

# The Bee Genera of Eastern Canada

LAURENCE PACKER\*, JULIO A. GENARO\*\* & CORY S. SHEFFIELD\*\*\*

York University, Department of Biology, 4700 Keele St., Toronto, ON, Canada, M3J 1P3.

\*laurencepacker@yahoo.com, \*\*polimita@hotmail.com, \*\*\*corysheffield@yahoo.ca



**Abstract.** The 39 genera of bees found in Canada east of Manitoba are keyed in dichotomous format with all key features illustrated. Habitus photographs of males and females of representatives of all genera are provided. The biology of bees in general, and outlines of the biology of each genus are summarized.

## Introduction

### What are bees?

Bees are one of the most economically important groups of insects as a result of their pollination of agricultural crops (Berenbaum et al., 2006). Although the number of species currently managed for pollination in North America is comparatively small, native wild bees are thought to be responsible for quite a large proportion of the economic benefits attributed to honey bees (Buchmann and Nabhan, 1996). Sometimes, it is not only the number of visits to a flower, but also the diversity of bee species visiting (controlled for total number of insect visits) that determines crop yield (Kremen et al., 2002). Wild bees are also crucial for the pollination of most non-crop flowering plants, and thus play an even greater role in most terrestrial ecosystems (Kevan, 2001, 2003; Kevan and Imperatriz-Fonseca, 2002).

Bees are generally considered well known to the general public and thought to be easy to recognize as such. The reality of this is somewhat different, as yellowjackets and hornets (Hymenoptera: Vespidae; Vespinae), hover flies (Diptera: Syrphidae) and other flies are commonly mistaken as being bees.

Conversely, many species of bees are superficially more similar to wasps (e.g. *Hylaeus* Fig. 167 and *Nomada* Figs. 176, 177) than are the comparatively hairy and well known honey bees (Fig. 144) and bumble bees (Fig. 149). The easiest way to know that a specimen at hand is a bee is to locate branched hairs on the body. Most bees are covered in branched hairs, but the comparatively bald groups, such as *Hylaeus* and *Nomada*, will require more careful inspection to locate the few and inconspicuous branched hairs. These are generally most easily found on the propodeum or around the pronotal lobe. In Eastern Canada, any insect that is actively collecting pollen onto its hind

legs (Figs. 149, 188) or the ventral surface of the metasoma is a bee (Fig. 172).

Bees are most similar to the apooid wasps (Hymenoptera: Apoidea, families Ampulicidae, Sphecidae and Crabronidae are the ones found in Canada) from which they arose. The branched hair characteristic mentioned above will work to tell these wasps apart from bees in all cases. Other features that differentiate bees from their wasp relatives include the laterally compressed hind basitarsus of bees (which ranges from only weakly compressed, as in *Megachile*, (Fig. 102) to extremely flattened, as in *Bombus* (Fig. 4)), and the lack of strongly metallic silvery or golden facial hairs in male bees (many of the related wasps have the lower face covered in strongly reflective hairs).

### Canadian Bee Diversity

Published estimates of the number of bee species in Canada range between 520 (Krombein et al., 1979) to over 970 (Danks, 1979). Our current list for Canada has approximately 730 species confirmed in Canada (Sheffield and Packer, unpublished), about 4.5% of the world's total of approximately 16,000 described species, most of which are found in semi-arid and desertic environments (Michener, 2000). It seems likely that additional surveys and the application of genetic methods to reveal cryptic species (Packer and Taylor, 1997) will increase the number of species in Canada substantially.

Worldwide, bees are divided into nine families (Danforth et al., 2006), three of which (Stenotritidae, Dasypodidae and Meganomiidae) are not found in Canada (and of these three, only the Dasypodidae are found anywhere in North America). Of the remaining six families, the Melittidae is rarely found in eastern Canada, while the other five (Megachilidae, Apidae, Andrenidae, Halictidae, and Colletidae) are common throughout

Canada except in the far north. The number of bee species in different genera from Canada east of Manitoba is shown in Table 1. Some genera are monotypic, while others contain over 70 species; *Andrena* and *Lasioglossum* are the most speciose in our area.

The classification adopted here is that of Michener (2000), with the recent changes at the family level suggested by Danforth et al. (2006) and for the tribe Epeolini by Rightmyer (2006). The least stable aspect of the classification adopted is that of the subfamily Panurginae for which the delimitation of genera is under review (John Ascher, American Museum of Natural History, pers. comm., 2006). In the absence of published phylogenetic analyses, we have opted to follow Michener (2000) for this group, placing bees previously considered to belong to *Pseudopanurgus* (i.e., Mitchell, 1960) into the genus *Protandrena*.

