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The bees of Singapore (Hymenoptera: Apoidea: Anthophila): First comprehensive country checklist and conservation assessment for a Southeast Asian bee fauna

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Abstract. Reports of global bee declines have raised an urgent call for assessments of the conservation status of these key pollinators. The first published checklist and conservation status assessment for the bee fauna of a Southeast Asian country is presented here. A total of 133 species, comprising 106 named species and an additional 27 distinct morphospecies, have been recorded in the Singapore checklist. Conservation statuses were assessed for all species using a decision table adapted from the IUCN Red List criteria, accounting for documented site occurrences, habitat associations, and year of last record. Of key conservation importance are six Nationally Extinct species, six Critically Endangered species, two Endangered species, and 12 Vulnerable species. A relatively high proportion of stingless bee species (five of fourteen) in tribe Meliponini are either Nationally Extinct or Critically Endangered, suggesting that these highly eusocial bees are of particular conservation concern. Whereas 16 bee species have been recorded only from historical records (from 1976 or before), 117 species persist (recorded 2009–2021), with 79 (68%) of these in urban or semi-urban areas such as city parks and rooftop gardens. The 44 (33.1%) Data Deficient species are poorly known locally and continued monitoring and inventorying of bees is needed to inform management of Singapore's pollinators. Several bee species have only recently been confirmed for Singapore. Some synonymies and taxonomic comments presented first in a recently published book on Singaporean bees are discussed. *Eupetersia* (*Nesoeupetersia*) *malayensis* (Blüthgen, 1927) is treated as a provisional senior synonym of *Eupetersia* (*Nesoeupetersia*) *singaporensis* Pauly, 2012, and *E.* (*N.*) *sabahensis* Pauly, 2012. We recognise *Trigona* (*Tetragonula*) *pagdeniformis* Sakagami, 1987, as a junior synonym of the *Trigona laeviceps* Smith, 1857 (non auct.), with current combination *Tetragonula* (*Tetragonula*) *laeviceps* (Smith, 1857), and recognise *Tetragonula* (*Tetragonula*) *valdezi* (Cockerell, 1918) as a valid species.

Key words. red list, species inventory, pollinator, tropics, biodiversity

INTRODUCTION

Reports of global bee declines along with the trends of rising threats to bees have raised an urgent call for assessments of the conservation status of these crucial pollinators (Potts et al., 2010; Winfree, 2010; Sánchez-Bayo & Wyckhuys, 2019). Species status assessments at the regional, national, and local levels are particularly needed as they can inform practical conservation management, inspire improved documentation by local naturalists, and further scientific research (Miller et al., 2007). However, such assessments encompassing all bee taxa are only available for a few areas, notably Europe (Nieto et al., 2014). In Asia, the most recent print taxonomic and distributional catalogue dates to 1896 (Dalla Torre, 1896; online checklists covering Asian species can be found online at ITIS (https://www.itis.gov/) and Discover Life (https://www.discoverlife.org/mp/20q?act=x_checklist&guide=Apoidea_species&flags=HAS:)), and published species checklists are available for only a few countries (e.g., Cambodia; Ascher et al., 2016a). Type specimens of the Asian fauna, crucial to the determination of species with poor taxonomic descriptions, are also scattered across different natural history repositories. Given the lack of accessible taxonomic material for tropical Asian bees and the difficulty of interpreting historical descriptions (van der Vecht, 1950) it has been challenging to identify species. This taxonomic impediment and numerous additional difficulties in interpreting declines in bees and other insects (Didham et al., 2020) has precluded credible status assessments of bees for any country in this region. Overcoming these challenges is especially urgent given the rapid habitat destruction and consequently high rates of extinction across Southeast Asia (Turner et al., 1994; Brook et al., 2003; Koh et al., 2004;

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Sodhi et al., 2004, 2010; Sodhi & Brook, 2006; Jain et al., 2018). To this end, a recently established IUCN Wild Bee Specialist Group for Asia will identify and address threats to bee pollinators and initiate regional red-listing.

Knowledge of the Singapore bee fauna has historically been poor. For example, the second edition of the Singapore Red Data Book (Murphy et al., 2008), a broad conservation status assessment of Singapore's flora and fauna, listed a single bee species of conservation importance for Singapore, *Xylocopa iridipennis* (as *Biluna auripennis*), with the status of 'Data Deficient' and erroneously considered parasitic. Only recently has a comprehensive national status assessment of the bees for Singapore become feasible. This shift entailed both digitisation of historical data for bees from Singapore in both local and global collections, as well as targeted inventorying across a range of habitat types and localities in Singapore (e.g., Soh & Ngiam, 2013; Roscoe, 2015; Clerbois, 2018; Ascher et al., 2019; Ronse de Craene, 2020). Collections records were also supplemented with image-based citizen science records contributed online to iNaturalist and other websites. The status assessments presented here based on these newly available data are a contribution to the ongoing update of the Red Data Book for Singapore.

Historical bee records in Singapore begin with collections made by Alfred Russel Wallace, most likely in 1854, from remnant forest sites in the Bukit Timah vicinity (Van Wyhe, 2014; Ascher et al., 2019). His collections, comprising mostly forest-associated stingless bees, were described by pioneering melittologist Frederick Smith (Smith, 1857). The next major collector of bees in Singapore was Henry Nicholas Ridley, first director of the Singapore Botanic Gardens, active in the early twentieth century and collector and namesake of *Ceratina ridleyi* and *Nomia iridescens* var. *ridleyi* (= *N. strigata*), both described by Theodore Dru Alison Cockerell (1910). Soon after, Charles Fuller Baker and an entomological assistant Julian Hernandez, whom he supported with his own salary, made extensive collections evidently from forested mainland sites in Singapore during his tenure as acting director of the garden from 1917 to 1918, when, "His entomological collections received the greater part of his spare time" (Essig, 1931). Subsequently, Cockerell, the world's most prolific describer of bees (Zuparko, 2007), described from Baker's collections five valid species and two subspecies from "Singapore" as well as 11 additional bee taxa now regarded junior synonyms (Cockerell, 1918a, b, 1919a, b, 1920a). In his taxonomic papers, Cockerell also reported collections of various widespread species, establishing a fragmentary historical baseline. Schwarz (1939), van der Vecht (1952), and Lieftinck (1962) included material from Singapore in their revisionary studies of Meliponini, *Ceratina*, and *Thyreus* respectively, but Singapore's bees were otherwise relatively neglected during the mid-20th century (see timeline of bee discovery in Soh & Ascher, 2020, p. 9). As with many other insect taxa in Singapore, records of bees from the 1960s to 1970s are almost entirely from vouchers collected by Dennis H. "Paddy" Murphy, who was a naturalist, taxonomist and academic based at the National University of Singapore (Chan, 1991; Ng, 2020), and his associates. Much of this material was deposited in the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum (LKCNHM; formerly the Raffles Museum of Biodiversity Research). These records provide an insight into the bee fauna at a later stage in Singapore's large-scale deforestation of primary habitat (a process well underway by the mid-19th century) but at an early state of urbanisation as a young nation-state developed after independence in 1965 (Corlett, 1992).

Contemporary studies include Liow et al. (2001) who surveyed bees in 1999 by honey baiting in Singapore (five sites) and Peninsular Malaysia (three sites) as part of an ecological study across a disturbance gradient. In Singapore, three stingless bees (Meliponini), along with six identified non-eusocial species (seven were reported; *Amegilla insularis* was recorded under two names) and fifteen unidentified morphospecies were recorded (Liow, 2001). Later, Soh & Ngiam (2013) published a more extensive survey of flower-visiting insects, that included bees, in seven of Singapore's parks. They reported several new country records for bees, notably of seasonal *Megachile* species, and rediscovered forest-associated bees last seen locally in the 1910s. Subsequent surveys of bees by the authors and students and associated taxonomic work on both historical and recent vouchers further expanded the Singapore checklist (Ascher et al., 2016b; Soh et al., 2016; Soh & Ascher, 2020). The range of habitats covered by recent surveys include forest nature reserves such as Bukit Timah Nature Reserve (Ascher et al., 2019), urban parks, offshore islands, and rooftop gardens (e.g., Roscoe, 2015; Clerbois, 2018; Ronse de Craene, 2020; several Honours projects conducted by undergraduates of the National University of Singapore). Net collecting from these areas was supplemented with malaise trap samples from an intensive inventory of the mangrove insects in Singapore, initiated in 2009 through a collaboration with the National Parks Board (NParks) and the National University of Singapore (NUS) (Grootaert & Shamshev, 2012; Grootaert & Puniamoorthy, 2014; Yeo et al., 2021).

Species accounts covering identification, floral associations, life history, and status for the majority of Singapore's bees were recently summarised in a book 'A Guide to the Bees of Singapore' (Soh & Ascher, 2020) which included a complete checklist of Singaporean species in an appendix. Novel information presented therein about the taxonomy, distribution, and abundance of Singapore bees is further documented in this paper. The availability of this field guide has facilitated species identification by members of public in Singapore as demonstrated by a growing number of correctly identified images contributed to online platforms including both social media (Bees & Wasps of Singapore, 2021) and biodiversity portals such as iNaturalist (2021).

This first comprehensive species checklist and conservation status assessment for Singapore (and also for any tropical Asian country) provides a baseline for further conservation and ecological purposes, as well as to appeal to the wider public (i.e., through common names taken from Soh & Ascher, 2020). This checklist consolidated all known and

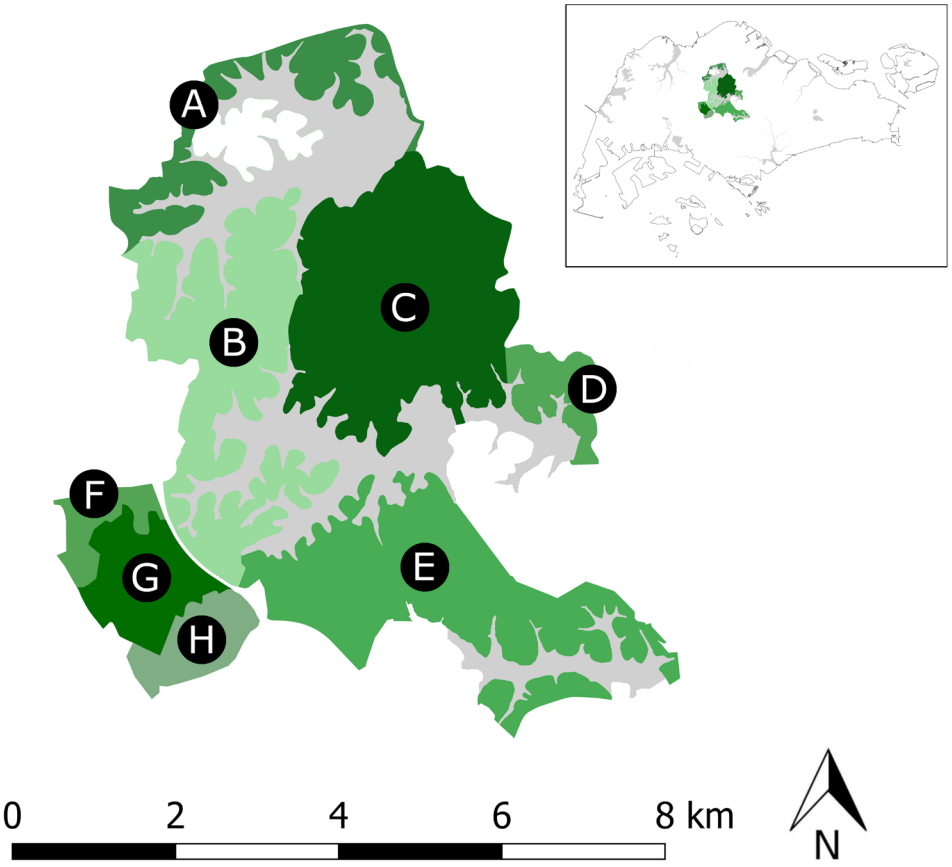

Fig. 1. Map of delineated forest patches of CCNR and BTNR. A, Mandai Forest; B, Seletar Forest; C, Nee Soon Swamp Forest; D, Peirce Forest; E, MacRitchie Forest; F, Dairy Farm Nature Park; G, Bukit Timah Nature Reserve; H, Rifle Range.

accessible prior work, specimen vouchers, taxonomic literature, as well as sightings contributed by citizen science. All bee species recorded from Singapore were assigned to one of the six categories established by the International Union for Conservation of Nature (IUCN) Red List (https://www.iucnredlist.org/) or to an additional Non-Native (NN) category. Short species accounts are presented in the results section for all valid species classified as Nationally Extinct (NE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and for some of the species classified as Near Threatened (NT) and Data Deficient (DD). Other salient information such as taxonomic synonymies and country, state, or province, and island records are accessible online as part of a global checklist of world bee taxonomy and distribution (Ascher & Pickering, 2020) while the Biodiversity of Singapore (2021) portal (https://singapore.biodiversity.online/taxon/A-Arth-Hexa-Hymn-Anth) provides images of all Singaporean bee species and most morphospecies. Future publications include taxonomic reviews treating the bees of Singapore in more detail with scientific descriptions and validation of names for some of the better known morphospecies (Ascher et al., in preparation).

