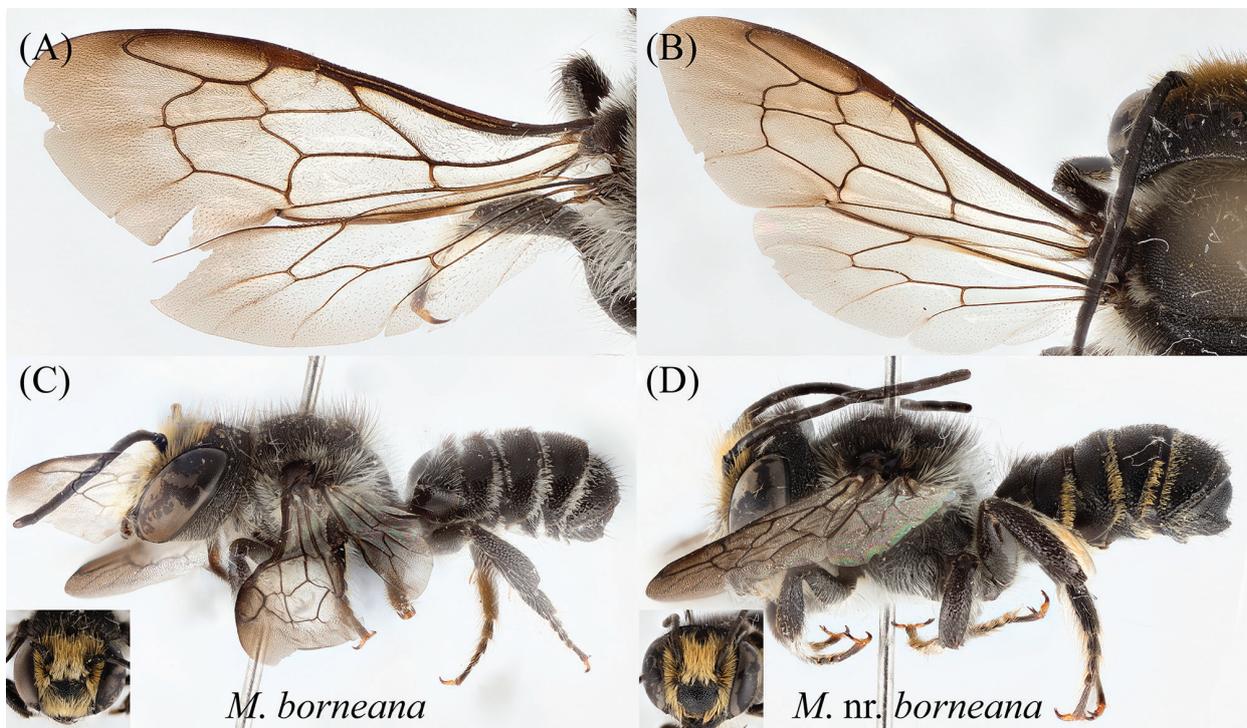


Fig. 2. Comparing habitus and wing of *Megachile borneana* (A, C) and *M. nr. borneana* (B, D).

**Singaporean distribution.** (Fig. 3)



Fig. 3. Singaporean distribution of *Megachile (Aethomegachile) borneana*.

**References.** Cited as *Megachile* cf. *griseopicta* by Soh & Ngiam (2013). The male type of *Megachile griseopicta* Radoszkowski, erroneously placed in subgenus *Amegachile* by Wu (2006), belongs to subgenus *Eutricharaea* (SR, unpublished).

***Megachile (Aethomegachile) nr. borneana***  
(Fig. 1B; 2B, D)

**Diagnosis.** True *Megachile borneana* has an elevated knob on sternum 1 and forebasitarsal segments 2 and 3 with pale integument, whereas *M. nr. borneana* lacks these characters and has a dense patch of white hairs on hindtibia posteriorly (Fig. 2C, D). It is also larger, with very slightly more infuscated wings (Fig. 2A, B), and with slightly darker orangish facial hairs (Fig. 2 inset).

**Materials examined.** 1 male (IDL), Dairy Farm Nature Park, coll. ZWWS, 13 June 2012, ex. *Asystasia gangetica* [collected with *borneana*]; 2 males (IDL), Upper Peirce Reservoir Park, coll. ZWWS, 19 September 2012, ex. *Cratoxylum cochinchinense*; 1 male (IDL), Kent Ridge Park, coll. J. S. Ascher et al., 20 October 2015, ex. *Syzygium zeylanicum*.

**Singaporean distribution.** (Fig. 4)



Fig. 4. Singaporean distribution of *Megachile (Aethomegachile) nr. borneana*.

**Remarks.** A new record for Singapore. Males were found in primary and mature secondary forest. A colourful female bee cutting leaves of *Uncaria* (Rubiaceae) at Nee Soon Swamp Forest in Singapore on 10 March 2004 (Cheong, L. F., pers. comm.) appears to be this morphospecies (Fig. 1B). The only specimens are males collected by ZWWS, one of which was caught together with similar-looking *M. (Aethomegachile) borneana* (see entry on *M. borneana*). These bees resemble *Megachile* sp3 of Barthélémy (2012) in color pattern, but that is a resin bee identified based on the photo as matching the female holotype in the Smithsonian National Museum of Natural History of *Megachile strupigera* Cockerell, 1922, from Canton, China (now Guangzhou, Guangdong Province). Although *M. strupigera* was placed by Wu (2006) in subgenus *Amegachile*, which consists of leaf-cutter bees, it is actually a *Megachile (Callomegachile)*, very similar to or conspecific with *Megachile faceta* Bingham (1897), described from Burma (SR, unpublished).

***Megachile (Aethomegachile) conjuncta* Smith**  
(Fig. 5)

*Megachile conjuncta* Smith, 1853: 175.

**Global distribution.** China: Fujian, Hainan; India: “Bengal” [type female, NHML 17a.2147, examined and imaged by ZWWS], Sikkim; Indonesia; Malaysia: Johor (Dover, 1929), Kelantan (Dover, 1929), Perak (Pagden, 1934, as *disjuncta*), Penang, Selangor; Singapore [type locality of the junior synonym *Megachile luctuosa* Smith, 1857]; Sri Lanka; Thailand.



Fig. 5. *Megachile (Aethomegachile) conjuncta* female (A) and male (B).

**Material examined.** 1 female (Smithsonian), Singapore, coll. Charles Fuller Baker, ca. 1917–1918, with species determination label by T. D. A. Cockerell. 1 female (ZRC JXQL0047), Toa Payoh Town Park, Singapore, coll. JXQL, 22 February 2010; 2 females (IDL), Tampines Eco Green, coll. ZWWS, 9 May 2012, ex. *Crotolaria retusa*; 1 male (IDL), Pasir Ris Park, coll. ZWWS, 1 May 2012; 1 female (IDL), Pulau Ubin, Butterfly Hill, coll. JSA & A. Seah, 23 July 2014; 2 males (IDL), Ang Mo Kio Town Park West, coll. ZWWS et al., 22 August 2014, ex. *Grammatophyllum speciosum*; 1 female (IDL), Dairy Farm Nature Park, 21 October 2015, ex. *Syzygium zeylanicum*; 1 male (IDL), National University of Singapore University Hall, 20 October 2015.

**Singaporean distribution.** (Fig. 6)



Fig. 6. Singaporean distribution of *Megachile (Aethomegachile) conjuncta*.

**Remarks.** Associated with managed gardens and scrubland, and on one occasion from Dairy Farm Nature Park, which is an old secondary forest. Observed collecting pollen from *Crotolaria retusa* (Fabaceae) (Fig. 10). Other pollen plants noted in Karunaratne et al. (2005) include *Crotolaria pallida* (Fabaceae). Male genitalia imaged in Fig. 9A.

**References.** Cited for Singapore by Smith (1857, as *luctuosa*), Dover (1929), and Soh & Ngiam (2013). Pagden's (1934) report of nesting by *Megachile disjuncta* in Perak, Malaysia, likely refers to this species instead, based on use of various leaves in nest construction and a description of the male dissimilar to the female and with fulvous pubescence.

*Megachile (Aethomegachile) laticeps* Smith  
(Fig. 7)

*Megachile laticeps* Smith, 1853: 183.

**Global distribution.** India; Indonesia: Moluccas; Malaysia: Pahang (Tioman Island), Penang, Sarawak; Philippines [type male, NHML 17a.2042, examined and imaged by ZWWS]: Luzon, Panay; Singapore [type locality of *Megachile subignita* Cockerell, 1918: 389. NHML, type No. Hym. 17a 206]; Thailand. Presumably introduced to New Caledonia and to numerous oceanic islands including Federated States of Micronesia (East Caroline Islands): Chuuk (Truk); Fiji (Davies et al. 2013); French Polynesia; Republic of the Maldives; Guam; Northern Mariana Islands: Saipan; Palau; Seychelles; United States: Hawaii: Hawaii [new record, based on a female specimen examined by JSA from near City of Refuge (now Puuhonua o Hōnaunau National Historical Park), coll. J. R. Powers, 30 May 1983, in the California Academy of Sciences].

**Material examined.** 2 males (ZRC), Tanglin Preparatory School, coll. DHM, 27 April 1977; 1 female (ZRC), Kranji Nature Trail, coll. Sungei Buloh Wetlands Reserve Volunteers Group 2, 12 July 2008; 1 male (ZRC JXQL0045), Jalan Pari Burong near Simpang Bedok, coll. JXQL, 15 May 2010; 2 females (ZRC JXQL0207, JXQL0208), Lorong Danau, coll. JXQL, 3 March 2012, ex. *Bidens pilosa*; 2 females (ZRC JXQL0216, JXQL0217), Pulau Ubin, coll. JXQL, 6 April 2012, ex. *Asystasia gangetica*; 1 male (ZRC JXQL0262), Portsdown Road, coll. JXQL, 14 April 2012; 1 male (ZRC JXQL0044), Tampines Street 45, coll. JXQL, 26 May 2010; 1 female (IDL), Tampines Eco Green, coll. ZWWS, 4 June 2012, ex. *Turnera subulata*; 2 males (ZRC), Pasir Ris Park, coll. ZWWS, 10 May 2012; 1 female and 1 male (ZRC), Singapore Botanic Gardens, coll. ZWWS, 21 June 2012; 1 female and 2 males, Bedok Town Park, coll. ZWWS, 4 September 2012; 1 female and 1 male (ZRC), Pulau Ubin, coll. ZWWS, 6 September 2012; 1 male (IDL), Upper Peirce Reservoir Park, coll. ZWWS, 19 September 2012, ex. *Cratoxylum cochinchinense*; Kent Ridge: National University of Singapore: Science Drive 4: 1 female (IDL), coll. JSA, 10 June 2013, ex. *Memecylon caeruleum*; 4 females and 1 male (IDL), coll. JSA, 14 June 2013, ex. *M. caeruleum*; 5 females (IDL), coll. JSA, 17 June 2013, ex. *M. caeruleum*; 1 female (IDL), JSA, 18 June 2013; 1 female (IDL), coll.