Some authors (e.g. Mitchell, 1960; Krombein et al., 1979) prefer a more finely divided classification within the genus *Lasioglossum*, recognizing the subgenera *Lasioglossum*, *Evylaeus*, *Sphecodogastra* and *Dialictus* (and other extralimital taxa) at the generic level. Earlier treatments have also treated the Anthophoridae as a separate family (e.g. Krombein et al., 1979; Michener et al., 1994), but it has been shown that the corbiculate bees (honey bees, stingless bees, bumble bees and orchid bees) evolved from within the "Anthophoridae" (Roig-Alsina and Michener, 1993) and so the Apidae as currently understood includes the Anthophoridae of earlier authors.

### Bee Biology: Floral Relationships

Bees are digger wasps (Hymenoptera: Apoidea or apoid wasps) that took to a diet of pollen and nectar rather than provisioning animal prey to their offspring. Not surprisingly, bees are known to be almost as old as the flowering plants (Poinar and Danforth, 2006). Most species are mass provisioners, collecting all of the pollen and nectar required for the complete development of an offspring into a single pollen ball before the egg is laid. In such species, there is usually no contact between mother and offspring after oviposition. Bumble bees are the only indigenous bees in Canada in which progressive feeding occurs, the

larvae being provided with food by the adults throughout their growth. The only Canadian bee genus to use floral oils as a food source is *Macropis* which collects oil from *Lysimachia* (Myrsinaceae).

Some bees are specialists upon one or a few closely related species of flower. Such oligolectic species are generally restricted in their pollen hosts and collect nectar from a wider range of flowers. Examples of oligolectic species include *Lasioglossum oenotherae* (Stevens), which has scopal hairs adapted for carrying pollen of *Oenothera* (Onagraceae) (and which can be seen early in the morning visiting garden varieties such as sundrops (Knerer and MacKay, 1969)), and *Melissodes desponsa* Smith which collects pollen solely from thistles, *Cirsium* (Asteraceae). Polylecty, floral host generalization, is more common in the Canadian bee fauna. Individuals of species such as *Halictus ligatus* Say will collect pollen from more than one family of flowering plant on a single foraging trip.

Cleptoparasitic bees do not collect pollen themselves, but instead lay their eggs on or near the food provisions in the nests of other bees. Cleptoparasitism has arisen independently many times among the bees (Rozen, 2000). The genera which are cleptoparasitic, or include cleptoparasitic species, are shown in Table 1.

### Bee Biology: Nests

Most bees nest in the ground, excavating tunnels and constructing brood cells to the side of the tunnel or at the end of a blind burrow. Many ground-nesting bees choose specific soil types for nesting. Sandy soils being chosen by *Calliopsis andreniformis* Smith and *Andrena barbilabris* (Kirby) for example, whereas most ground-nesting bees are more common in heavier soils. Many species nest in sparsely vegetated ground, *Halictus ligatus* being one example (Packer and Knerer, 1986), whereas some prefer denser vegetation such that their nests are not so easily detectable. *Andrena clarkella* (Kirby) is an example of a species that will nest in dense grass. Some bees nest in dense aggregations of up to 300 per square metre, others nest more sparsely.

Another common nesting substrate is in pithy stems, such as those of blackberries and raspberries,

**Table 1.** Nesting biology, levels of sociality, distribution, seasonal occurrence, abundance and diversity of the bees of eastern Canada