MATERIAL AND METHODS

Type and other historical specimens in collections such as the Natural History Museum in London (NHMUK), Museum für Naturkunde Berlin (MFNB), Smithsonian National Museum of Natural History (USNM), and American Museum of Natural History (AMNH) were examined and photographed to ensure accurate species identification and historical data. Label data of available Singapore specimens and online citizen science records from the "Bees & Wasps of Singapore" Facebook group (from 2013 to 2021; Bees & Wasps of Singapore, 2021) and iNaturalist (from 2005 to 2021; iNaturalist, 2021) were captured in an Airtable database (https://airtable.com/). Online citizen science records were evaluated critically, with all accepted image-based records having been identified or verified by the authors (especially JSA and ZWWS). Most images had plausible dates and were reported from sites where validated specimens were already known to the authors; in cases where essential data was missing, doubtful, or otherwise required verification contributors were queried directly for further information. Specimens of adult field-collected bees examined included both historical and recent material stored in the LKCNHM Zoological Reference Collection (ZRC) and records from standardised and opportunistic surveys in Singapore's nature reserves, offshore islands, and urban greenery by the authors, students and other researchers associated with the Insect Diversity Lab and the Mangrove Insect Project (Grootaert & Shamshev, 2012; Grootaert & Puniamoorthy, 2014; Ascher et al., 2019; Yeo et al., 2021).

Records were georeferenced and assigned to a sampling locality or "site", which is defined as a distinct homogeneous area. These were used to determine the number of sites and

Table 1. The decision table formulated and used for assignment of national conservation status of bee species in Singapore, based on semi-quantitative methods.

Native status	**Non-native**	**Native**					
Last recorded status		Recently recorded (1977–2021)				Last recorded in the past 45–50 years (1971–1977[#])	Not recorded for more than 50 years (since 1971)
Habitat types▲		Widespread in urban[*] and/or semi-urban[†] areas	Associated largely with natural habitats and/or offshore islands[‡]				
Number of sites recorded▲			>5	2–5	1		
Status/ IUCN Red List category	**Non-native (NN)**	**Least Concern (LC)**	**Near Threatened (NT)**	**Vulnerable (VU)**	**Endangered (EN)**	**Critically Endangered (CR)**	**Nationally Extinct (NE)**

[*]Urban areas refer to environments dominated by high-density residential and commercial buildings. Includes rooftop gardens and urban parks.
†Semi-urban areas refer to parks containing extensive vegetation, with the exception of nature parks as they are near or contiguous to nature reserves.
‡ Natural habitats refer to forests, mangroves (includes coastal forests in some sites), and coastal scrub. Offshore islands are considered as one habitat category as they often comprise a mixture of various natural habitats within a small area.
[#]1977 was the year subsequent to the period of active collecting by D. H. Murphy and colleagues, and is used as a benchmark year.
▲Assessed based on recent records (1979–2021).
Note: Bees not assessed with this decision table were treated as Data Deficient (DD). See Material and Methods for more information on DD category.

habitat types where each species occurred and later used in the national conservation assessment. The sites were classified into "Forest Reserve", "Forest Fragment", "Mangrove", "Coastal Scrub", "Semi-Urban", and "Urban" according to major vegetation types and Planning Areas defined in the Urban Redevelopment Authority's Master Plan 2014 (Urban Redevelopment Authority, 2016). The list of major sites and their corresponding habitat classification are available in Supplemental Table S1. Following a conservation assessment of dragonflies of Singapore (Ngiam & Cheong, 2016), the Central Catchment Nature Reserve (CCNR) was delineated into separate sites: Mandai Forest, Upper Seletar Forest, Nee Soon Swamp Forest, Peirce Forest, and MacRitchie Forest (Fig. 1). The CCNR sites are separated by major reservoirs that may act as a barrier for bees, because bees tend to have short foraging ranges of 600 m or less (Gathmann & Tscharntke, 2002), with the exception of the largest bees (e.g., *Xylocopa latipes*). The only differences from Ngiam & Cheong (2016) were that Peirce Forest (including Lower and Upper Peirce) and Seletar Forest were considered in the present study as two separate sites, as they are spatially separated by the floristically distinct Nee Soon Swamp Forest; in addition, Rifle Range, Dairy Farm Nature Park, and Bukit Timah Nature Reserve were also considered as separate sites (Fig. 1). Spatial joins between site polygons and bee point records were performed using QGIS Desktop 3.4.4 (QGIS Development Team, 2019).

For the conservation assessment, all bee species and morphospecies known from Singapore were categorised into seven categories, i.e., six IUCN conservation categories: Nationally Extinct (NE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD); and an additional Non-Native (NN) status. The IUCN risk criteria may not be directly applicable to diverse invertebrate groups as they have poorly documented local and global distributions (Cardoso et al., 2011; Ngiam & Cheong, 2016). Thus, we formulated a decision table for use as a conservation assessment criterion based on semi-quantitative methods (summarised in Table 1). Firstly, the decision table was based on two significant time points—when the species was last recorded at least 45 years ago (i.e., 1976) to delineate Critically Endangered species as 1976 was the last documented year of active collecting by D. H. Murphy and colleagues, and 50 years ago (i.e., 1971) as recommended by IUCN to assess extinction (Baumsteige & Moyle, 2017). Secondly, as habitat is a major driver for bee species decline (Murray et al., 2009; Potts et al., 2010; Winfree, 2010), we also used documented association with habitat types in Singapore as an ecological correlate for conservation risk. Four habitat types ("Forest Reserve", "Forest Fragment", "Coastal Scrub", "Mangrove") were treated as natural habitat types that are threatened as they are limited and have seen major declines in extent (Corlett, 1992; Yee et al., 2010, 2011; Lai et al., 2015), and two ("Semi-Urban" and "Urban") were treated as relatively stable or increasing (Tan et al., 2013). Bee species that occur in habitat types that are stable or increasing were considered of lower conservation risk than those that only associate with habitat types that are limited or have been extensively

cleared (e.g., forest sites). Third, the remaining threatened statuses (NT, VU, and EN) were assigned based on the number of sites as a proxy for Area of Occurrence (AOO) from 1977 to 2021.

Species that were assessed to be likely under-recorded, such as small-bodied, solitary, or parasitic species, were assigned as DD. Some of these have been scarcely detected after 1976, with only a few specimens, and/or found only in one or two sites. Their DD status may be attributed to diet specialisation on under-sampled plants or bee hosts (for parasitic species), association with an under-sampled habitat (e.g., mangroves), or unusual activity patterns (e.g., crepuscular fauna). Urban-associated species that have been newly detected in Singapore relatively recently and were likely to be occurring beyond their native range as established by region-wide historical collections were listed as NN. For all species assessed as NE or CR we note relevant observations of visually distinctive bees and their nests made during ca. ten general natural history and photography trips conducted under favourable weather conditions by one or more of the authors at Panti Bird Sanctuary (PBS), a forest reserve in Peninsular Malaysia relatively near to Singapore. In the absence of thorough baseline samples from Singapore prior to extensive loss of its primary forests, PBS serves as a relevant comparison site for stingless bees and other forest-associated species.

CHECKLIST OF THE BEES OF SINGAPORE

The bee checklist (Appendix) and text accounts follow the family-group and species-group taxonomy of Ascher & Pickering (2020), which is based largely upon Michener (2007) (and references therein) and in most cases, subsequent revisionary and/or phylogenetic studies. After critical examination of more than 9,800 records, including several hundred online citizen science records of at least 56 visually identifiable species, the total number of bee species for Singapore is 133, comprising of 106 valid names and 27 morphospecies (see Appendix) from 27 genera and four families (Table 2). Of the morphospecies, at least five are recognised as species new to science, e.g., *Nomia* (*Maculonomia*) sp. aff. *apicalis*, *Euaspis* n. sp. 1, *Coelioxys* (*Torridapis*) n. sp., with descriptions in preparation. The others of less certain status belong to species groups lacking regional taxonomic revisions. Cryptic species, such as a newly detected morphospecies (*Nomia* aff. *lusoria*) also diagnosable by subtle morphological characters (Tee, 2017), confirmed by preliminary DNA barcoding studies of bees from Singapore are cited as morphospecies in the checklist.

To assess species discovery and faunal turnover, the year of the first and last Singapore record for each taxon is included in the checklist. A total of 117 taxa were recorded from 1977 to 2021, of which all except one (from 2009) were also recorded in the last decade (Table 3) and 79 (68%) occur in urban or semi-urban habitats. Over the same 45-year period, 48 taxa were recorded for the first time in Singapore with most (38) having been detected only in the last decade.

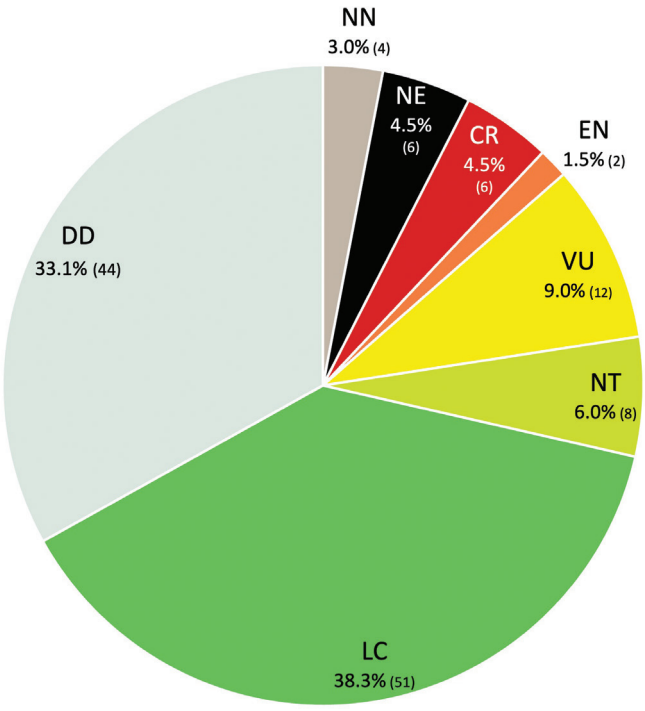

Fig. 2. Proportion of Singapore's bee species in the national conservation statuses based on the International Union for Conservation of Nature (IUCN) Red List categories: Nationally Extinct (NE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concerned (LC), Data Deficient (DD) and Non-Native (NN). A total of 133 bee species and morphospecies were recorded in Singapore.