Fig. 7. *Megachile (Aethomegachile) laticeps* female (A) and male (B).

JSA, 21 June 2013; 1 female (IDL), coll. JSA, 23 June 2013, ex. *M. caeruleum*; 1 female (IDL), coll. JSA, 8 July 2013; 1 female (IDL), coll. JSA, 10 July 2013; 1 female (IDL), coll. JSA, 11 July 2013; 1 male (IDL), coll. JSA; 1 male (IDL), coll. JSA, 21 December 2013; University Hall: 1 male (IDL), coll. JSA, 2 August 2013; 1 female (IDL), coll. S. L. Ng, 3 June 2015; Dairy Farm Nature Park: 2 males (IDL), garden near WELL centre, coll. EJYS, 4 June 2014, reared from trap-nest; 1 male (IDL), coll. JSA et al., 18 July 2014; 2 males (IDL), outside Bukit Timah Nature Reserve at Bukit Drive, coll. ZWWS & EJYS, 28 July 2014; 1 male (IDL), coll. JSA, 31 June 2013; 9 females, coll. EJYS, 11 June 2014, ex. *M. caeruleum*; male (IDL), Colbar Eating House, Whitchurch Road, coll. JSA, 2 July 2013, ex. *Vitex trifolia*; 2 females (IDL), former railway tracks along Upper Bukit Timah Rd (near Rail Mall), coll. JSA, no date; 1 female (IDL), MacRitchie Reservoir, coll. S. X. Chui et al., 11 June 2014; 1 male (IDL), along track at Mandai Lake Road, coll. JXQL & EJYS, 1 June 2014, ex. *Bidens pilosa*; 2 females (IDL), Sungei Buloh Wetland Reserve, coll. JXQL et al., 31 May 2014; HortPark: 2 males (IDL), coll. EJYS, June 2014, reared from trap-nest; 1 male (IDL), coll. K. Y. Ng & S. X. Chui, 6 August 2014; Khoo Tech Puat Hospital rooftop: 1 male (IDL), coll. C. Roscoe, 17 May 2015, ex. *Averrhoa carambola*; 1 male (IDL), coll. C. Roscoe, 1 June 2015; 1 male (IDL), coll. C. Roscoe, 9 June 2015; 1 female (IDL), coll. M. S. Chua, 8 June 2015; 1 female (IDL), coll. M. S. Chua, 18 June 2015; 1 male (IDL), coll. M. S. Chua, 18 June 2015; 28 Dover Crescent Rooftop: 1 male (IDL), coll. C. Roscoe, 27 April 2015, ex. *Vitex*; 1 male (IDL), coll. M. S. Chua, 19 June 2015.

**Singaporean distribution.** (Fig. 8)



Fig. 8. Singaporean distribution of *Megachile (Aethomegachile) laticeps*.

**Remarks.** Numerous and widely distributed in Singapore. Considered to belong to a new Oriental subgenus by D. B. Baker (fide Pauly, 2001), we place this species and its relatives in subgenus *Aethomegachile* Engel & Baker (2006), although it lacks the remarkable autapomorphies of the type species. Male abdominal sternites and genitalia illustrated by Yasumatsu (1942). Male genitalia imaged in Fig. 9B. Has been trap-nested in bamboo internodes with entrance diameter of 7–9 mm, making it potentially manageable. Larval-to-adult stage is approximately one month. Observed collecting pollen from *Crotolaria pallida* (Fig. 10), *Peltophorum pterocarpum* (Fabaceae), *Memecylon caeruleum* (Melastomataceae), and *Vitex trifolia* (Lamiaceae).

**References.** Cited by Cockerell (1918) as *M. subnigita* and as *M. laticeps* in Soh & Ngiam (2013).

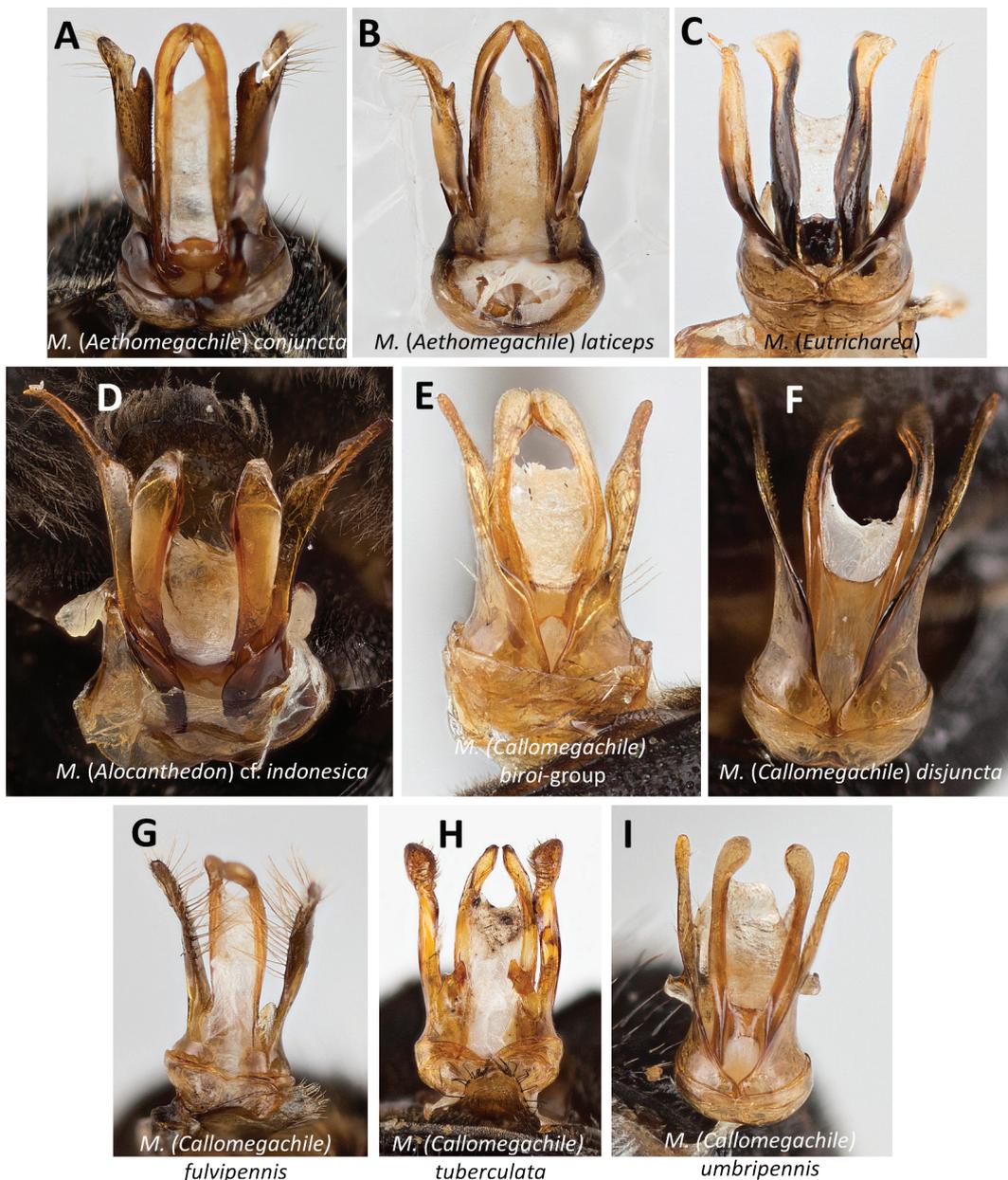


Fig. 9. Genitalia of representative *Megachile* males (A, C, D, E, F, G, H, I – dorsal view, B – ventral view). Names of each species are appended below each diagram. Black arrows in A and B point to diagnostic features.



Fig. 10. *Megachile laticeps* collecting pollen from *Croton pallidus*.

*Megachile (Aethomegachile) ramera* Cockerell  
(Fig. 11)

*Megachile ramera* Cockerell, 1918: 388.

**Global distribution.** Singapore [type female, NHML no. Hym. 17a 2028, coll. C. F. Baker, examined and imaged by ZWWS]; Peninsular Malaysia: Pahang [specimen examined at UMKL]; Thailand: Koh Samui [coll. SR].

**Material examined.** 1 female (IDL), Dairy Farm Nature Park, coll. ZWWS, 5 June 2012, ex. *Asystasia gangetica*.

**Remarks.** The one recent collection is from a park adjacent to native forest, and also observed and photographed at Zhenghua Park visiting *Grammatophyllum speciosum* on 8 August 2014 (ZWWS). Pollen host is unknown. The male for this species is unknown.

**References.** Described from Singapore by Cockerell (1918). Soh & Ngiam (2013) reported the only modern specimen record for Singapore.



Fig. 11. *Megachile (Aethomegachile) ramera* female.

*Megachile (Aethomegachile) sp. (fusciventris group)*  
(Fig. 12)

**Material examined.** 1 female and 3 males (IDL), Upper Peirce Reservoir Park, coll. ZWWS, 19 September 2012, ex. *Cratoxylum cochinchinense*; Dairy Farm Nature Park: 1 male (IDL), coll. ZWWS, 13 June 2012, ex. *Asystasia*; 1 male (ZRC), 5 September 2012; 1 male (ZRC), coll. JXQL, 5 September 2012; 1 male (IDL), Bukit Timah Nature Reserve entrance, coll. ZWWS, 4 August 2014; 1 male (IDL), outside MacRitchie Park, Ranger Station, coll. ZWWS, 7 August 2014, ex. *Grammatophyllum speciosum*; 1 male (John X. Q. Lee personal collection), Pulau Ubin, Mamam Beach, coll. JXQL, 18 September 2014, ex. *Scaevola taccada*; 1 male (IDL), Kent Ridge Park, ex. S. X. Chui, G. W. J. Low, 21 October 2015, ex. *Syzygium zeylanicum*.

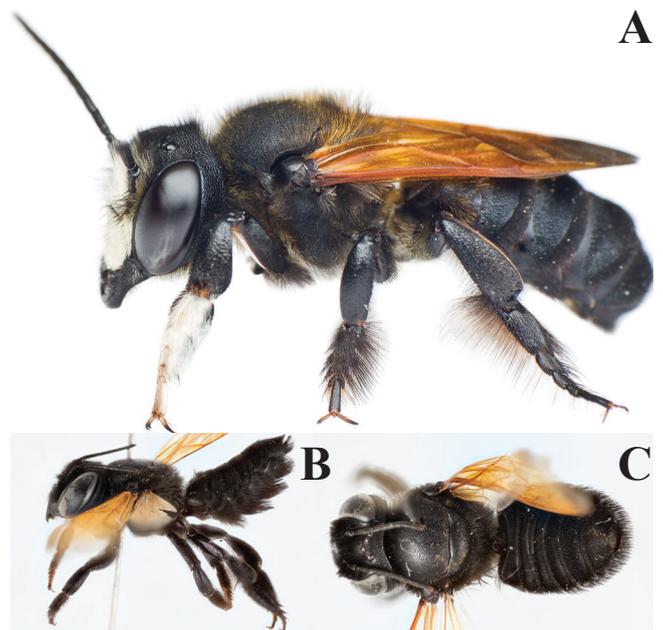


Fig. 12. *Megachile (Aethomegachile) sp. (fusciventris group)* male (A), female (B, C).