Family	Genus	Nest site <sup>1</sup>	Sociality <sup>2</sup>	Time of Year <sup>3</sup>	Provinces <sup>4</sup>	Abundance <sup>5</sup>	# of species
Melittidae	<i>Macropis</i>	Ground	Solitary	Summer	ON-NS	Rare	2
Megachilidae	<i>Anthidiellum</i>	Mason	Solitary	Summer	ON, QC	Rare	1
	<i>Anthidium</i>	Cavities	Solitary	Summer	ON-NS	Common Urban	1
	<i>Chelostoma</i>	Cavities+stems	Solitary	Summer	ON	Common Urban	3
	<i>Coelioxys</i>	Parasite	N/A	Summer	All	Common	10
	<i>Dianthidium</i>	Mason	Solitary	Summer	ON, QC	Rare	1
	<i>Heriades</i>	Cavities+stems	Solitary	Summer	ON-NS	Uncommon	2
	<i>Hoplitis</i>	Cavities+stems+mason*	Solitary	Summer	All	Local	8
	<i>Megachile</i>	Stems, wood*, cavities, ground	Solitary	Summer	All	Abundant	18
	<i>Osmia</i>	Cavities, under rocks*	Solitary	Spring+summer	All	Abundant	23
	<i>Paranthidium</i>	Ground	Solitary	Summer	QC	Rare	1
	<i>Stelis</i>	Parasite	N/A	Summer	All	Uncommon	10
<i>Anthophora</i>	Ground+stems*	Solitary	Spring+summer	All	Local	1	
Apidae	<i>Apis</i>	Hives	Perennial eusocial	All season	All	Abundant	1
	<i>Bombus</i>	Rodent burrows, on ground, in trees	Annual eusocial	All season	All	Abundant	27
	<i>Ceratina</i>	Stems	Solitary	All season	ON-NS	Abundant	3
	<i>Epeoloides</i>	Parasite	N/A	Summer	ON-NS	Extremely rare	1
	<i>Epeolus</i>	Parasite	N/A	Summer+fall	ON-NS	Local	11
	<i>Holcopasites</i>	Parasite	N/A	Summer	ON-NS	Uncommon	1
	<i>Melissodes</i>	Ground	Solitary	Summer+fall	ON-NS	Common	10
	<i>Nomada</i>	Parasite	N/A	All season	All	Abundant	37
	<i>Peponapis</i>	Ground	Solitary	Summer	ON	Local	1
	<i>Svastra</i>	Ground	Solitary	Summer	ON, QC	Rare	1
	<i>Triepeolus</i>	Parasite	N/A	Summer+fall	ON-NS	Local	10
<i>Xylocopa</i>	Wood	Nest sharing	All season	ON, QC	Common Urban	1	
Andrenidae	<i>Andrena</i>	Ground	Solitary+Commun/AI*	All season	All	Abundant	75
	<i>Calliopsis</i>	Ground	Solitary	Summer	ON-NS	Local	1
	<i>Perdita</i>	Ground	Solitary+Commun/AI*	Summer	ON-NS	Local	5
	<i>Protandrena</i>	Ground	Solitary	Summer	ON-NS	Local	6
Halictidae	<i>Agapostemon</i>	Ground	Commun/AI + Solitary	All season	ON-NS	Common	4
	<i>Augochlora</i>	Wood	Solitary	Summer	ON-NS	Common	1
	<i>Augochlorella</i>	Ground	Annual eusocial	All season	ON-NS	Common	1
	<i>Augochloropsis</i>	Ground	Nest sharing?	Summer	ON	Local	1
	<i>Dufourea</i>	Ground	Solitary	Summer	ON-NS	Local	3
	<i>Halictus</i>	Ground	Annual eusocial and solitary	All season	All	Abundant	4
	<i>Lasioglossum</i>	Ground, wood*	Solitary, Commun/AI, Annual eusocial	All season	All	Abundant	71
	<i>Sphecodes</i>	Parasite	N/A	All season	All	Abundant	24
Colletidae	<i>Colletes</i>	Ground	Solitary	All season	ON-NS	Common	16
	<i>Hylaeus</i>	Stems, ground*	Solitary	Summer	All	Common	12
* uncommon option							
<b>Total</b>							<b>409</b>

1. **Ground:** nests made by burrowing into the soil. **Mason:** nests made on a substrate from resin or mud. **Cavities:** nests made in naturally occurring cavities such as beetle borings in wood, snail shells, etc. **Wood:** nests excavated in woody substrates. **Stems:** nests excavated in pithy stems. **Under rocks:** (one species) brood cells made under rocks. **Hive:** the honey bee is the only species that nests in hives, although feral colonies can be found in other hollows and cavities. **Rodent burrows:** on the ground and in hollow trees; bumble bees nest in these diverse locations. **Parasites:** make no nests. 2. **Solitary:** females nest alone. **Annual eusocial:** overwintered queens start a nest in spring and produce workers before producing males and the next season's queens. **Communal:** females share a nest entrance but each constructs her own brood cells and forage for food for their own offspring. **Nest sharing:** a few females may share a nest, exact details rarely known. **Perennial eusocial:** the honey bee has colonies that last for many years. 3. Times of year are approximate and will depend upon location. For example, summer bees are unlikely to be found in May or after mid August. All season means that the bees can usually be found from spring to the first frosts. 4. Bees listed as from all provinces can be expected to occur even in northern regions, such as Hudson's Bay and Labrador. Species listed as ON-NS – or subsets of these provinces, are not generally found far to the north. ON-NS also includes PEI although the bee fauna there has not been well studied yet. 5. **Abundant:** easily found almost anywhere. **Common:** seasonally abundant in most locations. **Common Urban:** common within urban settings, including gardens. **Local:** seasonally abundant within specific habitats and locations. **Uncommon:** seldom encountered but usually widespread. **Rare:** seldom encountered. **Extremely rare:** known recently from only a few specimens, possibly extirpated from most of former range.