Whereas 117 bee species are known to have persisted until at least 2009 (with all but one having been from 2013–2021), 16 have not been recorded since 1976.

CONSERVATION ASSESSMENT FOR THE BEES OF SINGAPORE

The conservation assessment of bees in Singapore is summarised below (see also Fig. 2). The full assessment for all species is presented in the Appendix. Photographs of bee species selected as exemplars of each conservation status are presented in Fig. 3.

Nationally Extinct (NE). Six species unrecorded since 1970 are considered Nationally Extinct. Of the six species in this category, four are stingless bee (Meliponini) species.

Critically Endangered (CR). Six of the eight species recorded from 1969 to 1976, but not subsequently, are placed in this category whereas the other two, *Sphecodes* sp. 4 and *Nomada polyodonta*, both parasitic species, are regarded as Data Deficient. *Geniotrigona thoracica*, the largest-bodied stingless bee in Southeast Asia with distinctive orange colouration, was last recorded in 1976 (Appendix) and is assessed as CR for now. It is very unlikely to be overlooked by naturalists if currently present in Singapore and will most likely be reassessed as Nationally Extinct (Ascher et al., 2019) in the near future after the 50-year timespan since the last record has been surpassed.

Table 2. Families and genera of Singapore bees, with information on the number of valid and morphospecies, as well as the number of Nationally Extinct (NE), Critically Endangered (CR), and Data Deficient (DD) species of each genus. NE, CR, and DD are categories from the International Union for Conservation of Nature (IUCN) Red List.

Family	Subfamily and Tribe	Genus	Valid species	Morpho-species	Total 'species'	No. of NE species	No. of CR species	No. of DD species
Colletidae	Hylaeinae	*Hylaeus*	2	7	9			8
Halictidae	Nomiinae							
	Nomiini	*Lipotriches*	4		4			2
		Nomia	8	2	10	1	1	1
		Pseudapis	1		1			
	Halictinae							
	Nomioidini	*Ceylalictus*	2		2			2
	Halictini	*Eupetersia*	2		2			2
		Lasioglossum	8	3	11		1	3
		Patellapis	2		2		1	
		Sphecodes	1	5	6			6
Megachilidae	Lithurginae							
	Lithurgini	*Lithurgus*		2	2			1
	Megachilinae							
	Anthidiini	*Anthidiellum*	1		1			
		Euaspis	1	1	2			1
	Osmiini	*Heriades*	1		1			
	Megachilini	*Coelioxys*	2	3	5			4
		Megachile	16	4	20			4
Apidae	Xylocopinae							
	Xylocopini	*Xylocopa*	8		8			3
	Ceratinini	*Ceratina*	12		12			2
	Allodapini	*Braunsapis*	6		6			2
	Nomadinae							
	Nomadini	*Nomada*	4		4		2	1
	Apinae							
	Anthophorini	*Amegilla*	3		3			
	Melectini	*Thyreus*	4		4	1		
	Apini	*Apis*	4		4			
	Meliponini	*Geniotrigona*	1		1		1	
		Heterotrigona	2		2	1		
		Homotrigona	3		3	2		
		Lepidotrigona	2		2			1
		Tetragonula	6		6	1		1
		Total	106	27	133	6	6	44

Endangered (EN). This category comprises two species encountered since 2014 from a single site.

Vulnerable (VU). The 12 species that were recently encountered from two to five sites, largely comprising of natural, declining habitats, are placed in this category. At present, natural populations of *Lepidotrigona terminata* are encountered routinely in Singapore only at Chek Jawa on Pulau Ubin, but it has also been recorded from Pulau Tekong. *Megachile* (*Aethomegachile*) *ramera* exemplifies a forest-associated species that is seasonal and associated with general flowering events.

Table 3. Summary of first and last Singapore records for all 133 bee taxa between 1854 to 2021 according to different time periods.

	Period			
	1854 – 1900	**1901 – 1976**	**1977 – 2011**	**2012 – 2021**
Number of species first recorded	13	72	10	38
Number of species last recorded	2	14	1	116

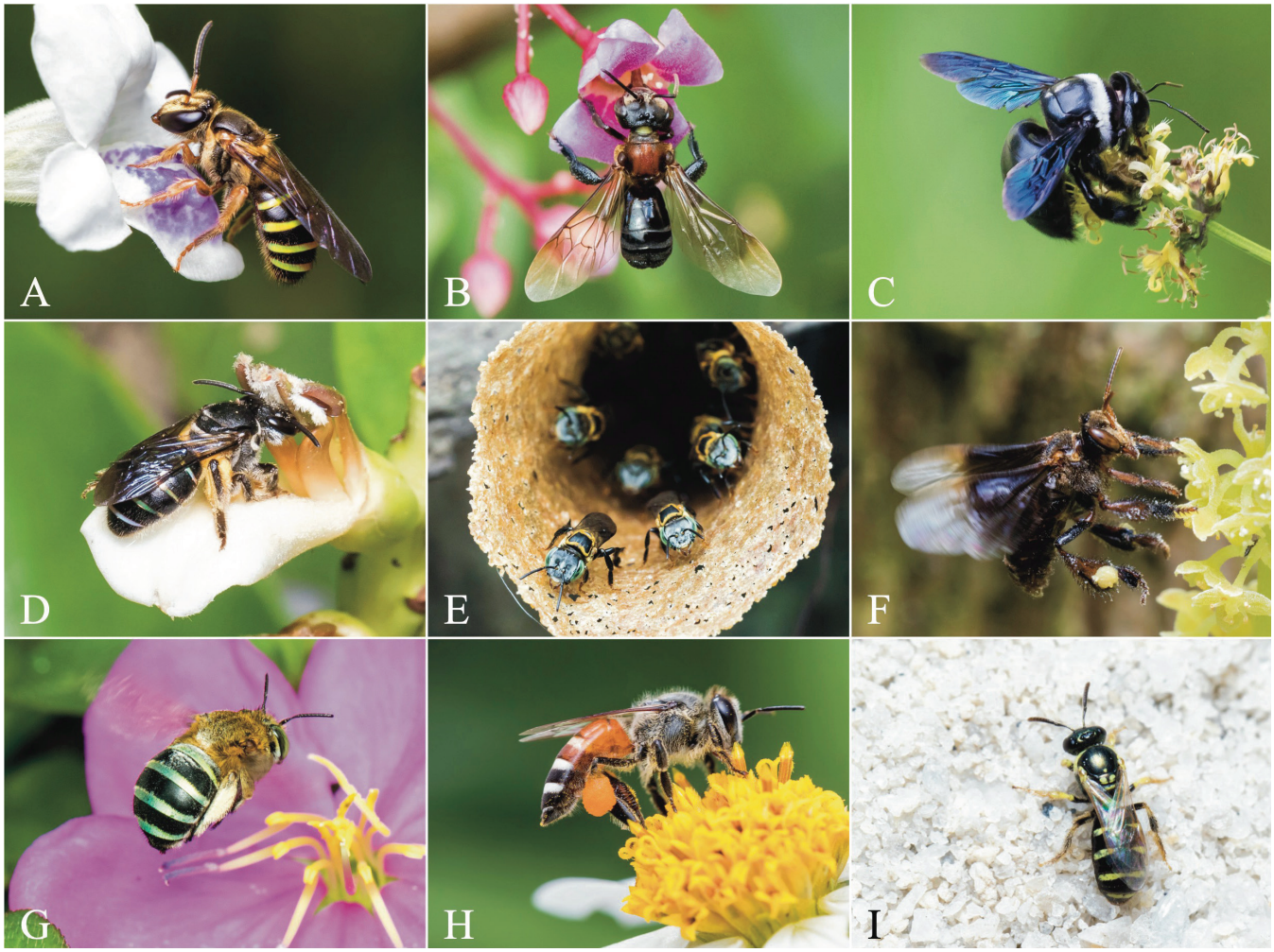

Fig. 3. Photographs of selected bee species exemplifying each conservation status. A, NE, *Nomia* (*Maculonomia*) *elegans* (photographed at Ulu Temburong, Brunei); B, CR, *Geniotrigona thoracica* (photographed in Seremban, Malaysia); C, EN, *Xylocopa* (*Zonohirsuta*) *dejeanii penangensis* (photographed at Ulu Temburong, Brunei); D, VU, *Nomia* (*Acunomia*) *lusoria*; E, VU, *Lepidotrigona terminata*; F, NT, *Homotrigona* (*Tetrigona*) *apicalis*; G, LC, *Amegilla* (*Zonamegilla*) *andrewsi*; H, NN, *Apis* (*Micrapis*) *florea*; I, DD, *Ceylalictus* (*Ceylalictus*) *communis*. (All photographs by Zestin W. W. Soh)

Near Threatened (NT). This category consists of eight uncommon species found recently in more than five sites that largely comprise of natural habitats or offshore islands.

Least Concern (LC). This category includes 52 common to abundant species found regularly at multiple locations and mostly from semi-urban and urban sites.

Non-Native (NN). Three urban-associated species, *Apis florea*, *Megachile disjuncta*, and *Megachile umbripennis* are placed in this category as these were first recorded in Singapore in relatively recent times (post-1974), and, in our view, unlikely to have escaped historical detection if they were truly indigenous to the country. Their wide global distributions in modern times and ability to nest in wood, on twigs or in manmade structures (in the case of the *Megachile*) suggest that they may have spread through accidental transport (Ascher et al., 2016b; Russo, 2016; Soh & Khoo, 2018; Silva et al., 2019). While these species may not be truly indigenous to Singapore, they are nonetheless native to the Indomalayan region. We believe that there has been much expansion of bee species within Asia due to a combination of human transport of nests and of forest clearance and other anthropogenic change (Silva

et al., 2019), whereas most discussion of non-native bees to date has focused on species clearly originating from distant continents (Russo, 2016). The fourth species in this category, *Tetragonula* (*Tetragonula*) *pagdeni* was discovered at Gardens by the Bay and is noteworthy since this group is notoriously poor at dispersing. The most likely explanation for its occurrence in Singapore is transport of a tree with a nest from further north, perhaps Thailand, to Gardens by the Bay. A few additional species recently detected in Singapore may have arrived in Singapore and Indonesia only subsequent to widespread deforestation of the Malay Peninsula but are conservatively treated as native species in this assessment. An example is *Pseudapis siamensis*, known as a distinctive species only recently detected in Singapore, Sumatra, and Java (where it is unlikely to have been overlooked by historical bee specialists resident there had it been present).

Data Deficient (DD). This category comprises 21 named species and 23 morphospecies that in our view could not be evaluated reliably due to their life history specialisation or habitat association and consequent elusiveness, or our inability to routinely access historical collecting sites in Singapore. Most of the species in question are scarcely recorded but some may be locally and seasonally numerous, especially during mass blooming of favoured host plants (e.g., *Syzygium* species in the case of several morphospecies of *Hylaeus*). For example, *Xylocopa* (*Cyaneoderes*) *insularis* has few specimens and site records (i.e., fewer than ten sites) which may be due to its largely crepuscular activity and habit of foraging between at canopy level (John X. Q. Lee, personal observation) resulting in a lower detection rate. This category also includes most small-bodied parasitic bee species that are collected by net infrequently yet are revealed by malaise traps to be surprisingly prevalent in mangrove swamps.