**Singaporean distribution.** (Fig. 13)



Fig. 13. Singaporean distribution of *Megachile (Aethomegachile) sp. (fusciventris group)*.

**Remarks.** A species recorded in primary or mature secondary forest. A distinctive male *Megachile* with modified front legs was illustrated by Soh & Ngiam (2013). Subsequently, the female of this leaf-cutter species, which resembles *Megachile atrata*, was recognised among vouchers.

**References.** Newly recorded for Singapore under this name, as Soh & Ngiam (2013) cited it as *Megachile* sp. (species-group of *Megachile fulviventris* Friese) [sic]. *Megachile fusciventris* was described from “Toli-Toli (Nord-Celebes)” in Sulawesi, Indonesia, by Friese (1903) based on females in ZMHB.

*Megachile (Alocanthedon)* Engel & Gonzalez

*Megachile (Alocanthedon) indonesica*  
(Engel & Schwarz)  
(Fig. 14)

*Chalicodoma (Alocanthedon) indonesicum* Engel & Schwarz, 2011: 430.

**Global distribution.** Indonesia: Java [holotype m, Gunung Muria (Moerjo), 3000 feet, NHML], Siberut Island (Mentawai Islands, West Sumatra Province); Singapore [new record].

**Material examined.** 1 female and 2 males (IDL), Bukit Timah Nature Reserve entrance, coll. ZWWS, 4 August 2014, ex. *Grammatophyllum speciosum*; 2 males (IDL), outside MacRitchie Park, Ranger Station, coll. ZWWS, 7



Fig. 14. *Megachile (Alocanthedon) indonesica* female (A) and male (B).

August 2014, ex. *G. speciosum*; 1 female and 1 male (IDL), Dairy Farm Nature Park, coll. S. X. Chui, G. W. J. Low, 20 October 2015.

**Singaporean distribution.** (Fig. 15)



Fig. 15. Singaporean distribution of *Megachile (Alocanthedon) indonesica*.

**Remarks.** This subgenus is new for Singapore, having been first detected visiting Tiger Orchids in 2014 in primary and mature secondary forest. The pollen host is unknown. Male genitalia are imaged in Fig. 9D. Males were identified as this species rather than *M. memecylonae* Engel and Gonzalez, a very similar *Alocanthedon* known from at least four states in Peninsular Malaysia, based on the large hooked anterobasal lamellate tooth of the protarsus with apical margin concave and the tawny rather than reddish orange clypeal hairs. The female of *M. indonesica*, identified here on the basis of the associated male, is newly discovered, as the species was described based on two males (Engel & Schwarz, 2011). Diagnostic characters that might separate females from *M. memecylonae* are unknown.

*Megachile (Callomegachile)* Michener

*Megachile (Callomegachile) disjuncta* (Fabricius)  
(Fig. 16)

*Apis disjuncta* Fabricius, 1781: 481.

**Global distribution.** China [southern]; India; Indonesia [western]; Malaysia; Singapore; Sri Lanka; Thailand. Introduced to Madagascar; Mauritius (including Rodrigues); Reunion; Seychelles (Pauly, 2001). The putative West Indian type locality [type female, ZMUC] is inconsistent with lack of subsequent confirmed records from the New World.

**Material examined.** Pulau Ubin: 1 female (ZRC JXQL0218), coll. JXQL, 6 April 2010; 2 males (IDL), coll. ZWWS, 6 September 2012; 1 male (ZRC JXQL0046), Jalan Pari Burong near Simpang Bedok, coll. JXQL, 15 May 2010; Pasir Ris Park: 1 female (ZRC JXQL0048), coll. JXQL, 11 May 2011, ex. nesting in wooden shelter; 2 males (IDL), coll. ZWWS, 10 May 2012, ex. *Vitex trifolia*; 1 male (IDL), coll. ZWWS, 28 June 2012, ex. *Tamarindus indica*; 1 female

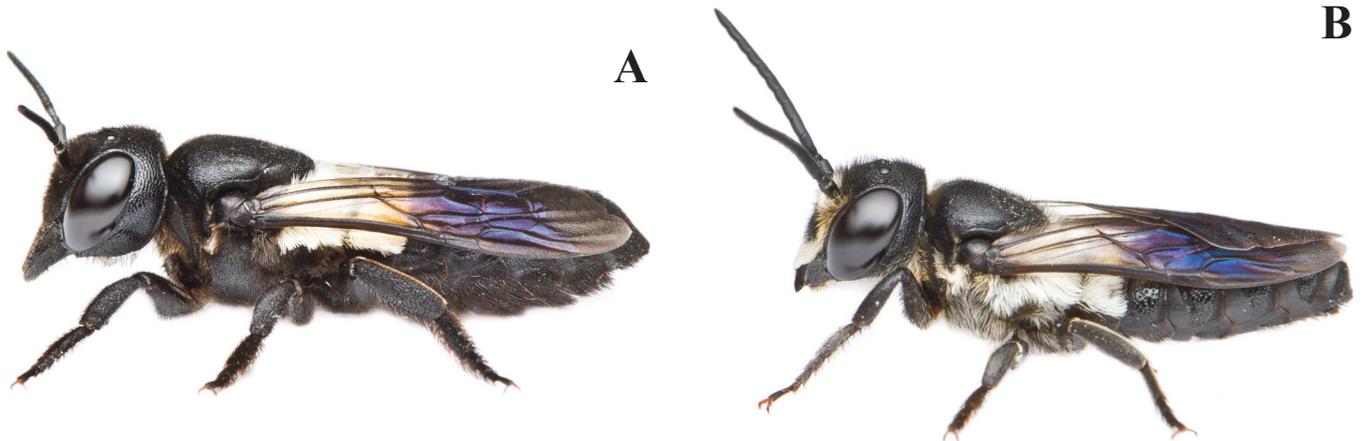


Fig. 16. *Megachile (Callomegachile) disjuncta* female (A) and male (B).

(IDL), coll. K. Y. Ng et al., 16 August 2014, ex. *T. indica*; 1 male (IDL), Lorong Sarhad, coll. ZWWS, 22 April 2012; 1 female (IDL), Singapore Botanic Gardens, coll. ZWWS, 27 April 2012; Tampines Eco Green: 2 males (IDL), coll. ZWWS, 4 May 2012; 1 female (IDL), coll. ZWWS, 9 May 2012; 4 males (IDL), coll. K. Y. Ng & S. X. Chui, 11 August 2014; Kent Ridge: National University of Singapore: 1 male (IDL), AS7 rooftop, coll. C. Roscoe, 18 May 2015, ex. *Bidens*; University Hall: 1 female (IDL), coll. JSA, 21 June 2013, ex. *Memecylon caeruleum*; 2 males (IDL), coll. JSA, 26 July 2013; 3 males (IDL), coll. JSA, 2 August 2013; 1 male (IDL), coll. JSA, 5 August 2013; 3 males (IDL), coll. JSA, 6 August 2013, ex. *Premna foetida*; 1 male (IDL), coll. JSA, 27 September 2013; 1 male (IDL), west of University Hall, coll. JSA, 1 October 2013, ex. *Syzygium zeylanicum*; 2 males (IDL), coll. JSA, 2 October 2013; 1 male (IDL), coll. JSA, 19 October 2013; 1 male (IDL), coll. David Tan, 21 October 2013; 1 male (IDL), coll. S. L. Ng, 15 July 2015; 9 males (IDL), managed garden at Chinese Garden, coll. EJYS, 18 June 2014, ex. *Antigonon leptopus*; 2 females (IDL), Punggol Promenade and wasteland near it, coll. EJYS, 16 June 2014, ex. *Crotolaria pallida*; 1 female (IDL), Gardens by the Bay, coll. P. Unadirekkul, 20 April 2014; 1 female (IDL), along track at Mandai Lake Road, coll. EJYS & JXQL, 1 June 2014; 1 female (IDL), Pasir Ris Park Kitchen Garden, coll. JSA et al., 29 May 2014; 1 female (IDL), West Coast Crescent, West Cove Condominium (level 6), coll. EJYS, 12 March 2012; 1 male (IDL), Science Drive 4, coll. EJYS, 2 August 2014; 2 males (IDL), Holland Woods, coll. EJYS et al., 4 August 2014, ex. *Asystasia gangetica*; 1 male (IDL), HortPark, coll. K. Y. Ng & S. X. Chui, 6 August 2014; 3 males (IDL), Clementi Woods, coll. ZWWS & EJYS 9 August 2014; Khoo Teck Puat Hospital rooftop: 1 male (IDL), coll. M. S. Chua, 18 June 2015, ex. *Averrhea carambola*; 2 males (IDL), coll. M. S. Chua, 2 August 2015; 28 Dover Crescent Rooftop: 1 male (IDL), coll. C. Roscoe, 29 May 2015; 2 females (IDL), coll. M. S. Chua, 11 July 2015, ex. *Vitex trifolia*; 2 females (IDL), coll. M. S. Chua, 15 July 2015; 4 females and 1 male (IDL), coll. M. S. Chua, 18 July 2015; 2 females (IDL), coll. M. S. Chua, 2 August 2015.

#### Singaporean distribution. (Fig. 17)



Fig. 17. Singaporean distribution of *Megachile (Callomegachile) disjuncta*.

**Remarks.** The oldest available specimen is from 2010, yet it now occurs widely in Singapore across diverse habitats including secondary forest, parks, and scrublands. Observed to nest opportunistically in cavities including a cavity of a wooden bench sheltered from rain. Collects pollen from *Crotolaria pallida*, *Peltophorum pterocarpum*, *Memecylon caeruleum*, *Tamarindus indica* (Fabaceae) and *Vitex trifolia* (Lamiaceae). Other nectaring plants noted in Karunaratne et al. (2005). Male genitalia are imaged in Fig. 9F. Also been observed 15 August 2015 in the Southern Islands (records not mapped) on Saint John's Island, where females were nesting in the roof of the pier, and on Lazarus Island, where males were observed to visit *Asystasia gangetica*.

**References.** Cited by Soh & Ngiam (2013) as *Chalicodoma disjuncta* [sic, correctly *C. disjunctum*].

#### *Megachile (Callomegachile) fulvipennis* Smith (Fig. 18)

*Megachile fulvipennis* Smith, 1879: 68.

**Global distribution.** India: Nicobar Islands [type female, NHML 17a.2055, examined and imaged by ZWWS]; Indonesia: Java, Sumatra; Singapore [new record]; Thailand.