*Rubus* spp. (Rosaceae). Examples of bees that nest in stems include most of the yellow-faced bees *Hylaeus*, all species of small carpenter bee *Ceratina*, and many species of the family Megachilidae. Many of the latter also nest in pre-existing cavities in wood, such as holes created by wood-boring beetles, and many of these species accept trap-nests (Krombein, 1967). These bees construct blind, unbranched burrows with the brood cells arranged in a linear series. Abandoned snail shells, or other naturally occurring cavities (even locks) are used by a few species of *Osmia* (Michener, 2000; O'Toole and Raw, 2004). Some bees, such as *Lasioglossum coeruleum* (Robertson) (Barrows, 1973), *Augochlora pura* (Say) (Stockhammer, 1966; Barrows, 1973), *Megachile frigida* Smith and *M. inermis* Provancher (Stephen, 1956), excavate burrows in rotting wood, or in harder wood - the large carpenter bee, *Xylocopa virginica* (L.) being our best example. Bumble bees mostly nest in abandoned rodent burrows, underground or in hollow trees, although some make their nest on the ground (Lavery and Harder, 1988). Honey bees are managed in hives, but feral colonies can be found in hollow trees.

Most bees do not use extraneous materials in constructing their nests. The main exceptions to this are in the family Megachilidae. Species in the genus *Megachile* line their brood cells with pieces of leaves or petals. The almost perfectly semicircular holes cut in the edges of rose leaves are examples of the work of these bees. *Anthidium* species line their brood cells with plant hairs, commonly from *Stachys* (Lamiaceae). Some bees, for example *Paranthidium jugatorium* (Say), use resin collected from trees or pebbles or mud to line their brood cells and/or to plug nest entrances.

### Bee Biology: Social Behaviour

Most bees are solitary, females constructing a nest and provisioning their brood cells entirely

alone. At the opposite extreme are the perennially social colonies of honey bees, comprising one queen and thousands of workers; colonies divide by fission, the old queen leaving in a swarm of approximately half the colony's workforce to inhabit a new hive (Winston, 1987; O'Toole and Raw, 2004). Honey bees, bumble bees and some sweat bees are eusocial (terminology *sensu* Michener, 1974): there is a reproductive division of labour between queens that perform all (or at least most) of the reproduction, and their worker daughters. Bumble bees and the eusocial sweat bees have nests started in spring by a single female (some of the sweat bees have nests initiated by several females) which forages to produce the first worker brood. The workers then perform foraging and nest construction activities to produce either more workers (as in bumble bees) or males and next year's queens (as in the eusocial sweat bees in Canada and late summer workers of bumble bees). Bumble bee colonies can have workforces numbering hundreds of individuals, Canadian sweat bees rarely have more than a dozen workers and some may have an average of less than one worker per nest (Packer, 1990).

Two other forms of social organization are known among Canadian bees: semisociality and communal nesting. Semisocial societies have a reproductive division of labour between females that are of the same generation. The multiple female spring associations in otherwise eusocial sweat bees are examples of this, but some species are known to have at least some colonies that are purely semisocial (e.g. *Lasioglossum comagenense* (Knerer and Atwood) (Packer et al., 1989)). Communal bees have no reproductive division of labour, but females share a nest entrance and act as solitary females beneath the ground surface, each constructing and provisioning her own brood cells. The best known example of a communal bee in Canada is *Agapostemon virescens* (Fabricius), the females of which are readily identified because they

are the only eastern Canadian species with the head and mesosoma a brilliant metallic green and the metasoma entirely black with white hair bands. Up to several dozen females may share the same nest in this species (Abrams and Eickwort, 1980).

### Bee Conservation

Bees are economically and ecologically important organisms and yet they are more extinction-prone than are most other groups of insects (Zayed and Packer, 2005). Oligolectic species may be particularly at risk of extirpation and extinction (Packer et al., 2005; Zayed et al., 2005). There have been dramatic declines in some bumble bee species in recent years, and one species (from the western USA) may have become extinct (Thorp, 2005). One reason why bumble bees are particularly prone to environmental change is that their colonies need large amounts of food over the duration of the entire spring and summer in order to produce males and next year's queens; solitary bees are not so limited.

Bees need floral and nesting resources. Comparatively few species can use horticultural varieties of flowers for food, whereas many species feed upon plants most people would consider "weeds". Encouraging bees by planting wildflowers and providing suitable nesting sites would be beneficial. The latter can be done by leaving patches of ground sparsely vegetated and not disposing of dead stems of plants such as raspberry canes. Stem and wood-nesting bees can be encouraged by the placement of trap-nests in gardens (Hallett, 2001a, 2001b).