SPECIES ACCOUNTS

This section presents information on all valid species assessed to be NE, CR, EN, VU, and NT. Accounts for a selection of DD and NN species are included to note interesting, challenging, or potentially controversial categorisations, and to explain the rationale for the decisions taken.

Nationally Extinct.

1. ***Nomia* (*Maculonomia*) *elegans*** Smith, 1857, Elegant Forest-Nomia

This species was described from Wallace-collected specimens from Malacca, and subsequently redescribed from Singapore as *Nomia tuberculifrons* Cockerell, 1920b (for synonymy see Pauly, 2009), based on specimens of both sexes collected at Seletar in 1911. There are no subsequent local records, and we have not seen any at Panti Bird Sanctuary (PBS) in Johor, Malaysia, the nearest relatively intact forest site to be visited regularly.

2. ***Thyreus novaehollandiae signatus*** (Meyer, 1921), Diamond-waisted Cloak-and-dagger Bee [subspecies of Indomalayan Cloak-and-dagger Bee]

This specific epithet is misleading as the type specimens is believed to have been collected in the Lesser Sunda Islands of Indonesia, most likely from Timor, as opposed to Australia (the erroneous published locality is "Nouvelle-Hollande") where there are no verified records (Lieftinck, 1962). To highlight the correct distribution, we proposed the modifier "Indomalayan" for the common name of the species. Subspecies *T. n. signatus* was recorded in Singapore in November 1932 by F. N. Chasen (Lieftinck, 1962) and also by Baker ca. 1917–1918. There are no subsequent local records, although the suitably small-bodied *Amegilla* (*Zonamegilla*) *korotonensis* is found in eastern Singapore and could be a potential extant host.

3. ***Heterotrigona* (*Sundatrigona*) *moorei*** Schwarz, 1937, Moore's Stingless Bee

This species was recorded from Singapore based on the holotype of *Trigona* (*Tetragona*) *matsumurai* (Sakagami, 1959), with no subsequent local records (Sakagami, 1975). Unlike the other stingless bees recorded as Nationally Extinct, there is some reason to hope for rediscovery of *H. moorei*, given its small body size, superficial resemblance to the ubiquitous *Tetragonula valdezi* (=*laeviceps* sensu Sakagami, 1978, in part; and sensu Ascher et al., 2019), and its specialised nesting habits (Sakagami & Inoue, 1989). We did not observe this inconspicuous species at PBS.

4. ***Homotrigona* (*Homotrigona*) *fimbriata*** Smith, 1857, Bristle-faced Stingless Bee

Wallace captured the type worker in Singapore, perhaps in the Bukit Timah vicinity, ca. 1854 (Ascher et al., 2019). There are no subsequent records from Singapore, although the species persists in Peninsular Malaysia. Such a large-bodied and conspicuous species is unlikely to have been overlooked by all subsequent studies (Schwarz, 1939; Sakagami, 1975; Liow et al., 2001). We have not observed this species at PBS, raising concerns about its conservation status in Johor and elsewhere in southern Peninsular Malaysia. A distinctively orange form is confirmed to persist on Tioman Island, i.e., distinctively coloured material discussed by Schwarz (1939) has proven to be characteristic of an insular population as opposed to a trait unique to a callow or otherwise anomalous individual worker bee.

5. ***Homotrigona* (*Lophotrigona*) *canifrons*** (Smith, 1857), Woolly Stingless Bee

This species was recorded in Singapore only from Bukit Timah, where it was collected in 1911, putatively by Baker (Schwarz, 1939), and has not been found locally since (Sakagami, 1975; Ascher et al., 2019), nor have we recorded it at PBS.

6. ***Tetragonula* (*Tetragonula*) *atripes*** Smith, 1857, Orange-and-black Stingless Bee

This species was recorded from Singapore at Bukit Timah by D. H. Murphy in 1965, but not subsequently. Although only just meeting our fifty-year cut-off for this category,

this distinctively coloured species is likely to be extirpated (Ascher et al., 2019). We have recently observed an active nest at PBS.

Critically Endangered.

7. ***Nomia* (*Maculonomia*) *apicalis*** Smith, 1857, Black-tipped Forest-Nomia

The male holotype in OUM was collected by Wallace in Singapore ca. 1854. Subsequent records in Singapore extend to 1976, when it was last recorded at Dairy Farm. This species persists at PBS, but in Singapore all recent (2008 onwards) local records of a bee with similar appearance pertain to what we believe to be a similar undescribed species, *Nomia* (*Maculonomia*) sp. 1 aff. *apicalis* (description in preparation). True *Nomia apicalis* seems to be a forest-associated species, whereas the similar morphospecies now present in Singapore has broader habitat tolerances.

8. ***Lasioglossum* (*Ctenonomia*) *semirussatum*** (Cockerell, 1920a), Singapore Combed-Sweat Bee

The male type from Singapore was collected ca. 1917–1918 by Baker. Subsequently, it was found at Bukit Timah in 1976 by D. H. Murphy (see Fig. 3 in Ascher et al., 2019), but no subsequent records from anywhere of this distinctively coloured bee were detected.

9. ***Patellapis* (*Pachyhalictus*) *intricata*** Vachal, 1895["1894"], Vachal's Reticulate-Furrow Bee

This species was recorded from Singapore at Bukit Timah and Rifle Range Road by D. H. Murphy in 1975 and 1976 (Ascher et al., 2019). It has a distinctively lamellate pronotum and is therefore readily identified. It persists at PBS, but all recent specimens of *Patellapis* (*Pachyhalictus*) records from Singapore pertain to *P. murbanus*.

10. ***Nomada penangensis*** Cockerell, 1920c, Penang Nomad

This species was described from Penang and recorded from Singapore from the Alumni Car Park Garden of the old National University of Singapore Campus (near the Singapore Botanic Gardens) in 1975. This and other species of the *furva* group of *Nomada*, an "almost certainly monophyletic" group within the genus comprising "the only group present in Southeast Asia, the Malay Archipelago, New Guinea, and Australia" (Alexander, 1994) are presumed to be cleptoparasites of *Lasioglossum.* Small-bodied cleptoparasites can be easy to overlook away from nest sites, but this and other local *Nomada* are distinctively coloured, and thus are relatively conspicuous. Both this and the following species are evidently very rare in collections, although this attribute does not necessarily entail global rarity.

11. ***Nomada sandacana*** Cockerell, 1920b, Sandakan Nomad

This species was described from Sandakan in Sabah, Malaysian Borneo, and unrecorded subsequently until specimens in LKCNHM were identified (with some uncertainty) as this species. One specimen was collected in 1975, at the Alumni Car Park Garden of the old National University of Singapore Campus (near Singapore Botanic Gardens).

12. ***Geniotrigona thoracica*** (Smith, 1857), Long-chinned Stingless Bee

This species was described from a worker collected in Singapore by Wallace ca. 1854, and the obscure *Trigona pallidicincta* Cockerell, 1918a, recognised by us as a probable new synonym of *G. thoracica* (Ascher et al., 2019), also has a type locality from Singapore. The most recent records of this species in Singapore are from Taban Valley at Bukit Timah from 1976. As this is the largest-bodied stingless bee in the region and distinctive in colour and behaviour (e.g., form of nest entrance), we think it is unlikely that it would have been overlooked by us and other qualified investigators (e.g., Liow et al., 2001) if extant in Singapore. Although we think it is likely to be extirpated, we did not include it in the Nationally Extinct category because it does not meet the 50-year threshold.

Endangered.

13. ***Xylocopa* (*Zonohirsuta*) *dejeanii penangensis*** Cockerell, 1918a, Penang Collared Carpenter [subspecies of Collared Carpenter]

This large-bodied, distinctively patterned, territorial (in males) and thus conspicuous bee is notably absent from our recent field surveys in Singapore, but with records from Dover (1929) and from a 1962 specimen from MacRitchie collected by Murphy. An online video posted to the Bird Ecology Study Group by Leong Tzi Ming from 2014, attributed to Singapore but without precise locality, provides evidence for its persistence in Singapore. However, none of the authors of this study have detected it and it is at best very localised. We have observed it sporadically at PBS.

14. ***Thyreus abdominalis rostratus*** (Friese, 1905), Beaked Cloak-and-Dagger Bee [subspecies of Band-tailed Cloak-and-Dagger Bee]

This species was collected in "Singapore" by Ridley in 1901 and at Ulu Pandan by an unknown collector in 1920 (Lieftinck, 1962), and was recently rediscovered in Singapore at Nee Soon Swamp Forest in 2015 (record from a malaise trap sample shared by R. Meier and M. Foo). Lieftinck (1962) records this bee as a possible cleptoparasite of *Amegilla* (*Glossamegilla*) *elephas* Lieftinck, 1962, but that large-bodied species has not been recorded in Singapore, where the only plausible host among the known fauna is *Amegilla insularis* (see below). We have observed *Thyreus* resembling this subspecies at PBS, where *Amegilla insularis* is the only large-bodied member of subgenus *Glossamegilla* known to occur.

Vulnerable.

15. ***Lipotriches* (*Austronomia*) *takauensis*** (Friese, 1910), Takau Austral-Nomia

This species was collected by D. H. Murphy from "Changi Mangrove" and Linden Drive in 1961 and 1976, respectively. It was recently recorded largely from sites within the vicinity of forests, including Dairy Farm, Bukit Timah, Rifle Range, and Pulau Ubin.

16. ***Nomia* (*Acunomia*) *lusoria*** Cockerell, 1919c, Mangrove Nomia

This species was described from Palawan in the Philippines and only recently detected in Singapore, where it is clearly restricted to mangroves and their immediate vicinity, e.g., at Pasir Ris Park and Sungei Buloh Wetland Reserve. Its preferred habitat is relatively difficult to access and to sample by net, so the species may be more numerous than realised. Divergence in COI sequence between samples initially identified as *N. lusoria* with reference to Pauly's (2009) revision led to re-examination of sterna of available males, which revealed subtle differences in a unique divergent male sample and provided basis to delimit the morphospecies *N.* aff. *lusoria* (see Appendix). Further research is needed to discover diagnostic characters for females and to confirm which local records pertain to which cryptic form, but in any event available evidence suggests that the species complex in the broad sense is of conservation concern in Singapore.

17. ***Anthidiellum* (*Pycnanthidium*) *smithii smithii*** (Ritsema, 1874), Smith's Rotund-Resin Bee

The genus was newly recorded in Singapore in 2014 during a drought-induced flowering event from forest sites at Dairy Farm and Bukit Timah (Soh et al., 2016). Individuals of this species were observed to collect pollen from exotics (*Muntingia calabura*) and weeds (*Bidens pilosa*), but the origins of resin used in nest building is unknown (Soh et al., 2016). Attempts to locate this species at those localities were unsuccessful after its exotic pollen host plants were removed (Zestin W. W. Soh & Eunice J. Y. Soh, personal observation), but it was found in 2019 at a new locality at HortPark where it was observed to utilise artificial nesting blocks (Soh & Soh, 2020). The species is widely distributed in Southeast Asia, with considerable geographic variation in colour pattern (Pasteels, 1972; Soh et al., 2016).