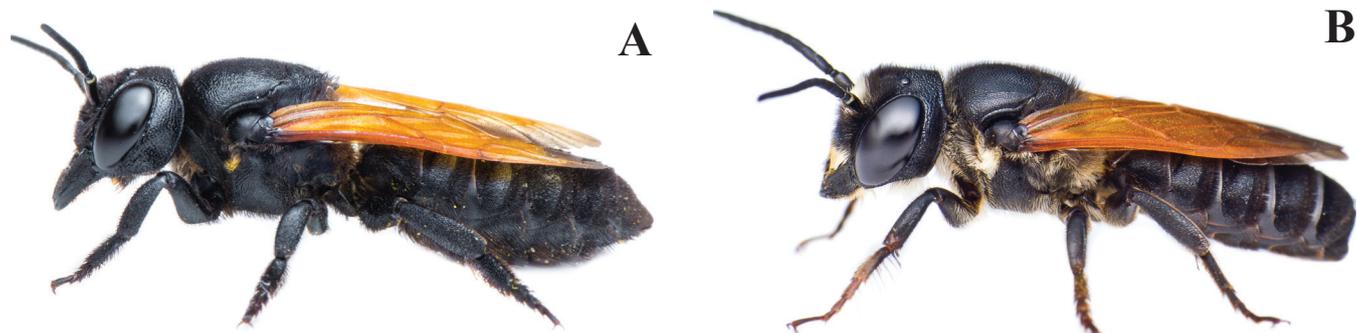


Fig. 18. *Megachile (Callomegachile) fulvipennis* female (A) and male (B).

**Material examined.** 1 female (ZRC), Changi, coll. DHM; 1 female (ZRC), University Campus [now the Bukit Timah Campus of the National University Singapore], coll. DHM, 12 April 1976; 1 female (ZRC), Race Course, secondary forest, coll. DHM, 5 December 1976; 1 female (ZRC), Kent Ridge, coll. unknown, 3 May 1983; 1 female (ZRC), Mei Ling Street, coll. Tan May Ling, 27 May 1987; 1 male (IDL), Tampines Eco Green, coll. ZWWS, 9 May 2012; 1 male (IDL), National University of Singapore, Faculty of Engineering along Clementi Road, coll. JSA, 8 Oct 2013, ex. *Syzygium*; 1 female (ZRC), Holland Woods, coll. D. Gan, 21 September 2013; Bukit Timah Nature Reserve entrance: 2 females and 2 males (IDL), coll. ZWWS, 4 August 2014, ex. *Grammatophyllum speciosum*; 5 females (IDL), coll. ZWWS, 15 August 2014; Zheng Hua Park: 1 male (IDL), Zheng Hua Park, coll. ZWWS, 8 August 2014; 3 males (IDL), coll. ZWWS, 16 August 2014, ex. *G. speciosum*; 1 male (IDL), Chinese Garden, coll. J. L. Lai, 26 October 2015.

**Singaporean distribution.** (Fig. 19)



Fig. 19. Singaporean distribution of *Megachile (Callomegachile) fulvipennis*.

**Remarks.** Resembles *M. tuberculata* as it has a median tubercle at the clypeus but smaller. Male genitalia are imaged in Fig. 9G. Unlike the former species, it has been found in both primary forest and open, developed sites. Observed to nest in a cavity of a wooden bench sheltered from rain in August 2014 (Soh, 2014) and to visit *Clitoria terneata* (Fabaceae), a possible pollen plant, on 12 December 2014 (JSA, pers. obs.).

**References.** Cited as *Chalicodoma* sp1 or Megachilid sp1 (greyish body, white pubescence and abdominal banding) by Soh & Ngiam (2013).

*Megachile (Callomegachile) ornata* Smith  
(Fig. 20)

*Megachile ornata* Smith, 1853: 183.

**Global distribution.** Indonesia: Borneo, Sumatra [type female from Sumatra (see Meade-Waldo, 1912), NHML]; Malaysia: Kuala Lumpur, Negeri Sembilan [Dover, 1929; and specimens examined at UMKL], Pahang (Dover, 1929), Sarawak, Selangor [Dover, 1929; and specimen examined at UMKL]; Nepal; Singapore [new record]; Thailand: Chiang Mai (Tadauchi & Tasen, 2009).



Fig. 20. *Megachile (Callomegachile) ornata* female.

**Material examined.** 1 female (IDL), Zheng Hua Park, coll. ZWWS, 8 August 2014, ex. *Grammatophyllum speciosum*.

**Remarks.** A distinctive species provisionally assigned to *Callomegachile* pending more comprehensive studies of this heterogeneous subgenus. The male is apparently unknown. Likely associated with more mature forest but may forage widely given its large body size. Pollen hosts in Singapore unknown.

*Megachile (Callomegachile) stulta* Bingham  
(Fig. 21)

*Megachile stulta* Bingham, 1897: 476.

**Global distribution.** India: Karnataka, Sikkim [type female, NHML 17a.2161B, examined and imaged by ZWWS; the type series was composite with the putative male from Bangalore having been misidentified, as it correctly refers to *M. lerma* Cameron, a synonym or close relative of *M. umbripennis*]; Peninsular Malaysia: Kuala Lumpur, Selangor [specimens examined at UMKL]; Singapore [new record].



Fig. 21. *Megachile (Callomegachile) stulta* female (A) and male (B).

**Material examined.** 10 females and 3 males (IDL), Upper Peirce Reservoir Park, coll. ZWWS, 19 September 2012, ex. *Cratoxylum cochinchinense*; 1 male (IDL), outside Bukit Timah Nature Reserve at Bukit Drive, coll. EJYS, 1 July 2014, ex. *Muntinga calabura*; Dairy Farm Nature Park: 1 male (IDL), coll. EJYS, 10 June 2014; 2 males (IDL), coll. EJYS, 19 June 2014, ex. *Bidens pilosa*; 1 female and 3 male (IDL), coll. JSA et al., 18 July 2014, ex. *B. pilosa*; 1 male (IDL), University Hall, coll. JSA, 25 October 2014.

**Singaporean distribution.** (Fig. 22)



Fig. 22. Singaporean distribution of *Megachile (Callomegachile) stulta*.

**Remarks.** Found locally at sites with old secondary or primary forest, and once at the edge of young secondary forest. Collects pollen from non-native *Bidens pilosa* (Asteraceae) and *Muntinga calabura* (Muntingiaceae).

*Megachile (Callomegachile) sp. 1 (nr. stulta)*  
(Fig. 23)

**Diagnosis.** Very closely resembles *M. stulta* but is slightly larger and has no orange hairs on the metasoma.

**Material examined.** 1 male, Upper Peirce Reservoir Park, coll. ZWWS, 19 September 2012, ex. *Cratoxylum cochinchinense*.



Fig. 23. *Megachile (Callomegachile) sp. 1 (nr. stulta)* male.

**Remarks.** A new record for Singapore based on a unique male collected in mature forest visiting *Cratoxylum cochinchinense* (Hypericaceae).

*Megachile (Callomegachile)* sp. (*biroi* group)  
(Fig. 24)

**Diagnosis.** The female resembles *M. disjuncta* but the scopal hairs are largely pale orangish-white (paler than in the similarly coloured *M. conjuncta*) clypeal apex is simple, lacking tubercles, the clypeus has a median impunctate ridge, and the scutum is dull throughout with no distinct punctures or shiny interspaces. The male differs from *M. disjuncta* in having black hairs on the pleuron below the wing bases and in having smaller and much denser tergal punctation.

**Material examined.** All coll. ZWWS, ex. *Grammatophyllum speciosum*: 1 female and 1 male (IDL), Bukit Timah Nature Reserve entrance 4 August 2014; 2 males (IDL), outside MacRitchie Park, Ranger Station, 7 August 2014, 2 females (IDL), Zhenghua Park, 8 August 2014; 1 male (IDL), Dairy Farm Nature Park, 20 August 2014.

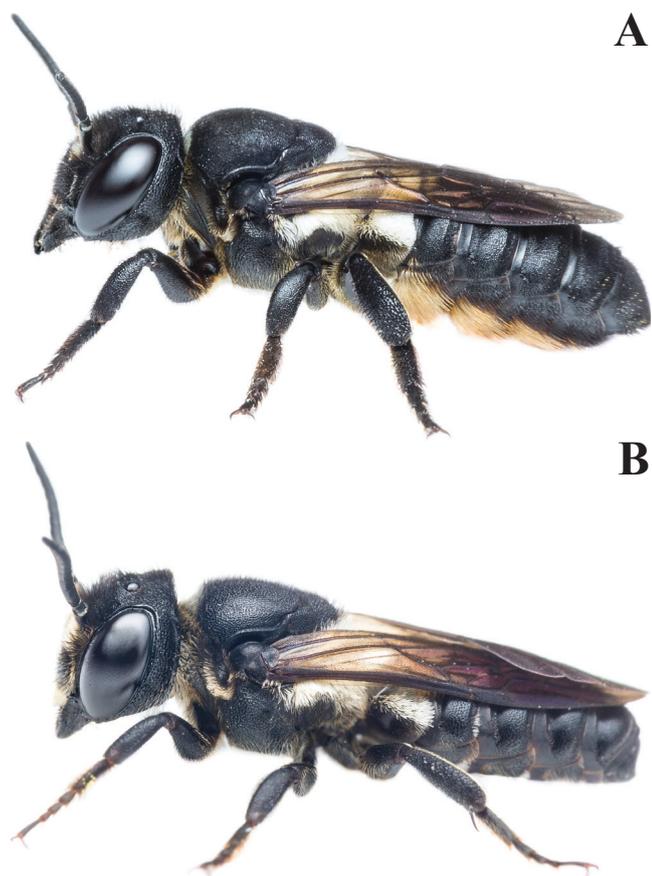


Fig. 24. *Megachile (Callomegachile)* sp. (of *biroi* group) female (A) and male (B).

**Singaporean distribution.** (Fig. 25)



Fig. 25. Singaporean distribution of *Megachile (Callomegachile)* sp. (*biroi* group).

**Remarks.** A new record for Singapore. Only recorded in mature forest visiting Tiger Orchids (*Grammatophyllum speciosum*). Pollen host are unknown. Also recorded from Peninsular Malaysia, from Perak (FRIM specimen) and Selangor (UMKL specimen). Male genitalia imaged in Fig. 9E.

*Megachile (Callomegachile) tuberculata* Smith  
(Fig. 26)

*Megachile tuberculata* Smith, 1857: 46.