### The Keys

Our key is loosely based upon Michener et al. (1994). We have avoided the use of the most troublesome couplets from that work and have also ensured that the most commonly recognized bee genera (*Apis* and *Bombus*) key out early.

We do not present a key to the families of bees for the simple reason that this is based almost entirely on mouthpart characteristics (Michener, 1993) and requires dissections that are not easily performed and are time consuming. Nonetheless, there are some higher level categories that are worth noting.

Bees are divided into short-tongued and long-tongued groups based upon the form of the labial palpi. In short-tongued bees (with few exceptions) the labial palpi are unmodified, whereas in long-tongued bees the basal two segments are considerably elongate, forming a sheath, and the last two segments are very small and at right angles to the basal two. Long-tongued bees evolved from

short-tongued ancestors. There are two families of long-tongued bees: the Megachilidae and Apidae (including the Anthophoridae of earlier authors). The remaining families are short-tongued bees.

One short-tongued bee family can be readily identified if the tongue is exposed: the Colletidae are unique in having a glossa that has a concave apex (Fig. 79; the few exceptions to this are Australian), so that it is broad at the apex. They use this to brush glandular secretions to make nest cell linings (Torchio et al., 1988). There are only two genera of Colletidae in Canada: *Colletes* and *Hylaeus*. Bees with a concave apex to the tongue will either be *Colletes* (three submarginal cells, lots of pubescence including a scopa on the hind leg in females, face without yellow markings) (Fig. 156), or *Hylaeus*, (two submarginal cells, body almost entirely lacking pubescence, without a scopa, and almost always with yellow/white markings on the face) (Fig. 167).

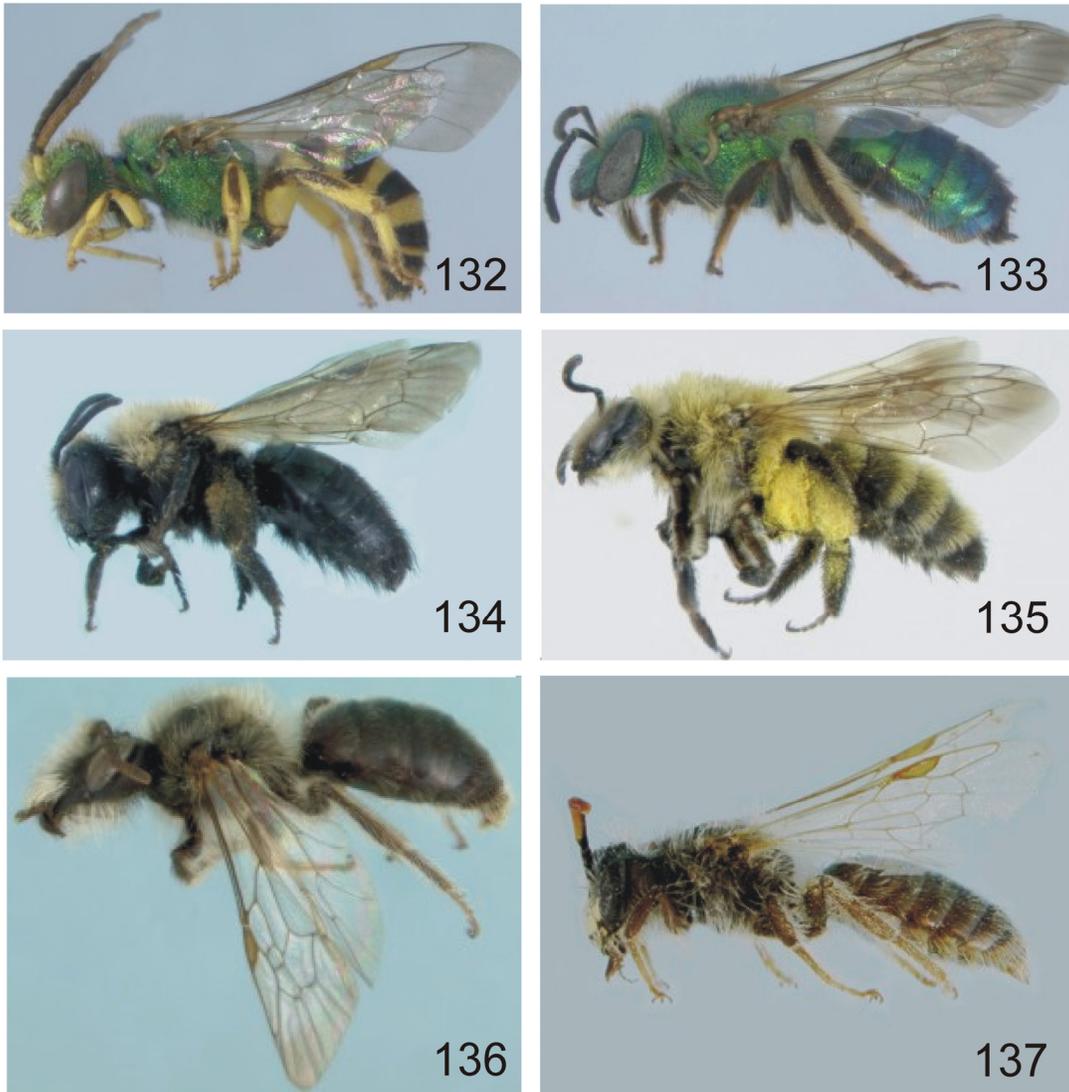
Most Canadian members of the bee family Halictidae can readily be identified by the strongly curved basal vein, most strongly curved towards the base (Fig. 11). Lastly, most Canadian non-parasitic members of the bee family Megachilidae can be easily identified by having the scopa entirely on the metasomal sternum of the female (Fig. 102), other bees with a scopa have it either entirely, or predominantly, on the hind leg (Fig. 63).