18. ***Megachile* (*Aethomegachile*) *ramera*** Cockerell, 1918a, Singapore Leafcutter

The type from Singapore was collected by Baker ca. 1917–1918. This species was only recently rediscovered in Singapore in 2012 at Dairy Farm Nature Park (Soh & Ngiam, 2013). It was also observed visiting *Grammophylum speciosum* at Zhenghua Park in 2014 (Ascher et al., 2016b) and nesting at Thomson Nature Park in 2020 (Soh et al., 2021b). We have identified a specimen from Pahang in the University of Malaya collection (access provided by Professor John-James Wilson), which is a new record for Malaysia.

19. ***Megachile* (*Callomegachile*) *indonesica*** (Engel & Schwarz, 2011), Indonesian Resin Bee

This forest-associated species was found from 2014 to 2015 in association with the bloom of tiger orchids at sites in or near to high quality forest, such as at Bukit Timah and Dairy Farm. Subsequently, it was recorded once by photography, visiting ornamental *Duranta erecta* at Upper Peirce Reservoir Park within the Central Catchment Nature Reserve in 2017, and visiting *Teijsmanniodendron pteropodum* in the Singapore Botanic Gardens in 2020.

20. ***Megachile* (*Callomegachile*) *ornata*** Smith, 1853, Ornate Resin Bee

This species was only recorded in 2014 during a mass blooming period, when many large-bodied *Megachile* were observed by ZWWS and colleagues to visit tiger orchids (Ascher et al., 2016b, 2019). Females of these species were collected once at Zhenghua Park and observed visually at Bukit Timah Nature Reserve visitor centre in 2014 at tiger orchids (*Gramamtophyllum speciosum*) planted on the ground.

21. ***Nomada malayana*** Cameron, 1909, Malay Nomad

This species was described from Kuching in Borneo and newly identified from Singapore based on specimens collected from Bukit Timah in 1976 and a remnant forest patch from Sentosa in 2014 (Ascher et al., 2019).

22. ***Ceratina* (*Lioceratina*) *ridleyi*** Cockerell, 1910, Ridley's Small Carpenter

The type from Singapore was collected by Ridley ca. 1895. Recent records (e.g., 2012) are from shaded understorey of MacRitchie Forest, Nee Soon Swamp Forest, and Bukit Timah Nature Reserve.

23. ***Ceratina* (*Xanthoceratina*) *fuliginosa*** Cockerell, 1916, Dusky-winged Small Carpenter

This species was recorded only from 2011 to 2014 and again in 2021 from forest sites, including Dairy Farm and the vicinity of Upper Peirce Reservoir. Available records are few and suggest habitat restriction to mature forests.

24. ***Amegilla* (*Glossamegilla*) *insularis*** (Smith, 1857), Island Forest-Digger

This bee is forest-associated, with scattered specimen and image records available from forested sites such as Bukit Timah, Dairy Farm, Bukit Batok, Lower Peirce, and Upper Seletar. It is also known from Sungei Buloh Wetland Reserve. Most records involve single individuals, suggesting a low population size. This species is the only plausible local host of *Thyreus abdominalis rostratus* (Friese, 1905), classified above as EN.

25. ***Lepidotrigona terminata*** (Smith, 1878), Gold-margined Stingless Bee

This species is best known in Singapore from Pulau Ubin, where it was first recorded in 2015 and subsequently found regularly visiting *Nypa fruticans* at Chek Jawa Reserve. Verified localities are few, but it has recently been found on Pulau Ubin outside Chek Jawa and on Pulau Tekong. A recent (2018) mainland occurrence in Sembawang in northern Singapore is from a transplanted nest rather than a natural population.

Near Threatened.

26. ***Lasioglossum* (*Ctenonomia*) *halictoides*** (Smith, 1858), Beach Combed-Sweat Bee

In Singapore this species is restricted to coastal areas including sandy beaches and coastal scrub, especially where its preferred host plant *Ipomoea pes-caprae* occurs.

27. ***Nomia* (*Maculonomia*) *fuscipennis*** Smith, 1875, Dusky-winged Forest-Nomia

This species was found only in forest and mangrove sites, such as MacRitchie, Dairy Farm, Zhenghua Nature Park, Bukit Timah Nature Reserve, and Sungei Buloh Wetland Reserve. Although restricted to more forested areas, numerous photographic records (29) on iNaturalist (2021) demonstrate persistence in relatively large numbers.

28. ***Megachile* (*Callomegachile* s.l.) *tuberculata*** Smith, 1857, Tuberculate Resin Bee

This large-bodied species is known from a limited number of records from forest sites such as Bukit Timah, Dairy Farm, and Nee Soon Swamp Forest (Ascher et al., 2016b), but has recently been found in a community garden outside but near to forest (Soh et al., 2017) and at HortPark, a semi-urban park near secondary forest, in 2020. Thus, the large-sized *M. tuberculata* is evidently able to disperse to floral resources located a considerable distance from forest sites.

29. ***Homotrigona* (*Tetrigona*) *apicalis*** (Smith, 1857), Milky-tipped Stingless Bee

Modern records of this species were from sites at or near to remnant dipterocarp forests, including Bukit Timah and Dairy Farm, and also Singapore Botanic Gardens. Like many stingless bees, it relies on large, mature trees with cavities for nesting sites. A relatively large number of observations (30) on iNaturalist (2021) suggest that conspicuous stingless bees, when present, can be effectively monitored by the public.

30. ***Tetragonula* (*Tetragonula*) *geissleri*** (Cockerell, 1918a), Geissler's Stingless Bee

Most recent records of this species were from forests in the central parts of Singapore including Bukit Timah, Dairy Farm, and Nee Soon, but it was also recorded from Singapore Botanic Gardens and acknowledged to be scarce. It was recorded in 1922 at Mandai (Schwarz, 1939), and has been noted to nest in termite mounds (Soh, 2018). A recent report on the bees of Cambodia (Ascher et al., 2016a reported this species from Cambodia, but when restudied it proved to be misidentified. We now suspect that this and all other reports of *T. geissleri* from far outside the Sundaic Region pertain instead to *T. hirashimai* (Sakagami, 1978) or to additional cryptic forms.

31. ***Tetragonula* (*Tetragonula*) *laeviceps*** (Smith, 1857) Smooth-headed Stingless Bee

All available records of this species in Singapore were from central forest areas, such as Bukit Timah, Dairy Farm, and Nee Soon. This species has a complicated taxonomic history that will be treated in detail elsewhere. To summarise concisely, we conclude that the small *Tetragonula* discovered by Wallace in Singapore and described as *Trigona laeviceps* Smith, 1857 (see Rasmussen & Michener, 2010), was redescribed as new, from Peninsular Thailand, as *Trigona* (*Tetragonula*) *pagdeniformis* Sakagami, 1978 (new synonymy). Sakagami (1978) applied the name *T. laeviceps* to a different, slightly larger bee species with weaker thorax hair bands and a redder metasoma. This larger bee corresponds, with respect to Singaporean material, to *Tetragonula valdezi* (the most common stingless bee in Singapore; material from elsewhere is composite, including additional species in this complex). We concur with a note on the identity and neotype of the very similar *Tetragonula laeviceps* (Rasmussen & Michener, 2010) that the name *T. laeviceps* applies to a smaller "form" (actually a separate species) of *T. laeviceps* auct. as opposed to the larger "form" (i.e., *T. valdezi*) but we do not think their lectotype designation was warranted because in our view minor discrepancies noted between Smith's (1857) description and putative type material in the Oxford University Museum of Natural History collection (see Baker, 1993) do not definitively refute its authenticity. Imprecisions are to be expected in historical descriptions from this era, when the first extensive documentation of "exotic" bees were initiated (Baker, 1996). In general, we concur with a recent classification of *Tetragonula* by Engel et al. (2017), but we regard *T. pagdeniformis* as a synonym of *T. laeviceps*. In addition, we recognise *T. valdezi*, described from Singapore and widespread in Malaysia, as provisionally distinct from the very similar but darker-tailed (i.e., less red) *T. testaceitarsis* (Cameron, 1901) described from Pattani in southern Thailand. The latter seems to be a geographic replacement in the continental (monsoonal) Southeast Asia to the north of Sundaland. Further integrative taxonomic studies are needed. A recent paper on the bees of Bukit Timah (Ascher et al., 2019) continued to employ the taxonomy of Sakagami (1978), so *Tetragonula* (*Tetragonula*) *laeviceps* (Smith) as reported there corresponds to *T. valdezi* as presently understood, whereas *T.* (*T.*) *pagdeniformis* (Sakagami) reported therein corresponds to true *T. laeviceps* of Wallace (and sensu Rasmussen & Michener, 2010; Engel et al., 2017, in part; but not Sakagami, 1978) as recognised here.

Data Deficient.

32. ***Eupetersia* (*Nesoeupetersia*) *malayensis*** (Blüthgen, 1927), Malay Smooth-Blood Bee (new combination)

The type specimen of *Sphecodes malayensis* Blüthgen in the NHMUK proves to be a *Eupetersia* and is similar to the recently described *Eupetersia* (*Nesoeupetersia*) *singaporensis* Pauly, 2012, and *E.* (*N.*) *sabahensis* Pauly, 2012. Diagnostic characters separating Pauly's two species such as "darker legs and larger head" of *E. singaporensis* were not compelling, especially in light of variability in colour, size, and shape observed in newly studied Singaporean material. For now, we treat these as provisional junior synonyms of *E. malayensis* pending taxonomic revision of this group. Few Asian *Eupetersia* have been collected by net, but these parasites appear regularly in malaise trap samples from Singapore's mangroves.

33. ***Ceylalictus* (*Ceylalictus*) *communis*** (Blüthgen, 1934), Kuala Lumpur Steppe Bee

This tiny species has been sporadically recorded from 2015 to 2021. We recently discovered it nesting in manmade fitness areas containing beach sand in semi-urban parks in Katong and at Kent Ridge, and it is likely to also utilise natural sandy shores for nesting. Targeted surveys in coastal habitats across Singapore may clarify its pollen hosts, natural nesting sites, and status.

34. ***Megachile* (*Aethomegachile*) *borneana*** Cameron, 1903, Bornean Leafcutter

This species was recorded from 2012 onwards in forest sites around the CCNR and BTNR (e.g., Dairy Farm) but also from the forest fragment at Kent Ridge Park (Ascher et al., 2016b). The female has not been detected in Singapore.

35. ***Megachile* (*Carinula*) *butteli*** Friese, 1918, Buttel-Reepen's Resin Bee

This species has only been recorded for Singapore twice. The first record, a male visiting *Cratoxylum cochinchinense* at Upper Peirce Reservoir Park in 2012, was provisionally listed as *Megachile* (*Callomegachile*) sp. 1 (nr. *stulta*) in Ascher et al. (2016b). In 2021, the more distinctive female was discovered at the Sungei Buloh Wetland Reserve, allowing confirmation of its specific identity (Soh et al., 2021a). It is listed as *Megachile* (*Carinula*) sp. aff. *butteli* in the Guide to the Bees of Singapore (Soh & Ascher, 2020). Subgeneric status of this group of resin bees is discussed by Chattanabun et al. (2020).

36. ***Megachile* (*Chelostomoda*) *moera*** Cameron, 1902, Orange-thighed Leafcutter

This species was recorded in Singapore from only three collection events: at Pasir Ris Park in 2012, where it was found nesting in a wooden garden stake, at Admiralty Park visiting *Cratoxylum cochinchinense* in 2015 (Ascher et al., 2016b), and nesting in a log at Sungei Buloh Wetland Reserve in 2021.