**Global distribution.** India; Indonesia; Malaysia: Johor, Negeri Sembilan (Dover, 1929); Pahang, Perak, Sarawak

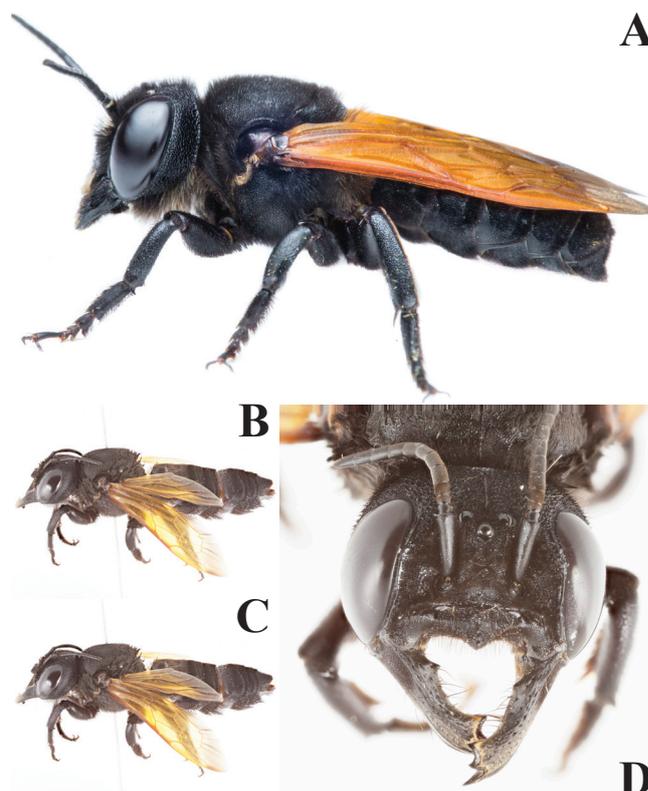


Fig. 26. *Megachile (Callomegachile) tuberculata* male (A), female (B–D).

[type NHML 17a.2258, examined and imaged by ZWWS; lectotype female, OUM], Selangor, Terengganu [specimens examined at UMKL]; Philippines, Singapore [new record]; Thailand [southern].

**Material examined.** 1 female (ZRC), University Grounds (University of Malaya) [now the Bukit Timah Campus of the National University Singapore, located adjacent to the Singapore Botanic Gardens], coll. DHM, January 1961; 1 female (MIP), Nee Soon 1, 26 September 2012; 1 female (MIP), Nee Soon 2, 9 May 2012; 2 males (IDL), Bukit Timah Nature Reserve entrance, coll. ZWWS, 4 August 2014, ex. *Grammatophyllum speciosum*.

**Singaporean distribution.** (Fig. 27)



Fig. 27. Singaporean distribution of *Megachile (Callomegachile) tuberculata*.

**Remarks.** The largest *Megachile* species in Singapore and associated with native forests. Previously collected by DHM in 1961, and subsequently obtained in recent malaise traps samples from Nee Soon swamp forest and at flowering Tiger Orchids (*Grammatophyllum speciosum*). Pollen hosts are unknown. Male genitalia are imaged in Fig. 9H.

*Megachile (Callomegachile) umbripennis* Smith  
(Fig. 28)

*Megachile umbripennis* Smith, 1853: 175.

**Global distribution.** China: Fujian, Shenzhen; Hong Kong; India; Malaysia: Kuala Lumpur, Kelantan, Pahang, Sarawak, Selangor [specimens examined at UMKL]; Myanmar; Nepal [type female, NHML 17a.2160, examined and imaged by ZWWS]; Laos: Vientiane; New Caledonia; Singapore; Sri Lanka; Thailand. Introduced to many Pacific islands including the Cook Islands: Aitutaki (Kuhlmann, 2006); Fiji (Davies et al., 2013); French Polynesia: Society Islands, Mo'orea, Tahiti; Northern Mariana Islands: Saipan; Tonga; United States: Florida [new record], Hawaii: Hawaii, Kauai, Midway, Maui, Molokai, Oahu.

**Material examined.** 1 male (ZRC), Sime Road, coll. DHM, 15 October 1974; male (ZRC), University Campus [now the

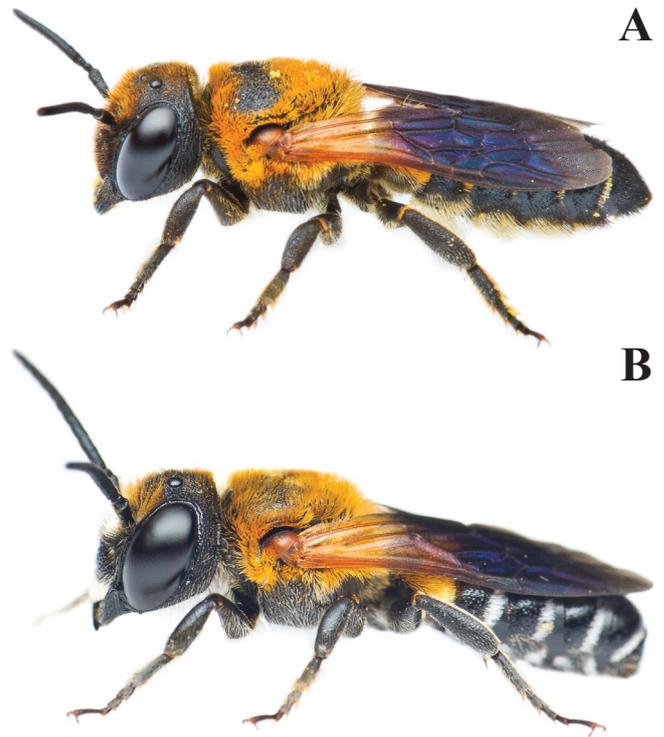


Fig. 28. *Megachile (Callomegachile) umbripennis* female (A) and male (B).

Bukit Timah Campus of the National University Singapore], coll. DHM, February 1976; Singapore Botanic Gardens: 1 female (IDL), coll. ZWWS; 2 females and 2 males (ZRC), coll. ZWWS, 21 June 2012; 1 female (IDL), Pasir Ris Park, coll. by ZWWS, 28 March 2012, ex. *Vitex trifolia*; Kent Ridge: National University of Singapore: 1 male (IDL), S2A slope, coll. S. L. Ng, 7 April 2015, ex. *Muntinga calabura*; AS7 rooftop: 2 males (IDL), coll. C. Roscoe, 18 May 2015, ex. *Asystasia* and *Bidens*; 1 male (IDL), coll. C. Roscoe, 2 June 2015; University Hall: 1 male (IDL), coll. S. L. Ng, 11 June 2015; 1 male (IDL), coll. S. L. Ng, 17 June 2015; 1 male (IDL), coll. S. L. Ng, 7 July 2015; 1 male (IDL), coll. S. L. Ng, 15 July 2015; 1 male (IDL), coll. S. L. Ng, 20 July 2015; NUS Science LT27: 1 female (IDL), coll. S. L. Ng, 5 Feb 2015, ex. *Premna serratifolia*; 1 male (IDL), coll. S. L. Ng, 11 August 2015; 1 male (IDL), coll. JSA, 5 June 2012; 1 female and 2 males (IDL) Holland Woods, coll. JSA, 2 October 2013; Kent Ridge: University Hall: 1 male (IDL), coll. David Tan, 8 October 2013; male (IDL), coll. JSA, 10 October 2013; 2 males (IDL), coll. JSA, 5 June 2013, ex. *Premna foetida*; male (IDL), coll. JSA, 6 June 2013; 1 male (IDL), coll. JSA, 23 June 2013; 4 males (IDL), coll. JSA, 26 July 2013, ex. *P. foetida*; 1 male, (IDL), coll. JSA, 31 July 2013; 1 male (IDL), coll. JSA, 2 August 2013; 2 males (IDL), coll. JSA, 6 August 2013; 1 male (IDL), coll. JSA, 15 August 2013; former railway tracks along Upper Bukit Timah Rd (near Rail Mall): 1 male (IDL), coll. JSA, 2013; 1 male (IDL), coll. EJYS, 10 June 2014, ex. *Asystasia gangetica*; 1 female (IDL), managed garden at Chinese Garden, coll. EJYS, 18 June 2014, ex. *Antigonon leptopus*; 1 female and 4 male (IDL), outside Bukit Timah Nature Reserve, at Bukit Drive, coll. ZWWS & EJYS, 28 July 2014; 6 females (IDL), Tampines

Eco Green, coll. K. Y. Ng et al., 16 August 2014; 1 female (IDL), Zhenghua Park, coll. ZWWS, 16 August 2014; 1 male (IDL), Holland Woods, coll. S. X. Chui et al., 1 August 2014; 2 males (IDL), Clementi Woods, coll. ZWWS & EJYS, 9 August 2014; 1 female and 2 males (IDL), HortPark, coll. K. Y. Ng & S. X. Chui, 6 August 2014; 28 Dover Crescent Rooftop: 1 female (IDL), coll. C. Roscoe, 2 April 2015; 1 female (IDL), coll. C. Roscoe, 27 April 2015, ex. *Wrightia religiosa* [female scopa without pollen]; 1 male (IDL), coll. C. Roscoe, 11 May 2015, ex. *Vitex trifolia*; 1 female (IDL), coll. M. S. Chua, 19 June 2015; 5 females (IDL), coll. M. S. Chua, 11 July 2015; 2 females (IDL), coll. M. S. Chua, 15 July 2015; 4 females (IDL), coll. M. S. Chua, 18 July 2015; 3 females (IDL), coll. M. S. Chua, 2 August 2015, ex. *Combretum indicum*; 3 females and 1 male (IDL), coll. M. S. Chua, 7 August 2015; 1 male (IDL), Khoo Teck Puat Hospital rooftop, coll. M. S. Chua, 2 Aug 2015, ex. *Averrhea carambola*.

**Singaporean distribution.** (Fig. 29)



Fig. 29. Singaporean distribution of *Megachile (Callomegachile) umbripennis*.

**Remarks.** Although numerous in all recent collections, this species was unrecorded by historical workers prior to 1974. Now common in Singapore across many habitat types including forest edges, scrublands, managed gardens and urban areas. Nests opportunistically in preformed cavities including, in Singapore, a hole in a wooden bench and the sill of a hotel window. Observed to collect pollen from *Vitex trifolia* (Lamiaceae). Other pollen plants noted in Karunarathne et al. (2005) include *Crotolaria juncea* (Fabaceae) and *Mitracarpus hirtus* (Rubiaceae). Male genitalia are imaged in Fig. 9I.

**References.** Cited by Soh & Ngiam (2013) as *Chalicodoma umbripennis* [sic, correctly *C. umbripenne*].

*Megachile (Chelostomoda)* Michener

*Megachile (Chelostomoda) moera* Cameron  
(Fig. 30)

*Megachile moera* Cameron, 1902: 120.

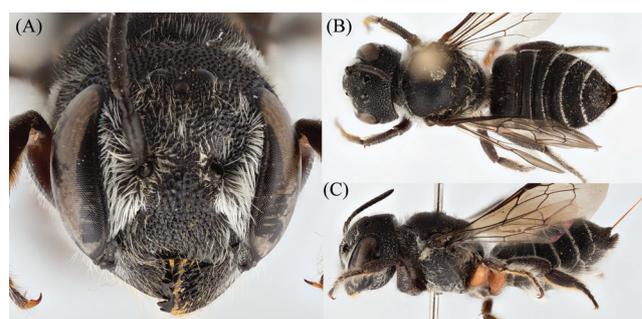


Fig. 30. *Megachile (Chelostomoda) moera* female. Head (A), dorsal (B), profile habitus (C).

**Global distribution.** Malaysia: Sarawak [syntypes, Kuching, NHML 17a.2491b, examined and imaged by ZWWS]; Singapore [new record].