Species level identification guides, where available, are discussed under each genus. Almost none of these are strictly for the Canadian fauna. We are planning a series of articles that will permit identification of all genera and species of Canadian bees. The Discover Life web site ([www.discoverlife.org](http://www.discoverlife.org)) has interactive keys to species of most of the genera listed below.

### Generic Accounts

In the following we attempt a simple diagnosis for each genus at the beginning of each treatment. We then summarize the known biology of the genus, state its distribution within the area of interest, list available keys and state the number of species in eastern Canada.

1. *Agapostemon*. (Figs. 132, 133). These bees are easily recognized through a combination of two features: bright green head and thorax with a pronounced carina around the posterior surface of the propodeum. The males are also the only bees that are bright green with yellow and black stripes on the metasoma. These are solitary or communal ground-nesting bees that are common in summer in southern regions of our area. Males in particular can often be found flying around Hollyhocks, *Alcea* spp., and Rose of Sharon, *Hibiscus syriaca* (both

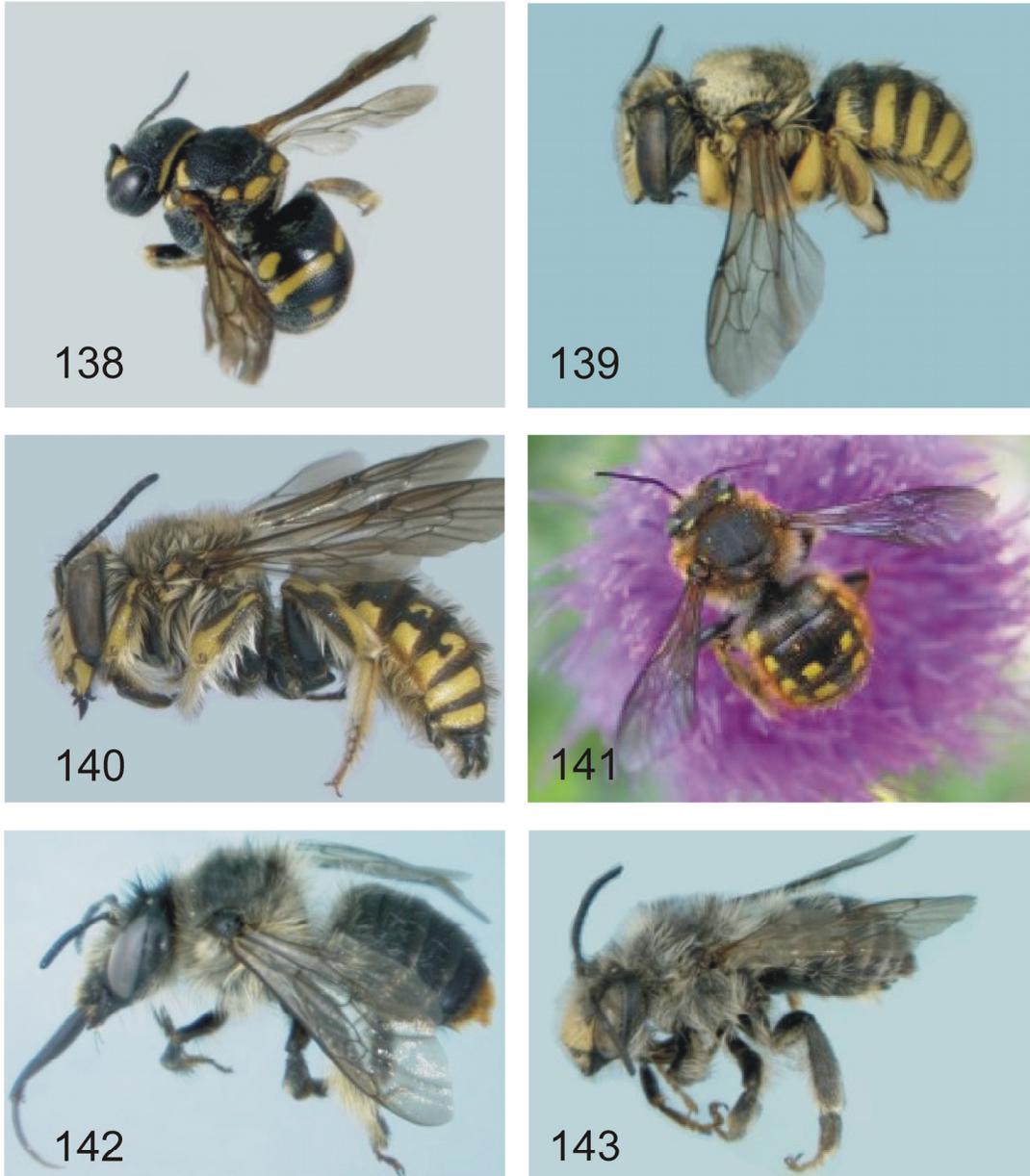


Figs. 132-137. Eastern Canadian bees. 132. *Agapostemon* male. 133. *Agapostemon* female. 134, 135. *Andrena* females. 136, 137. *Andrena* males.

Mavlaceae), flowers in August and September. The four eastern species can be easily separated using Mitchell (1960), though *A. radiatus* (Say) is now known as *A. sericeus* (Foster).

2. *Andrena*. (Figs. 134-137). Andrenidae can be distinguished from other bee families by the paired subantennal sutures. *Andrena* in our area most commonly have three submarginal cells whereas the other andrenids (*Calliopsis*, *Perdita*, *Protandrena*) have two. Female *Andrena* can also be readily identified by the facial foveae that are covered in short velvety hairs; all other Canadian bees have hairless facial foveae or, more commonly, no facial foveae at all. These are common solitary ground-nesting bees ranging in size from 5mm to over 15mm, which construct

nests in a wide variety of soil types and degrees of vegetation cover. Michener and Rettenmeyer (1956) remains the most detailed study of the nesting biology of any *Andrena* species. Most species have a black or dark brown integument (a few have red on the metasoma, males of quite a few have pale markings on the lower face). Variable in colour and density of pubescence, most species have dense, mostly brown hairs, while some have bright fuscous pubescence (e.g. *A. milwaukeeensis* Graenicher), others more whitish hairs. Some are comparatively hairless, such as *A. integra* Smith. They are particularly common visiting willows (*Salix*, Salicaceae) in spring, but the genus as a whole can be found throughout the spring, summer and autumn. Late summer species are common on