37. ***Xylocopa* (*Biluna*) *iridipennis*** Lepeletier, 1841, Purple-winged Bamboo-Carpenter

This species was recorded in the Singapore Red Data Book (Murphy et al., 2008; as *Biluna auripennis*) as DD and cited as the "Parasitic Carpenter Bee" even though this and all other Xylocopini are non-parasitic pollen collectors. It was said to have been seen "once from central catchment forest in Singapore" yet its survival was said to depend "entirely on the integrity and condition of the Bukit Timah forest". This bee has at least one additional historical record from Singapore (Dover, 1929) and has recently been found at Kent Ridge, One-North Park, the Singapore Botanic Gardens' Eco Garden, and far outside the central forest at Pulau Ubin. This species nests not in primary dipterocarp forest but rather in bamboo patches. Species of *Biluna* occupy bamboo internodes for nesting, entering from a hole they make with their mandibles (Hongjamrassip & Warrit, 2014). Targeted searches at and adjacent to the more extensive bamboo patches in Singapore would clarify its status. *Xylocopa iridipennis* has been treated by most recent authors as a subspecies of *Xylocopa auripennis*, but considerable DNA sequence divergence between these forms (Blaimer et al., 2018) suggests that these are specifically distinct.

38. ***Ceratina* (*Xanthoceratina*) *metaria*** Cockerell, 1920a, Bounded Small Carpenter

This small, forest-associated species has been found in forested areas, where it is known from Upper Peirce Reservoir Park, and from Pulau Ubin. It is likely to be overlooked due to its small size.

39. ***Lepidotrigona latipes*** (Friese, 1900) Broad-legged Stingless Bee

Both the taxonomic status and the type locality of this species have been controversial, with some authors treating it as a synonym or potential subspecies of *L. nitidiventris* (Smith, 1857) (Schwarz, 1937, 1939; Sakagami, 1975; Rasmusen, 2008). Attasopa et al. (2020) studied type material and concluded that *L. latipes* and also *L. trochanterica* (Cockerell, 1920c) from Sandakan, Borneo, belonged to the *L. nitidiventris* group but that they, "clearly differ from each other as well as from *L. nitidiventris* as stated in the diagnosis of the latter species". However, the diagnosis in question only notes differences in colour (of terga, tegulae, and vertex hairs) separating these forms and does not account for potential geographic variation within this complex. There are many remaining uncertainties about species delimitation in *Lepidotrigona* (see Sakagami, 1975), and in the absence of revisionary study of extensive material, the true status of *L. latipes* remains in doubt. Furthermore, the type locality of *L. latipes* has been a source of confusion as it is cited as "Malacca (Singapore)" in the description whereas the type label cites "India/ Singapore". Bees in this group are known from Southeast Asia, not India, so the latter is not a plausible locality, but it is not clear if the bee was from Singapore or from Malacca (=Melaka) state (or city) in southern Peninsular Malaysia. Attasopa et al. (2020) interpreted Singapore as pertaining to "the broader geographic-political designation of the locality in Friese's time, not the collecting site" without further justifying this. We are not familiar with a broad usage for Singapore, whereas Malacca remains the name of the straits separating Singapore from Sumatra (in addition to the city and state of that name) so in our view this (as opposed to Singapore) is a more plausible name for a general region. We therefore conclude that Singapore (not Malacca) is the most plausible precise type locality for this enigmatic bee. Nonetheless, the absence of collections subsequent to 1890 when the type material was collected leads to some remaining doubt as to the provenance of the specimens. For the moment we treat this as a valid taxon with DD status in Singapore (with both taxonomic status and provenance as sources of uncertainty). However, it may be a genuine and distinct member of the historical fauna now nationally extinct. We have not seen this bee at PBS, but further studies in Peninsular Malaysia may shed light on the identity and status of the nearest historical and extant populations of *Lepidotrigona* belonging to the *nitidiventris* group.

Non-Native.

40. ***Apis* (*Micrapis*) *florea*** Fabricius, 1787, Red Dwarf Honey Bee

Apis florea was detected for the first time in Singapore in 2011 by JSA along West Coast Highway; there are no genuine historical records of true *Apis florea* from Singapore or from southern Peninsular Malaysia, only confusion with the similar *A. andreniformis* (Otis, 1996; Oldroyd & Wongsiri, 2006; Hepburn & Radloff, 2011; Silva et al., 2019). While *Apis florea* is very widespread and numerous in Thailand, the species' range extends little if any further south than the Kra Isthmus in Southeast Asia, excepting populations reported

long ago from Jakarta Harbour on Java that are believed to have been accidentally introduced by ship (Hepburn & Radloff, 2011; Silva et al., 2019). Recently, *Apis florea* has been detected widely in Peninsular Malaysia including in Johor, Selangor, and Penang, indicating ongoing wide establishment across the now-deforested Malay Peninsula rather than an isolated point introduction to Singapore alone. The distribution and niche properties of this species across its range were modelled by Silva et al. (2019). A subsequent image posted to iNaturalist (2021; observations/62470663) from Kupang City, East Nusa Tenggara, Indonesia is a major range extension and first record for the island of Timor demonstrating ongoing spread to new areas in the region.

41. ***Tetragonula* (*Tetragonula*) *pagdeni*** (Schwarz, 1939), Pagden's Stingless Bee

This species is known in Singapore from a single nest found in an ornamental tree at Gardens by the Bay in 2016. It is well known in Thailand but not from the Sundaic region (Sakagami, 1978; Rasmussen, 2008). Both the origins of this nest and establishment of the species in Singapore are unclear, but it may represent an anthropogenic introduction, as has been documented at this site for an anole (Tan & Lim, 2012).

DISCUSSION

The 133 bee species and morphospecies recorded from Singapore includes 40 species newly discovered for the country from 2011 onwards during bee-focused studies by modern researchers employing an array of specialised methods such as trap nests and malaise trapping. The current total for Singapore is rather high for Southeast Asia, a region for which such comprehensive checklists are generally lacking, but considerably below totals reported for temperate cities (e.g., 266 for New York City, JSA unpublished; updated from the 219 species reported by Matteson et al., 2008). Lower species richness of bees in the humid tropics as compared to temperate regions is consistent with global patterns of bee distribution (Orr et al., 2021) and is thus likely genuine as opposed to merely a reflection of sampling or taxonomic effort.

Although the current inventory for Singapore is surely one of the most complete available for Asia or for the tropics more generally, discoveries of additional species can be expected when targeted field surveys are combined with concurrent advances in the integrative taxonomy and systematics of the Asian bee fauna (Orr et al., 2020). Both morphologically distinct and cryptic species of solitary and cleptoparasitic bee species continue to be discovered in the city-state and several await formal description. Remnant primary dipterocarp forests, such as Bukit Timah Nature Reserve, should be surveyed at the canopy level, especially during general flowering, as the existing data from such sites have mostly been limited to surveys at ground level where floral resources are sparse (Ascher et al., 2019). Other habitats such as mangroves have been shown to be hotspots of insect diversity in Singapore (Yeo et al., 2021), but have yet to be sampled thoroughly for bees. Malaise trap samples from these areas have yielded previously overlooked bees and large numbers of individuals of certain "rare" species rarely if ever found in netting surveys. With additional targeted sampling and enhanced contributions from citizen scientists, we also expect to be able to better assess species treated here as Data Deficient. Community science records are also important in monitoring the better known species, and have contributed to the documentation of 80 species from 2020 to 2021, with limited specimen-collecting during this period due to the pandemic response.

Reports of insect declines worldwide, particularly of wild bees, have led to concerns about the loss of key ecosystem functions and services, such as pollination (Sánchez-Bayo & Wyckhuys, 2019). However, interpreting insect declines is inherently difficult (Didham et al., 2020), and few extensive and reliable status assessments have been available for Asian bees, with almost none for the Southeast Asian fauna. Through this comprehensive comparison of historical and recently obtained records, we assess 12 species (9% of the bee species in Singapore) as Nationally Extinct or as Critically Endangered, providing evidence of species loss from a tropical Asian city. These numbers are in line with other recent insect studies in Singapore: Jain et al. (2018) found 30% of butterflies to be nationally extirpated while Ngiam & Cheong (2016) reported 23% of Odonata to be Nationally Extinct or Critically Endangered. These levels of national extinction are likely a result of major loss of forest habitats beginning in the 19th century followed by rapid urbanisation in the 20th century (Corlett, 1992). It is also critical to note that a large proportion of the stingless bees (tribe Meliponini) are Nationally Extinct or Critically Endangered, highlighting the conservation concerns associated with these forest-associated highly eusocial bees which have poor dispersal ability and are particularly sensitive to inbreeding (Mueller et al., 2012). Loss of stingless bees are of particular concern as they are key generalist pollinators present year-round in tropical forests (Momose et al., 1998; Nagamitsu et al., 1999; Corlett et al., 2004) and produce honey and hive products of cultural and economic value (Souza et al., 2006). Considering the bee fauna as a whole, our findings emphasise the need to conserve remaining natural habitat sites, including not only remnant dipterocarp forests, but also mangroves and associated coastal habitats in Singapore. Urban and residential gardens also provide key habitats for bees, including scarce local species, showing that the conservation value of urban landscapes for pollinators (Hall et al., 2017) extends to tropical Asia.

We also document novel faunal turnover, with forest-restricted species disappearing or decreasing, and non-forest species appearing or increasing. Despite the loss of native bee pollinators, Singapore still boasts at least 79 urban-tolerant species (i.e., those detected in urban or semi-urban areas). These are available as pollinators of edible crops in urban gardens and potentially also rooftop farms (Teh & Seow, 2019). Arrival in Singapore of some recently detected non-forest species may have been facilitated by anthropogenic activities such as regional forest clearance or long-distance

transport of bees and their nests in articles of trade (Silva et al., 2019). Further research is needed to determine how these recently arrived exotic bee species are affecting pollination networks and competing with native species.

To further improve conservation management of bees in Singapore, nesting and floral association records should be studied to identify and promote resources important for bees of conservation interest (e.g., Soh et al., 2019; Yong et al., 2019). Based on this information, we can preserve existing vegetation, including flowers that might be perceived as weeds or otherwise be at risk for removal. Targeted native plantings, such as that of *Premna serratifolia*, *Pluchea indica*, and *Dendrolobium umbellatum* (Soh et al., 2019), can be made at restoration sites of key bee resources to enhance existing populations and extend species to new areas. Care should also be taken to safeguard and enhance known or potential nest sites in the vicinity of these floral hosts. Ongoing monitoring of the bees in Singapore is required to inform management of Singapore's bee pollinators, and further inventorying is needed to document the several species new to science, revise several poorly known genera, and improve this first conservation assessment. Future research now being planned by the IUCN Wild Bee Specialist Group for Asia can build upon this first country-level assessment and provide a framework for regional red-listing, coordinated outreach, policy review, and conservation action.

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APPENDIX

List of Singapore bees and their national conservation status

Appendix Table 1. Status pertains to conservation status: Nationally Extinct (NE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concerned (LC), Data Deficient (DD), and Non-Native (NN). Site and habitat information pertain to recent records from 1977 to 2020, while those in parentheses are historical site records (prior to 1977). For habitat type, the following abbreviations apply: Forest reserve (FR), Forest fragment (FF), Mangrove (MG), Coastal Scrub (CS), Island (IS), Semi-urban (SU), Urban (UR). For sociality, the following abbreviations apply: Parasitic (P), Solitary (S), Subsocial (SS), Primitively eusocial (PE), Eusocial (Advanced) (E). All information is based on and pertains to specimens collected in Singapore. Parasitic species are mostly cleptoparasitic but *Braunsapis breviceps* and potentially some *Sphecodes* and *Eupetersia* are socially parasitic. Solitary as indicated here includes many halictid species, including nomiines, that may be communal rather than strictly solitary. Common names coined by the authors to promote public interest in bees were first published in a field guide (Soh & Ascher, 2020) and are also in use at iNaturalist. These are intended to be globally unique and hence employ some complex group names; in some instances, simplified versions may be preferred for use within Singapore. Species are ordered by family and subfamily. Genus and species are subsequently ordered alphabetically within the least inclusive group (tribe or, if tribe is not known, sub family).