**Material examined.** 1 female (IDL), Pasir Ris Park, coll. ZWWS, 28 March 2012, ex. from nest in wooden stake; 2 females and 1 male (IDL), Admiralty Park, coll. S. X. Chui, F. A. Tjong, G. Yong, 9 October 2015, ex. *Cratoxylum cochinchinense*.

**Singaporean distribution.** (Fig. 31)



Fig. 31. Singaporean distribution of *Megachile (Chelostomoda) moera*.

**Remarks.** Collected from two singleton events in managed garden, notably the female individual was nesting in a wooden garden stake.

*Megachile (Creightonella)* Cockerell

*Megachile (Creightonella) atrata* Smith  
(Fig. 32)

*Megachile atrata* Smith, 1853: 182.

**Global distribution.** India: Andaman and Nicobar Islands; Indonesia: Ambon, Bali, Flores, Java, Sulawesi, Sumatra, Sumba, Timor; Malaysia: Negeri Sembilan, Pahang [Tioman Island], Sarawak, Selangor, Terengganu [specimens examined at UMKL]; Philippines [type NHML 17a.2036, examined and imaged by ZWWS]: Luzon, Mindanao, Palawan, Samar; Singapore.



Fig. 32. *Megachile (Creightonella) atrata* male (A) and female (B).

**Material examined.** 2 females (ZRC), Toh Tuck Est. [Toh Tuck Hill Estate], Bukit Timah, wasteland with orchard and cattle shed, coll. DHM, 4 October 1976; Pasir Ris Park: 1 female (ZRC JXQL0060), coll. JXQL, 23 February 2010; 1 female and 1 male (IDL), coll. JSA et al., 29 May 2014; 1 female (IDL), Pasir Ris Park back mangroves, coll. JSA et al., 29 May 2014; 1 female and 1 male (IDL), coll. JSA, 2 June 2014; 1 female (IDL), HortPark, coll. ZWWS, 23 April 2012, ex. *Luffa aegyptica*; Pulau Ubin: 1 female (ZRC JXQL0224), Butterfly Hill, coll. JXQL, 10 June 2012; 1 female (ZRC JXQL0225), coll. JXQL, 6 September 2012, ex. *Asystasia gangetica*; 2 females and 1 male (IDL), coll. ZWWS, 6 September 2012; 1 female (ZRC JXQL0059), coll. JXQL, 12 July 2011; 1 female (MIP), Semakau new fragment, 6 June 2013; 1 male (IDL), Dairy Farm Nature Park, coll. ZWWS, 7 August 2014, ex. *Grammatophyllum speciosum*; 3 males (John X. Q. Lee personal collection), Off Mandai Hill Road, open scrub habitat at edge of forest, coll. JXQL, ex. *Bidens pilosa*; Kent Ridge Park: 1 male (IDL), coll. J. S. Ascher, S. X. Chui, G. W. J. Low, 20 October 2015; 1 male (IDL), coll. S. X. Chui, F. A. Tjong, 23 October 2015.

**Singaporean distribution.** (Fig. 33)



Fig. 33. Singaporean distribution of *Megachile (Creightonella) atrata*.

**Remarks.** A species associated with managed gardens, mangroves and forests. A probable female of this species was observed through binoculars collecting pollen from the

canopy of *Peltophorum pterocarpum* (Fabaceae) at Pasir Ris Park on 2 June 2014 within flight range of active nests in nearby back mangroves. Also cited by Soh & Ngiam (2013) to collect pollen from *Crotolaria retusa* (Fabaceae). It excavates burrows in the ground and lines its nest with irregularly-cut leaves, and was observed to cut leaves of *Syzygium* (Myrtaceae) at St. John's Island on 8 September 2014.

**References.** Recorded from Singapore by Meade-Waldo (1912) based on a Ridley-collected specimen in the British Museum, in Dover (1929), and by Soh & Ngiam (2013, as *Creightonella atrata*).

*Megachile (Eutricharaea)* Thompson

*Megachile (Eutricharaea) subrixator* Cockerell  
(Fig. 34)

*Megachile abluta subrixator* Cockerell, 1915: 535.

**Global distribution.** Thailand; Malaysia: Kuala Lumpur, Sabah; Philippines: Luzon, Mindanao [types, Illigan, NMNH], Negros, Panay, Samar; Singapore. Yasumatsu's (1942) record from Palau is based on a mistaken synonymy (Krombein, 1950).

**Material examined.** 1 female (ZRC), Loyang 5, Singapore, coll. DHM, February 1962; 1 female (ZRC), University Singapore Campus [now the NUS law campus], Singapore, coll. DHM, 5 May 1972; 2 males (ZRC), Jurong Mangroves, Singapore, coll. DHM, 7 November 1975; 1 male (ZRC), Jurong Mangroves, Singapore, coll. DHM, 7 November 1975; 1 female (ZRC), Peirce Catchment Forest, Singapore, coll. DHM, 9 April 1976; 1 male (ZRC), University of Singapore, Singapore, coll. P. C. Sim, 22 January 1976; 1 female and 1 male (ZRC), Clementi Scrub, coll. DHM, 26 June 1977; 1 female (ZRC), University of Singapore, Bukit Timah campus, Singapore, coll. L. S. Y., 31 June 1981; 1 female (ZRC), Tampines, Sun Plaza, coll. JXQL, 26 May 2010; female (IDL), Bedok Town Park, coll. ZWWS, 4 June 2012; 1 female and 2 males (IDL), HortPark, Singapore, coll. ZWWS, 18 June 2012; 1 female (IDL), Tampines Eco Green, coll. ZWWS, 4 May 2012; Pulau Ubin: 1 male (IDL), coll.



Fig. 34. *Megachile (Eutricharaea) subrixator* female (A), male (B, C).

ZWWS, 6 September 2012; 1 female (ZRC), Butterfly Hill, coll. JXQL, 6 Sep 2012; 1 male (IDL), West Coast Park, coll. JSA, 8 June 2013; 3 males, former railway tracks along Upper Bukit Timah Rd (near Rail Mall), coll. JSA & JXQL, 2013; 2 males (IDL), along track at Mandai Lake Road, coll. EJYS & JXQL, 1 June 2014; 1 male (IDL), Pasir Ris Park, coll. JSA, 2 June 2014; 1 male (IDL), disused railway track between Bukit Timah Nature Reserve & Dairy Farm Nature Park, coll. EJYS, 10 June 2014; Dairy Farm Nature Park: 5 males (IDL), coll. JSA & EJYS, 11 June 2014; 1 male (IDL Batch04-017), coll. EJYS, 28 July 2014; 2 males (IDL), Punggol Promenade (park connector and wasteland), coll. EJYS, 16 June 2014; 2 females and 2 males (IDL), managed garden at Chinese Garden, coll. EJYS, 18 June 2014; 5 males (IDL), Dairy Farm, coll. JSA et al., 19 June 2014; 1 male (IDL), Pasir Ris Park, coll. JSA et al., 29 May 2014; 3 females and 1 male (IDL), Tampines Eco Green, coll. K. Y. Ng et al., 16 August 2014, ex *Bidens pilosa*; National University of Singapore: 1 male (IDL), RVR field (open), coll. S. L. Ng, 14 April 2015, ex. *Tridax procumbens*; 2 males (IDL), RVR field (open), coll. S. L. Ng, 15 July 2015; 1 female (IDL), AS7 (R), coll. C. Roscoe, 2 June 2015; 28 Dover Crescent Rooftop: 1 male (IDL), coll. C. Roscoe, 13 April 2015, ex. *Vitex*.

**Singaporean distribution.** (Fig. 35)



Fig. 35. Singaporean distribution of *Megachile (Eutricharaea) subrixator*.

**Remarks.** Male genitalia are imaged in Fig. 9C. Found in various habitats, including managed gardens, scrublands and secondary forest. Observed to collect pollen from the exotic *Bidens pilosa* (Asteraceae). Also observed 15 Aug 2015 in the Southern Islands (records not mapped) on Lazarus Island.

**References.** Cited for Singapore by Cockerell (1915, 1927) and by Soh & Ngiam (2013, as *Megachile* cf. *tricincta*).

***Megachile (Eutricharaea)* sp. 1**  
(Fig. 36, 37)

**Diagnosis.** A small species readily separated from *subrixator* because the female has entirely white scopal hairs on T1–T5, extensive pale appressed hairs across the scutum anteriorly, and paler, less punctate tegulae (Fig. 35). What we believe to be the male is readily identified based on a regularly crenulate margin to T6 (Fig. 36D), which is otherwise densely covered in pale-golden hairs, in combination with orange hair patches on sterna 3 and 4 and lack of distinct foveae on T2.

**Material examined.** 1 male (ZRC), Linden Drive, coll. DHM, 15 May 1986; 1 female (IDL), Tampines Eco Green, coll. EJYS, 28 March 2014; 1 female (IDL), Pasir Ris Park, Kitchen Garden, coll. JSA et al., 29 May 2014; Punggol

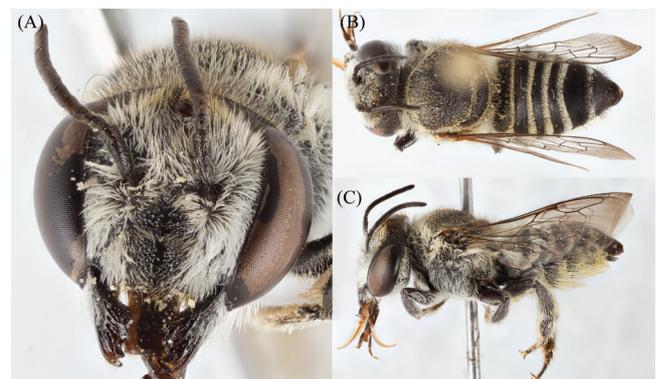


Fig. 36. A pinned specimen of *Megachile (Eutricharaea)* sp. 1 female head (A), dorsal (B), profile habitus (C).