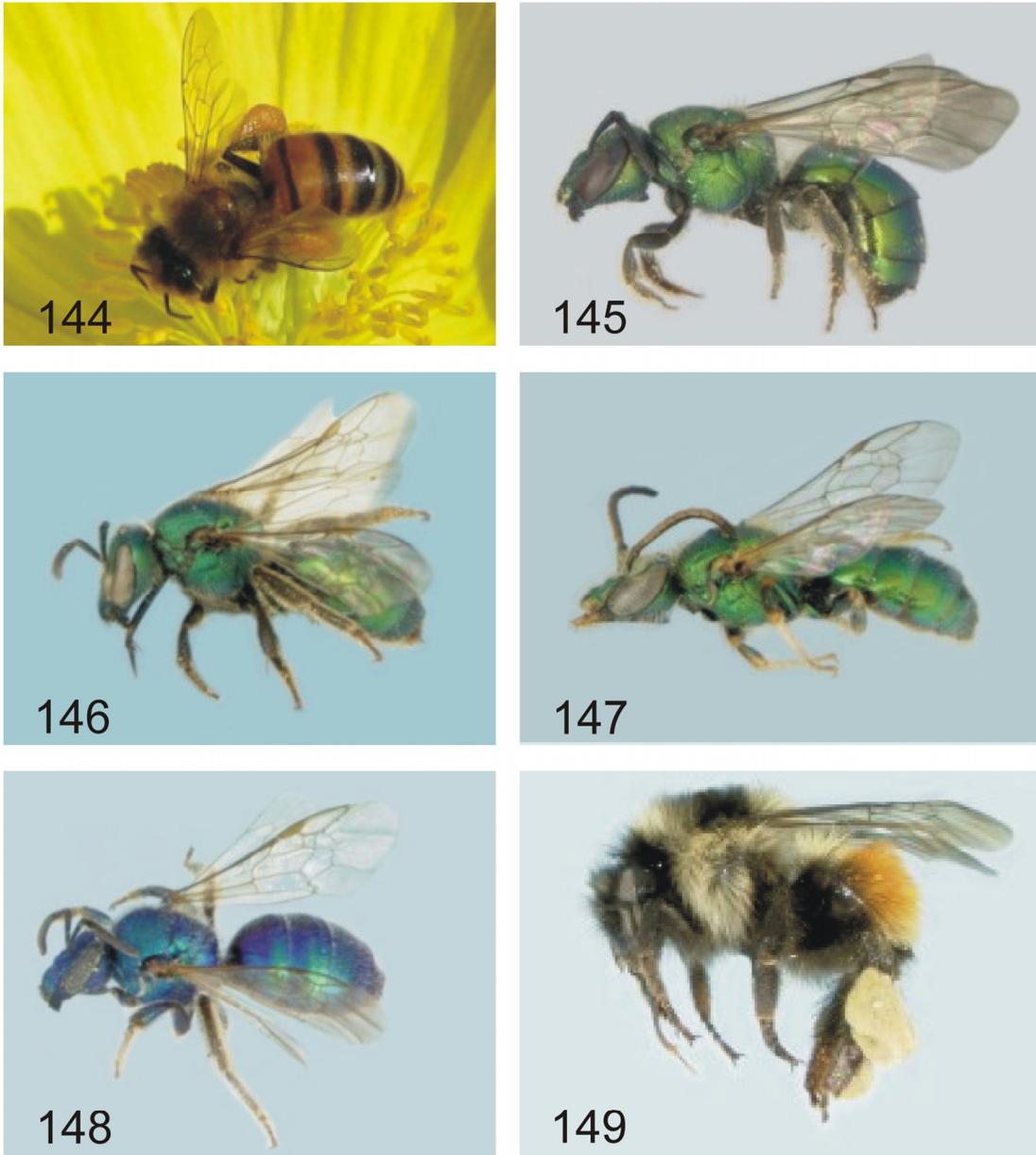


Figs. 138-143. Eastern Canadian bees. 138. *Anthidiellum* female. 139. *Anthidium* female. 140. *Anthidium* male. 141. *Anthidium* male on flower. 142. *Anthophora* female. 143. *Anthophora* male.

goldenrod (*Solidago*, Asteraceae). These bees can be found throughout eastern Canada, even in the warmer parts of the southern Arctic (Mitchell, 1960). There are approximately 74 species recorded from our area and they can be identified, albeit not easily, using Mitchell (1960), the Discover Life internet site, or using the keys of LaBerge (1967, 1969, 1971, 1973, 1977, 1980, 1986, 1987, 1989), LaBerge and Bouseman (1970), LaBerge and Ribble (1972, 1975), Donovan (1977),

Bouseman and LaBerge (1978) and Ribble (1967, 1968).

3. *Anthidiellum*. (Fig. 138). Along with *Anthidium*, *Dianthidium* and *Paranthidium* (discussed below), these bees are easily identified as yellow-marked Megachilidae that possess a scopa. Our only species, *A. notatum* Latreille, which occurs in Ontario, can be distinguished from other non-cleptoparasitic Anthidiini by its small size, and the angulate anterior margin of the mesoscutum which overhangs the pronotum