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
	Colletidae														
	Hylaeinae														
1	*Hylaeus* (*Gephryrohylaeus*) *sandacanensis*	Sandakan Masked Bee	DD	29	2013	2015	1							1	S
2	*Hylaeus* (*Indialaeus*) sp. 1 cf. *strenuus***	–	DD	1	2017	2017	1							1	S
3	*Hylaeus* (*Indialaeus*) sp. 2**	–	DD	2	1978	2015	2					2			S
4	*Hylaeus* (*Nesoprosopis*) *penangensis*	Penang Masked Bee	LC	211	1976	2021	13		1	1		1	6	4	S
5	*Hylaeus* (*Nesoprosopis*) sp. 1 cf. *transversalis*	–	DD	13	2014	2019	3	1		1				1	S
6	*Hylaeus* (*Nesoprosopis*) sp. 2**	–	DD	5	1977	2014	1			1					S
7	*Hylaeus* (*Nesoprosopis*) sp. 3	–	DD	6	2015	2021	5	1		1			2	1	S
8	*Hylaeus* (*Nesoprosopis*) sp. 4**	–	DD	1	2016	2016	1					1			S
9	*Hylaeus* (new *subgenus* nr. *Prosopisteron*) sp. 1 aff. *jacobsoni***	Singapore Blue Masked Bee	DD	3	2013	2016	2					2			S
	Halictidae														
	Nomiinae														
	Nomiini														
10	*Lipotriches* (*Austronomia*) *goniognatha*	Angle-jawed Austral-Nomia	DD	2	1918	2009	1			1					S
11	*Lipotriches* (*Austronomia*) *takauensis*	Takau Austral-Nomia	VU	30	1918	2019	5	3	1			1			S
12	*Lipotriches* (*Rhopalomelissa*) *ceratina*	Red-waisted Grass-Nomia	LC	85	1854	2021	22	6	3	2		1	5	5	S
13	*Lipotriches* (*Rhopalomelissa*) *minutula*	Minute Grass-Nomia	DD	1	[ca. 1960s]	[ca. 1960s]	(1)	(1)							S
14	*Nomia* (*Acunomia*) *iridescens*	Iridescent Nomia	LC*	43	1918	2021	12	6	2	1			2	1	S
15	*Nomia* (*Acunomia*) *lusoria*	Mangrove Nomia	VU	16	2012	2021	3			3					S
16	*Nomia* (*Acunomia*) sp. 1 aff. *lusoria***	–	DD	1	2013	2013	1			1					S
17	*Nomia* (*Acunomia*) *strigata*	Striped Nomia	LC	471	1910	2021	41	8	8	3	1	6	7	8	S

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
18	*Nomia* (*Gnathonomia*) *thoracica*	Felt-topped Nomia	LC*	11	1975	2021	6		2	2			2		S
19	*Nomia* (*Hoplonomia*) *incerta*	Black-waisted Pronged-Nomia	LC	142	1980	2021	34	4	4	2		3	14	7	S
20	*Nomia* (*Maculonomia*) *apicalis*	Black-tipped Forest-Nomia	CR	3	1854	1976	(1)	(1)							S
21	*Nomia* (*Maculonomia*) *elegans*	Elegant Forest-Nomia	NE	1	1911	1911	(1)	(1)							S
22	*Nomia* (*Maculonomia*) *fuscipennis*	Dusky-winged Forest-Nomia	NT	67	1947	2021	8	6	1	1					S
23	*Nomia* (*Maculonomia*) sp. 1 aff. *apicalis*	Spine-thighed Forest-Nomia	NT	32	2008	2021	17	4	5	1		1	4	2	S
24	*Pseudapis* (*Pseudapis*) *siamensis*	Siamese Epaulette-Nomia	LC	75	2009	2021	17	1	1	3		4	6	2	S
	Halictinae														
	Nomioidini														
25	*Ceylalictus* (*Ceylalictus*) *communis*	Kuala Lumpur Steppe Bee	DD	19	2015	2021	3		1				2		S
26	*Ceylalictus* (*Ceylalictus*) *malayensis*	Malay Steppe Bee	DD	2	2013	2013	1					1			S
	Halictini														
27	*Eupetersia* (*Nesoeupetersia*) *malayensis***	Malay Smooth-Blood Bee	DD	1	2009	2016	2			1		1			P
28	*Eupetersia (Nesoeupetersia*) *yanegai*	Yanega's Smooth-Blood Bee	DD	4	2012	2014	1								P
29	*Lasioglossum* (*Ctenonomia*) *albescens*	White Combed-Sweat Bee	LC	31	2012	2021	7	1	1	3		1	1		S or PE
30	*Lasioglossum* (*Ctenonomia*) *deliense*	Orange-legged Combed-Sweat Bee	LC	72	1976	2021	21	4	1	1		2	9	4	S or PE
31	*Lasioglossum* (*Ctenonomia*) *halictoides*	Beach Combed-Sweat Bee	NT	41	2013	2021	6				1	5			S or PE
32	*Lasioglossum* (*Ctenonomia*) *semirussatum*	Singapore Combed-Sweat Bee	CR	2	1918	1976	(1)	(1)							S or PE
33	*Lasioglossum* (*Ctenonomia*) *vagans*	Wandering Combed-Sweat Bee	LC	93	1972	2021	22	3	3	2		1	8	5	S or PE
34	*Lasioglossum* (*Ctenonomia*) sp. 1 [*vagans* species group]	Tan-haired Combed-Sweat Bee	LC	54	1976	2021	16	4	2	1	1	2	4	2	S or PE

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
35	*Lasioglossum* (*Ctenonomia*) sp. 2**	–	DD	18	1976	2017	3					3			S or PE
36	*Lasioglossum* (*Ctenonomia*) sp. 3 [*vagans* species group]**	–	DD	19	2013	2019	6			2		3		1	S or PE
37	*Lasioglossum* (*Homalictus*) *adonidiae*	Palm Plume-vented Bee	LC	129	1975	2021	11	1	1			5	1	3	S or PE
38	*Lasioglossum* (*Homalictus*) *latitarse*	Broad-footed Plume-vented Bee	DD	2	1978	2016	1					1			S or PE
39	*Lasioglossum* (*Homalictus*) *singapurellum*	Singapore Plume-vented Bee	LC	34	1918	2021	9	1	1			4		3	S or PE
40	*Patellapis* (*Pachyhalictus*) *intricata*	Vachal's Reticulate-Furrow Bee	CR	3	1975	1976	(2)	(2)							S or PE
41	*Patellapis* (*Pachyhalictus*) *murbanus*	Sunda Reticulate-Furrow Bee	LC	81	1918	2021	14	4	2			2	3	3	S or PE
42	*Sphecodes duplex*	Singapore Blood Bee	DD	3	1898	2015	2	1				1			P
43	*Sphecodes* sp. 2**	–	DD	1	2014	2014	1						1		P
44	*Sphecodes* sp. 3 cf. *redivivus***	–	DD	1	2014	2014	1							1	P
45	*Sphecodes* sp. 4**	–	DD	1	1976	1976	(1)					(1)			P
46	*Sphecodes* sp. 5 cf. *javanicus***	–	DD	1	2016	2016	1					1			P
47	*Sphecodes* sp. 6**	–	DD	5	2017	2017	1					1			P
	Megachilidae														
	Lithurginae														
	Lithurgini														
48	*Lithurgus* sp. 1†	Lesser Woodborer	LC	19	1976	2021	10			1		2	4	3	S
49	*Lithurgus* sp. 2 cf. *collaris*†	Greater Woodborer	DD	10	1974	2021	7			1		4		2	S
	Megachilinae														
	Anthidiini														
50	*Anthidiellum* (*Pycanthidiellum*) *smithii smithii*	Smith's Rotund-Resin Bee	VU	8	2014	2020	3	2					1		S
51	*Euaspis polynesia*	Asian Chilli-tail‡	LC	13	1968	2021	11	1				1	5	4	P

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
52	*Euaspis* n. sp. 1	–	DD	2	2013	2015	1		1						P
	Osmiini														
53	*Heriades* (*Michenerella*) *othonis*	Indomalayan Armoured-Resin Bee	LC	80	1970	2021	16	4	2	2		1	5	2	S
	Megachilini														
54	*Coelioxys* (*Allocoelioxys*) *angulatus***	Angulate Sharptail	DD	12	1975	2019	(2)	(1)						(1)	P
55	*Coelioxys* (*Allocoelioxys*) sp. 2	–	DD	1	2015	2015	1							1	P
56	*Coelioxys* (*Allocoelioxys*) sp. 3**	–	DD	2	2018	2021	3					1	1		P
57	*Coelioxys* (*Callosarissa*) *confusus*	Confusing Sharptail	LC	127	1970	2021	18	3	3	1		3	5	3	P
58	*Coelioxys* (*Torridapis*) n. sp.	–	DD	2	2015	2015	1		1						P
59	*Megachile* (*Aethomegachile*) *borneana*	Bornean Leafcutter	DD	5	2012	2021	3	2	1						S
60	*Megachile* (*Aethomegachile*) *conjuncta*	Dimorphic Leafcutter	LC	25	1854	2021	17	1	2	3		1	5	5	S
61	*Megachile* (*Aethomegachile*) *laticeps*	Broad-headed Leafcutter	LC	196	1917	2021	34	7	4	2	1	2	10	8	S
62	*Megachile* (*Aethomegachile*) *ramera*	Singapore Leafcutter	VU	5	1917	2021	2	2							S
63	*Megachile* (*Aethomegachile*) sp. 1 nr. *borneana*	Bright-legged Leafcutter	DD	5	2012	2015	3	2	1						S
64	*Megachile* (*Aethomegachile*) sp. 2 [*fusciventris* species group]	White-gloved Leafcutter	VU	19	1918	2021	4	3	1						S
65	*Megachile* (*Paracellav tricincta*	Golden-bellied Leafcutter	LC	47	1976	2021	7	2				2	2	1	S
66	*Megachile* (*Callomegachile*) *disjuncta*	Disjunct Resin Bee	NN	291	2010	2021	32	3	5	1		3	11	9	S
67	*Megachile* (*Callomegachile*) *fulvipennis*	Orange-winged Resin Bee	LC	92	1976	2021	19	6	2			3	5	3	S
68	*Megachile* (*Callomegachile*) *indonesica*	Indonesian Resin Bee	VU	41	2014	2020	5	4	1						S
69	*Megachile* (*Callomegachile*) *umbripennis*	Shadow-winged Resin Bee	NN	342	1974	2021	32	3	5	2			11	11	S
70	*Megachile* (*Callomegachile*) sp. 1 [*biroi* species group]	Yellow-bellied Resin Bee	NT	20	2014	2021	6	4					1	1	S
71	*Megachile* (*Callomegachile* s.l.) *ornata*	Ornate Resin Bee	VU	2	2014	2014	2	2							S