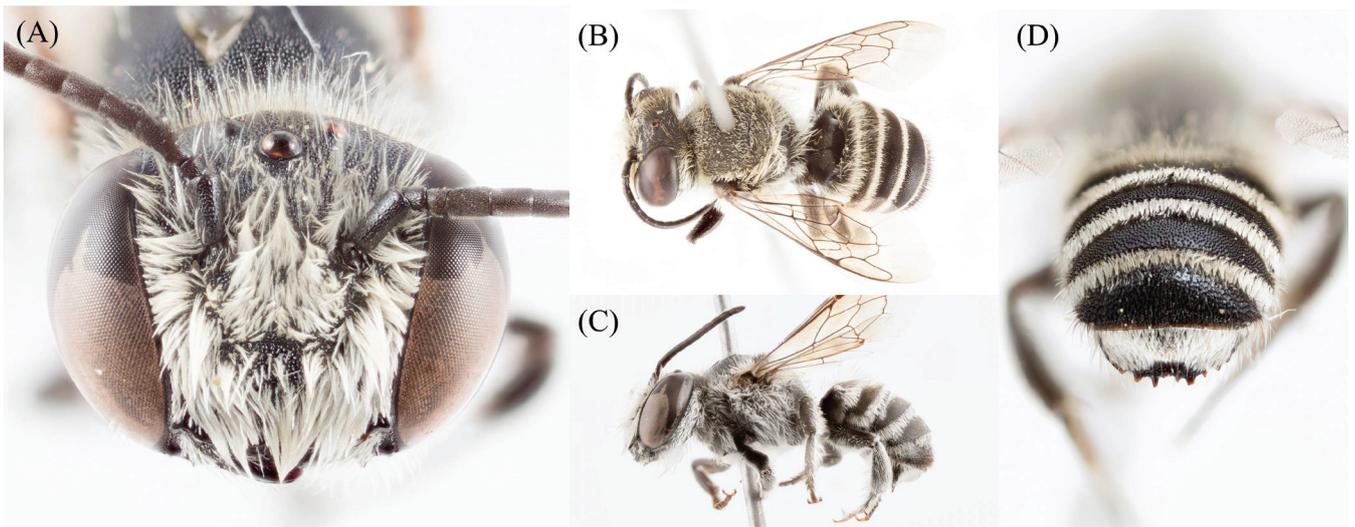


Fig. 37. A pinned specimen of *Megachile (Eutricharaea)* sp. 1 male head (A), dorsal (B), profile habitus (C), crenulated tergum 6 (D) (Photograph by: S. X. Chui).

Promenade: 1 female (IDL), coll. JSA, 23 March 2014; 9 females (IDL), coll. EJYS, 16 June 2014, ex. *Bidens pilosa*; 1 female (IDL), Tampines Eco Green, coll. K. Y. Ng et al., 16 August 2014; 28 Dover Crescent rooftop: 1 female (IDL), coll. C. Roscoe, 2 April 2015, ex. *Vitex*; 1 female (IDL), coll. C. Roscoe, 25 March 2015; Kent Ridge: National University of Singapore: 1 male (IDL), RVR field (open), coll. S. L. Ng, 2 April 2015; 1 female (IDL), AS7 (G), coll. C. Roscoe, 14 March 2015; SDE rooftop: 1 female (IDL), coll. M. S. Chua, 24 July 2015, ex. *Tridax procumbens*; 1 female (IDL), coll. C. Roscoe, 2 June 2015; SDE ground: 1 male (IDL), coll. C. Roscoe, 12 May 2015, ex. *Emilia sonchifolia*; 1 female & 1 male (IDL), coll. C. Roscoe, 29 April 2015, ex. *Tridax*; 1 female and 1 male (IDL), Orchard Central (ground), coll. C. Roscoe, 23 March 2015.

**Singaporean distribution.** (Fig. 38)



Fig. 38. Singaporean distribution of *Megachile (Eutricharaea)* sp. 1.

**Remarks.** A new record for Singapore. Associated with scrubland and managed gardens including those on rooftops (C. Roscoe, M. S. Chua, pers. obs.). Observed to collect pollen from *Bidens pilosa* (Asteraceae).

*Megachile (Paracella)* Michener

*Megachile (Paracella) tricincta* Bingham  
(Fig. 39)

*Megachile tricincta* Bingham, 1897: 489.

**Global distribution.** Myanmar [female type, Tenasserim, NHML 17a.2024, examined and imaged by ZWWS]; Peninsular Malaysia: Kuala Lumpur, Negeri Sembilan, Selangor [specimen examined at UMKL]; Singapore [new record].



Fig. 39. *Megachile (Paracella) tricincta* female (A) and male (B).

**Material examined.** 1 female (ZRC), Peirce Catchment Forest, coll. DHM, 9 April 1976; Dairy Farm Nature Park: 2 males (IDL), coll. JSA & EJYS, 11 June 2014; 2 males (IDL), coll. EJYS, 19 June 2014; 1 female and 2 males (IDL), coll. JSA et al., 18 July 2014; 1 female and 1 male (IDL), coll. EJYS, 28 July 2014; outside Bukit Timah Nature Reserve, at Bukit Drive: female and 3 males (IDL), coll. E. J. Y. Soh, 1 July 2014; 1 female and 4 males (IDL), coll. ZWWS & EJYS, 28 July 2014; 1 female (IDL), coll. EJYS, 1 July 2014, ex. *Muntinga calabura*; 1 female (IDL), NUS, between Science Drive 2 and 4, coll. EJYS, 13 August 2014, ex. *M. calabura*; 1 female and 1 male (IDL), Tampines Eco Green, coll. K. Y. Ng et al., 16 August 2014, ex. *Bidens pilosa*.

**Singaporean distribution.** (Fig. 40)



Fig. 40. Singaporean distribution of *Megachile (Paracella) tricincta*.

**Remarks.** Associated with a variety of habitats including managed gardens, scrubland and forests. Observed to collect pollen from *Bidens pilosa* (Asteraceae) and *Muntinga calabura* (Muntingiaceae).

**References.** Records of *M. cf tricincta* by Soh & Ngiam (2013) likely pertain instead to *M. subrixator* (see account for *M. subrixator*).

## DISCUSSION

Of the 20 species and morphospecies of leaf-cutter and resin bees of the genus *Megachile* sensu lato currently known from Singapore, all five species recorded by historical workers prior to 1930 were found to persist, having been recorded during surveys conducted during 2012–2014 (Soh & Ngiam, 2013; present study).

Historical records from Singapore include the holotypes of three species: *M. luctuosa* Smith (1857), a junior synonym of *M. (Aethomegachile) conjuncta* (also recorded by Dover, 1929, and represented in Smithsonian collections made by C. F. Baker presumably during 1917–1918 when he was Director of Singapore Botanic Gardens), *M. (Aethomegachile) ramera* Cockerell (1918), and *M. subignita* Cockerell (1918; a junior synonym of *M. (Aethomegachile) laticeps*), and published reports for the additional species *M. (Creightonella) atrata*

(Meade-Waldo, 1912; Dover, 1929) and *M. (Eutricharaea) subrixator* (Cockerell, 1915).

*Megachile (Callomegachile) tuberculata*, first collected in 1961 and the following 10 *Megachile* species or morphospecies first collected during 2012–2014 are new records for Singapore: *Megachile (Aethomegachile) borneana*, *M. (A.) nr. borneana*, *M. (A.) sp. (fusciventris group)*, *M. (Alococanthon) indonesica*, *M. (Callomegachile) ornata*, *M. (C.) stulta*, *M. (C.) sp. 1 (nr. stulta)*, *M. (C.) sp. (biroi group)*, *M. (Chelostomoda) moera*, *M. (Eutricharaea) sp. 1*, *M. (Paracella) tricincta*. Seven of these were first reported for Singapore by (Soh & Ngiam (2013) under different names (see species accounts above).

Remarkably, two of the most numerous and widespread *Megachile* species in recent samples, the resin bees *Megachile (Callomegachile) umbripennis* and *M. (C.) disjuncta*, were first detected in Singapore in 1974 and 2010 respectively. This suggests the possibility that these they may be adventive from elsewhere in the region, rather than truly native to Singapore. In any event, the abundance of these conspicuous and putatively native species has evidently increased very dramatically. Another potentially adventive species is *M. (Eutricharaea) sp. 1*, first recorded in 1986 but now numerous in scrub and managed gardens including those on rooftops. Most of these putative adventive bees are found more abundantly in scrubland, managed gardens and rooftop gardens rather than natural forests.

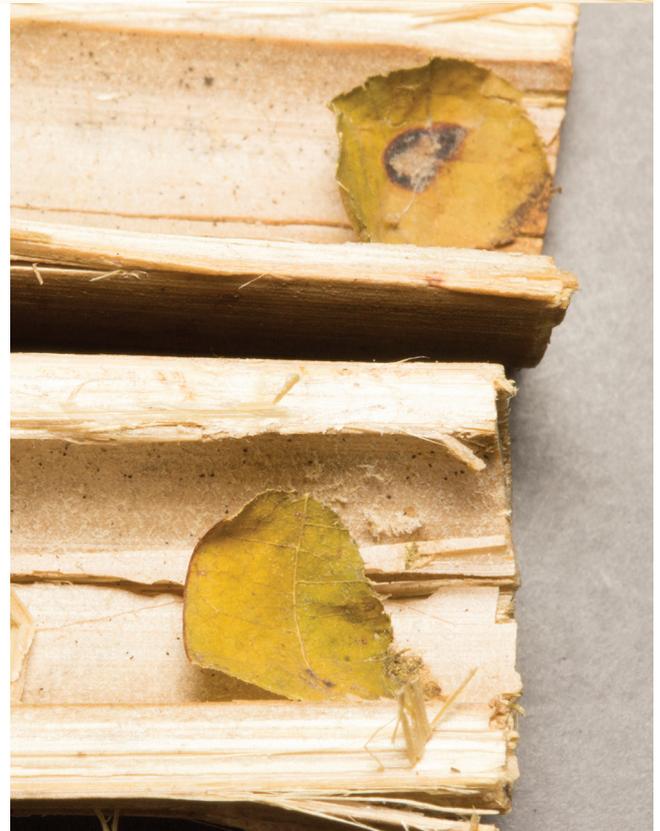
All *Megachile* species ever found in Singapore were collected during 2012–2014 (10 for the first time). Species newly detected in Singapore include three, *M. indonesica*, *M. sp. (biroi group)*, and *M. ornata*, discovered by (ZWWS et al., in prep.) during surveys of an unprecedented bloom of Tiger Orchids *Grammatophyllum speciosum* and recorded exclusively from these. Thus, the Singaporean *Megachile* fauna has apparently increased in historical times, due to discovery of scarce native species and possible establishment of adventive species native to the Southeast Asian region but not necessarily to Singapore. There is no evidence of any documented or even potential extinction, in sharp contrast to severe losses well documented in better-studied groups such as birds (Castelletta et al., 2000; Brook et al., 2003; Wang & Hails, 2007). Solitary bees, including *Megachile*, often can tolerate or even prefer disturbed habitats so may be less vulnerable to loss of primary forests (Barlow et al., 2007), but historical baseline data are too sparse to preclude undetected species loss in this and many other insect taxa. However, persistence of large-bodied, forest-associated species such as *M. indonesica* and *M. ornata*, suggests that the Singaporean *Megachile* fauna may be relatively intact despite loss of most primary forest. Furthermore, few potentially “missing” *Megachile* occur in southern Peninsular Malaysia and to our knowledge none of these are recorded from the neighboring state of Johor. No *Megachile* at all were observed by JSA during 11 visits from November 2011 to August 2015 across different seasons to the Panti Bird Sanctuary (Johor), one of the nearest high quality forest patches to Singapore.



Fig. 41. *Megachile laticeps* nest in bamboo trap-nest. The entire nest (A), the nest plug (B). Scale bar = 1 cm.

Striking cases of Müllerian mimicry occur among Singaporean *Megachile* and sympatric aculeate Hymenoptera. *Megachile atrata* (Fig. 32), *M. (Callomegachile) fulvipennis* (Fig. 18), *M. (Aethomegachile) sp.* of the *fusciventris* group (Fig. 12), *M. cf. indonesica* (Fig. 14), and *M. tuberculata* (Fig. 26), which are black with orange wings and relatively large, belong to four subgenera. Similar coloration occurs in large-bodied wasps including *Delta* (Vespidae) and *Sphex* (Sphecidae) and in at least one Batesian mimic (an unidentified moth in family Sesiidae). Three smaller *Megachile* species associated with more open habitats are black with whitish hairs on the posterior thorax (propodeum) and anterior metasoma (tergum 1) and with the wings pale basally and heavily infuscated apically: *M. disjuncta* (Fig. 16), a species of the *biroi* group (Fig. 10), and the female of *M. conjuncta* (Fig. 5A). These three species appear very similar in dorsal view, the effect being of a black bee bisected by a pale midsection, but differ in the color of their scopal hairs, which are black, pale-yellow, and orange-red respectively. The small species *M. subrixator* (Fig. 34) and *M. tricincta* (Fig. 39A) are nearly identical in color (e.g., with orange scopae) as are *M. borneana* (Fig. 1A) and *M. nr. borneana* (notably with orangish facial hairs). *Megachile laticeps* (Fig. 7) and *M. umbripennis* (Fig. 14) have orange hairs on the head, thorax, and anterior of the metasoma (especially first tergum) and pale apical bands on the terga. The male of *M. conjuncta* (Fig. 5B) closely resembles *M. laticeps* and therefore also, to a lesser degree *M. umbripennis*, whereas the remarkably different female resembles *M. disjuncta* and has often been misidentified as such (e.g., by Pagden, 1934). This is the only case of such striking sexual dimorphism documented among Singaporean *Megachile*. *Megachile ornata*, *M. ramera*, and *M. stulta* species are alike in having bright orange scopae and at least some orange on their terga, but differ greatly in size and in details of their tergal pattern. These species all have wings heavily infuscated apically, as do *disjuncta* and mimics, *M. borneana* (and *nr. borneana*), *M. sp. 1* (*nr. stulta*), and *M. umbripennis* among others, and this appears to be the most general mimetic pattern, conspicuously diverging from the less prevalent orange-winged pattern. In most cases, close mimics among Singaporean *Megachile* belong to different subgenera or to separate lineages with the diverse and heterogeneous subgenus *Callomegachile*. *Megachile conjuncta* and *M. laticeps* may be an exceptional case, as these similar bees are close relatives (Gonzalez, 2008).

Singaporean *Megachile* show strong habitat associations that differ between species (see Table 1). Associates of mature forest include *M. borneana* and *nr. borneana*, *M. sp.* (*fusciventris* group), *M. indonesica*, *M. ornata*, *M. ramera*, and *M. tuberculata*. These species, which include



the largest-bodied found in Singapore and also medium-sized species, may also occur in younger secondary forest, in addition to primary dipterocarp or freshwater swamp forest, especially when these habitats occur in proximity. By contrast, *M. disjuncta* and *M. umbripennis*, two species that are only recently detected in Singapore, occupy truly urban habitats in addition to parks, gardens, scrub, and forest edge. Medium- to small-sized species such as *M. conjuncta*, *M. fulvipennis*, *M. subrixator* (and other morphospecies of subgenus *Eutricharaea*), and *M. tricincta* occur in managed gardens, scrub, and secondary forests, but are not strongly associated with either primary (or old) forests or urban areas.

*Megachile (Creightonella) atrata* has been found nesting in back mangroves but forages more widely including in old secondary forest and managed gardens. Information about the nesting habits of Singaporean *Megachile* is fragmentary, but nearly all are thought to be cavity-nesters excepting *M. atrata* which excavates a burrow in a sloped surface and lines it with irregularly-cut leaves. A trap-nesting program conducted in March to May 2014 in nine sites, comprising both managed gardens and natural areas in Singapore found a low percentage of occupancy by cavity-nesting *Megachile*, with only *M. laticeps* confirmed to occupy bamboo trap-nests (Fig. 41). This can be attributed in part to the high occupation rates of ants (Formicidae) and the seasonal nature of *Megachile* where a peak in catch per effort was

Table 1. Assessment of species present in various habitat types in Singapore. The following abbreviations apply: MG – managed garden; SC – Scrubland (abandoned) YSF – young secondary forest; OSF – old secondary forest; PD – primary dipterocarp forest; SF – freshwater swamp forest; MN – mangroves where habitat types are based on Yee et al. (2009); RT – rooftop gardens; n – Total number of habitat types that species is known to occur within; Specimens – Singaporean specimens examined (six are singleton collections). TL – Total length; IT – intertegular distance measured with a reticle on a light microscope.

	MG	SC	YSF	OSF	PD	SF	MN	RT	n	Specimens	TL (mm)	IT (mm)
<i>Megachile (Aethomegachile) borneana</i>			×	×					2	2	♂: 8.1	♂: 2.6
<i>M. (Aethomegachile) nr. borneana</i>			×	×		×			3	3	♂: 9.8	♂: 2.9
<i>M. (Aethomegachile) conjuncta</i>	×			×					2	6	♀: 11.9; ♂: 9.2	♀: 3.2; ♂: 2.7
<i>M. (Aethomegachile) laticeps</i>	×	×	×	×	×		×	×	7	83	♀: 11.8; ♂: 7.4-10.2	♀: 3.40; ♂: 2.5-3.1
<i>M. (Aethomegachile) ramera</i>				×					1	1	♀: 12.0	♀: 4.6
<i>M. (Aethomegachile) sp. (fusciventris group)</i>			×	×	×				4	9	♀: 13.2; ♂: 10.9	♀: 4.3; ♂: 3.3
<i>M. (Alocantheodon) indonesia</i>			×	×	×				3	15	♀: 21.9; ♂: 15.6-20.9	♀: 4.9; ♂: 4.0-4.9
<i>M. (Callomegachile) fulvipennis</i>	×		×	×					3	37	♀: 17.3; ♂: 10.8	♀: 4.2; ♂: 2.9
<i>M. (Callomegachile) disjuncta</i>	×	×	×	×	×			×	6	116	♀: 13.5-16.3; ♂: 8.6-10.5	♀: 3.2-3.7; ♂: 2.2-2.9
<i>M. (Callomegachile) sp. (biroi group)</i>			×	×	×				3	10	♀: 10.7; ♂: 10.2	♀: 3.2; ♂: 2.7
<i>M. (Callomegachile) stulta</i>			×	×	×			×	4	25	♀: 8.7; ♂: 6.0-7.3	♀: 2.5; ♂: 1.6-2.1
<i>M. (Callomegachile) sp. 1 (nr. stulta)</i>						×			1	1	♂: 7.3	♂: 2.4
<i>M. (Callomegachile) ornata</i>			×						1	1	♀: 17.6	♀: 5.2
<i>M. (Callomegachile) tuberculata</i>			×	×	×			×	3	7	♀: 26.6 ♂: 17.3	♀: 6.5 ♂: 4.9
<i>M. (Callomegachile) umbripennis</i>	×	×	×	×	×			×	5	136	♀: 8.4-10.7; ♂: 7.2-8.8	♀: 2.3-2.8; ♂: 2.1-2.3
<i>M. (Chelostomoda) moera</i>	×								1	3	♀: 8.3	♀: 2.1

	MG	SC	YSF	OSF	PD	SF	MN	RT	n	Specimens	TL (mm)	IT (mm)
<i>M. (Creightonella) atrata</i>	×		×	×			×		4	33	♀: 20.1; ♂: 12.5-14.0	♀: 4.3; ♂: 2.9-3.4
<i>M. (Eutricharaea) sp. 1</i>	×	×	×					×	5	22	♀: 6.5-7.9	♀: 2.1-2.6
<i>M. (Eutricharaea) subrixator</i>	×	×	×				×	×	5	28	♀: 7.2; ♂: 6.2	♀: 2.2; ♂: 2.0
<i>M. (Paracella) tricineta</i>	×			×	×				3	38	♀: 7.1-8.3; ♂: 6.0-7.4	♀: 2.7-2.8; ♂: 1.9-2.4
20 species in total	10	5	14	13	8	5	3	5		577		

observed from June to August 2014. Species such as *M. disjuncta* and *M. umbripennis* were notably absent from bamboo trap-nests despite their presence in the vicinity. Instead, these two species and also *M. fulvipennis* nested in grooves within a wooden bench situated at the third level of a university building rather than a bamboo trap nest placed in an adjacent bench (Soh, 2014).

*Megachile* of both sexes visit a wide variety of native and exotic flowers for nectar such as *Syzygium* (Myrtaceae), *Premna foetida* (Verbanaceae), *Asystasia gangetica* (Acanthaceae), and *Antigonon leptopus* (Polygonaceae), but females have strong preferences with respect to pollen sources. Provisioning females of smaller-sized species in the subgenus *Eutricharaea* and *Callomegachile* usually collect pollen from Asteraceae (e.g., *Bidens pilosa*, *Ageratum conyzoides*) and other plants with smaller anthers (e.g., *Muntinga calabura*). By contrast, larger-bodied *Megachile* of subgenus *Callomegachile*, *Creightonella* and *Aethomegachile* tend to collect pollen from Fabaceae (e.g., *Crotolaria* spp., *Tamarindus indica*, *Peltophorum pterocarpum*) or Lamiaceae (e.g., *Vitex trifolia*, *Plectranthus monostachyus*) with labiate flowers. Moderate-sized species such as *M. disjuncta* and *M. laticeps* routinely visit *Memecylon* for pollen, which has larger anthers. Most of the scrub and managed garden species seem to be polylectic, but the pollen hosts of the forest species remain poorly known largely because these plants of similar flower morphologies are in the canopy and are relatively inaccessible (see Kato, 1996; Kato et al., 2008).

Summarising knowledge of Singaporean *Megachile* is the first step towards more thorough characterisation of the regional fauna. Molecular diagnostic (DNA barcoding) studies now underway, together with further study of type and other reference specimens in non-Singaporean museums, should confirm sex associations, otherwise resolve remaining taxonomic uncertainties. Molecular data may also be informative regarding the status and native distribution of certain *Megachile*. Those that are now common in urban Singapore but absent from historical surveys (e.g., Dover, 1929) may prove to be adventive from drier regions of South or Southeast Asia. Rapid increase for the *Megachile* species list for Singapore during 2012–2014 and, in particular, discovery of multiple additional species during the spectacular 2014 bloom of Tiger Orchids (ZWWS and colleagues, in prep.) and representation of five taxa by singletons, suggest that future discoveries can be anticipated. To record additional species and ecological associations for *Megachile*, future sampling should extend to the forest canopy and incorporate improved trap-nesting techniques also needed to facilitate monitoring and management of these pollinators. Continued sampling of bees on flowers from both natural and urban sites will strengthen our understanding of the phenology, ecological niches, and ecosystem services of these attractive and useful bees.

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