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
72	*Megachile* (*Callomegachile* s.l.) *tuberculata*	Tuberculate Resin Bee	NT	11	1961	2020	6	5					1		S
73	*Megachile* (*Carinula*) *stulta*	Fiery Resin Bee	LC*	65	2012	2019	7	4	1				1	1	S
74	*Megachile* (*Carinula*) *butteli*	Buttel-Reepen's Resin Bee	DD	2	2012	2021	2	1		1					S
75	*Megachile* (*Chelostomoda*) *moera*	Orange-thighed Leafcutter	DD	5	2012	2021	3			2			1		S
76	*Megachile* (*Creightonella*) *atrata*	Orange-winged Leafcutter	LC	61	1976	2018	14	1	1	1		4	4	3	S
77	*Megachile* (*Eutricharaea*) *subrixator*	Orange-bellied Leafcutter	LC	155	1915	2021	30	4	4	2		4	10	6	S
78	*Megachile* (*Eutricharaea*) sp. 1	White-dusted Leafcutter	LC	65	1986	2021	16			1		2	8	5	S
	Apidae														
	Xylocopinae														
	Xylocopini														
79	*Xylocopa* (*Biluna*) [*auripennis*] *iridipennis*	Purple-winged Bamboo-Carpenter	DD	11	1929	2020	4		1			1	1	1	SS
80	*Xylocopa* (*Cyaneoderes*) *caerulea*[#]	Cerulean Carpenter	LC*	53	1854	2021	12	6	2					4	SS
81	*Xylocopa* (*Cyaneoderes*) *insularis*[#]	Blue-sided Carpenter	DD	4	1898	2021	2		1				1		SS
82	*Xylocopa* (*Maiella*) *aestuans*[#]	White-cheeked Carpenter	LC	448	1854	2021	60	6	5	2		4	20	23	SS
83	*Xylocopa* (*Maiella*) *flavonigrescens*[#]	Yellow-and-black Carpenter	LC	132	1972	2021	41	7	5	2		5	11	11	SS
84	*Xylocopa* (*Nyctomelitta*) *myops*	Sunda Night-Carpenter	DD	13	1901	2020	5	3						2	SS
85	*Xylocopa* (*Platynopoda*) *latipes*	Broad-handed Carpenter	LC	314	1854	2021	66	7	7	2	1	7	14	28	SS
86	*Xylocopa* (*Zonohirsuta*) *dejeanii penangensis*	Collared Carpenter	EN	3	1929	2014	1	1							SS
	Ceratinini														
87	*Ceratina* (*Catoceratina*) *perforatrix pyramidalis*	Plume-vented Small Carpenter	LC	52	1918	2021	19	2	3	2			8	4	SS
88	*Ceratina* (*Ceratinidia*) *accusator*	Short-nosed Small Carpenter	LC*	44	1962	2021	8	2	1			4		1	SS

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
89	*Ceratina* (*Ceratinidia*) *cognata*	Black-topped Small Carpenter	DD	12	1967	2020	5		1			1	1	1	SS
90	*Ceratina* (*Ceratinidia*) *collusor*	Companion Small Carpenter	LC	213	1918	2021	24	6	5	3		2	5	3	SS
91	*Ceratina* (*Ceratinidia*) *lieftincki*	Lieftinck's Small Carpenter	LC	179	1962	2021	26	5	2	2		3	10	4	SS
92	*Ceratina* (*Ceratinidia*) *nigrolateralis incerta*	Black-sided Small Carpenter	LC	190	1917	2021	30	7	5	3		3	8	4	SS
93	*Ceratina* (*Lioceratina*) *ridleyi*	Ridley's Small Carpenter	VU	14	1910	2019	3	3							SS
94	*Ceratina* (*Neoceratina*) *dentipes*	Tooth-legged Small Carpenter	LC	38	1972	2021	16	4	1	1		3	4	3	SS
95	*Ceratina* (*Pithitis*) *smaragdula*	Emerald Small Carpenter	LC	52	1970	2021	8	2		3		1	2		SS
96	*Ceratina* (*Pithitis*) *unimaculata palmerii*	One-spotted Small Carpenter‡	LC	74	1962	2021	14	5	1	1		1	2	4	SS
97	*Ceratina* (*Xanthoceratina*) *fuliginosa*	Dusky-winged Small carpenter	VU	12	2011	2021	3	3							SS
98	*Ceratina* (*Xanthoceratina*) *metaria*	Bounded Small Carpenter	DD	15	2012	2017	2	1				1			SS
	Allodapini														
99	*Braunsapis breviceps*	Short-headed Reed-Cuckoo	DD	2	2013	2013	2			1		1			P
100	*Braunsapis clarihirta*	Clear-haired Reed Bee	LC	58	2012	2021	12	4	2	1		2	2	1	SS
101	*Braunsapis cupulifera*¶	Cup-legged Reed Bee	LC	195	1905	2021	28	5	5	3		5	5	5	SS
102	*Braunsapis hewitti*¶	Hewitt's Reed Bee	LC	238	1962	2021	24	4	2	1		4	8	5	SS
103	*Braunsapis philippinensis*	Philippine Reed Bee	DD	3	1929	2015	2	1	1						SS
104	*Braunsapis puangensis*	Puang Reed Bee	LC	111	2013	2021	20	1	1	1		6	5	6	SS
	Nomadinae														
	Nomadini														
105	*Nomada malayana*	Malay Nomad	VU	4	1976	2014	2	(1)				1			P
106	*Nomada penangensis*	Penang Nomad	CR	5	1975	1976	(1)		(1)						P

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
107	*Nomada polyodonta*	Many-toothed Nomad	DD	1	1970	1970	(1)								P
108	*Nomada sandacana*	Sandakan Nomad	CR	1	1975	1975	(2)	(1)	(1)						P
	Apinae														
	Anthophorini														
109	*Amegilla* (*Glossamegilla*) *insularis*	Island Forest-digger	VU	17	1897	2021	6	4	1	1					S
110	*Amegilla* (*Zonamegilla*) *andrewsi*	Sunda Blue-banded Digger	LC	381	1918	2021	56	8	9	2		7	11	19	S
111	*Amegilla* (*Zonamegilla*) *korotonensis*	Koroton Blue-banded Digger	LC	76	1972	2021	19	1	1	1		2	10	4	S
	Melectini														
112	*Thyreus abdominalis rostratus*	Band-tailed Cloak-and-dagger Bee	EN	5	1901	2015	1	1							P
113	*Thyreus* [*ceylonicus*] *lilacinus*§	Black-notched Cloak-and-dagger Bee	LC	72	1902	2021	18	4	3	2		2	4	3	P
114	*Thyreus himalayensis*	Himalayan Cloak-and-dagger Bee	LC	237	1908	2021	33	5	4	2	1	3	10	8	P
115	*Thyreus novaehollandiae signatus*	Indomalayan Cloak-and-dagger Bee	NE	2	1918	1932	No site information	P							
	Apini														
116	*Apis* (*Apis*) *cerana javana*	Asian Honey Bee	LC	444	1919	2021	86	7	9	3	1	10	19	37	E
117	*Apis* (*Megapis*) *dorsata dorsata*	Giant Honey Bee	LC	221	1905	2021	52	8	4	2		5	8	25	E
118	*Apis* (*Micrapis*) *andreniformis*	Black Dwarf Honey Bee	LC	254	1919	2021	42	3	6	2		1	10	20	E
119	*Apis* (*Micrapis*) *florea***	Red Dwarf Honey Bee	NN	175	2011	2021	30	3	2	3		4	7	11	E
	Meliponini														
120	*Geniotrigona thoracica*	Long-chinned Stingless Bee	CR	19	1854	1976	(3)	(2)	(1)						E
121	*Heterotrigona* (*Heterotrigona*) *itama*	Notch-toothed Stingless Bee	LC*	112	1911	2021	12	3	1			1	1	6	E

S/N	Species	Common Name	Status	No. of Records	First Record	Most recent record	No. of sites	Habitat type							Sociality
								FR	FF	MG	CS	IS	SU	UR	
122	*Heterotrigona* (*Sundatrigona*) *moorei*	Moore's Stingless Bee	NE	2	1932	1932	No site information	E							
123	*Homotrigona* (*Homotrigona*) *fimbriata*	Bristle-faced Stingless Bee	NE	2	1854	1854	(1)								E
124	*Homotrigona* (*Lophotrigona*) *canifrons*	Woolly Stingless Bee	NE	4	1911	1911	(1)	(1)							E
125	*Homotrigona* (*Tetrigona*) *apicalis*	Milky-tipped Stingless Bee	NT	64	1907	2021	8	3	1			1		3	E
126	*Lepidotrigona latipes*[##]	Broad-legged Stingless Bee	DD	1	1890	1890	No site information	E							
127	*Lepidotrigona terminata***	Gold-margined Stingless Bee	VU	21	2015	2021	4					2	2		E
128	*Tetragonula* (*Tetragonilla*) *atripes*	Orange-and-black Stingless Bee	NE	2	1965	1965	(1)	(1)							E
129	*Tetragonula* (*Tetragonula*) *fuscobalteata*	Belted Stingless Bee	DD	22	1902	2021	2		1				1		E
130	*Tetragonula* (*Tetragonula*) *geissleri*	Geissler's Stingless Bee	NT	101	1918	2021	12	7	2					3	E
131	*Tetragonula* (*Tetragonula*) *valdezi*[▲]	Valdez's Stingless Bee	LC	816	1854	2021	37	6	6		1	6	8	10	E
132	*Tetragonula* (*Tetragonula*) *pagdeni***	Pagden's Stingless Bee	NN	3	2016	2016	2	2							E
133	*Tetragonula* (*Tetragonula*) *laeviceps*[&]	Smooth-headed Stingless Bee	NT	124	1967	2021	6	6							E

*Although LC, this species is relatively scarce or localised.

**New species record for Singapore.

[§]While officially a subspecies of *Thyreus ceylonicus*, the disjunct ranges of the nominate form vis-à-vis the other subspecies, and the quite different hair pattern and colour of the aforementioned suggest that multiple species are involved, with *T. lilacinus* being the oldest name applicable to Southeast Asian populations.

[†]At least two *Lithurgus* species occur in Singapore but more taxonomic is research is required to verify their identity and status. There is no comprehensive taxonomic revision for Asian members of this genus, and considerable size and hair colour variation can be observed among local material. More samples from Singapore and molecular diagnostics are required to confirm the delimitation of local species.

[‡]Cited as Sunda Chilli-tail by Soh & Ascher (2020), but this species occurs outside the Sundaic region, so a more general geographic descriptor is desirable.

[#]Classified in a very inclusive subgenus *Koptortosoma* by Michener (2007) but the molecular phylogeny of Blaimer et al. (2018) does not support inclusion of the Asian species along with the typical African species. For this reason, we prefer to revert to a more finely split classification, treating *Maiella* and *Cyaneoderes* as valid subgenera pending definitive resolution of genus-group classification for these taxonomically challenging carpenter bees.

[¶]Both the taxonomic revision of *Braunsapis* and preliminary DNA barcoding results from Singapore suggest that both *B. cupulifera* and *B. hewitti* may be species complexes. Both size and colour variation are evident, but neither could be readily associated with barcode clusters. Available data suggests that bees from mangrove sites may differ specifically from that of other sites in Singapore. Integrative taxonomic studies are needed before potential cryptic taxa can be delimited and named reliably, including studies of DNA and male genitalia from across the wide ranges of these species.

[##]Member of the *L. nitidiventris* species complex and often considered conspecific with *L. nitidiventris* prior to taxonomic review by Attasopa et al. (2020). It is only reliably known from the type material, and whether this was genuinely obtained from Singapore has been disputed, as noted in the species entry.

[▲]*Tetragonula valdezi* [=*laeviceps* sensu auct., in part]

[&]*Tetragonula laeviceps* [=*pagdeniformis*]