Figs. 144-149. Eastern Canadian bees. 144. *Apis mellifera* worker on flower. 145. *Augochlora* female. 146. *Augochlorella* female. 147. *Augochlorella* male. 148. *Augochloropsis* female. 149. *Bombus* female.

*Anthidiellum* are summer bees which use resin to construct cells that are attached individually to stems.

4. *Anthidium*. (Figs. 139-141). These are robust bees with yellow markings on the head and mesosoma, bands of yellow on the metasoma, and no arolia. One indigenous and two introduced Old World species occur in Ontario, one of these, *A. manicatum* (L.), was also recently reported from Nova Scotia (Hoebeke and Wheeler, 2005). These are the wool carder bees that line their brood cells

with hairs from the leaves and stems of plants such as cultivated Lamb's Ears (*Stachys*, Lamiaceae). Males are highly territorial and hover around the preferred floral hosts of the females, aggressively pursuing other individuals or other species of bee that visit the plants. *Anthidium manicatum* is very common in urban gardens in summer where they can be found at mint and other bluish-purple flowers with long corollas, even those kept in flower boxes on balconies of apartment buildings.



Figs. 150-155. Eastern Canadian bees. 150. *Calliopsis* female. 151. *Calliopsis* male. 152. *Ceratina* female. 153. *Chelostoma* female. 154. *Coelioxys* female. 155. *Coelioxys* male.

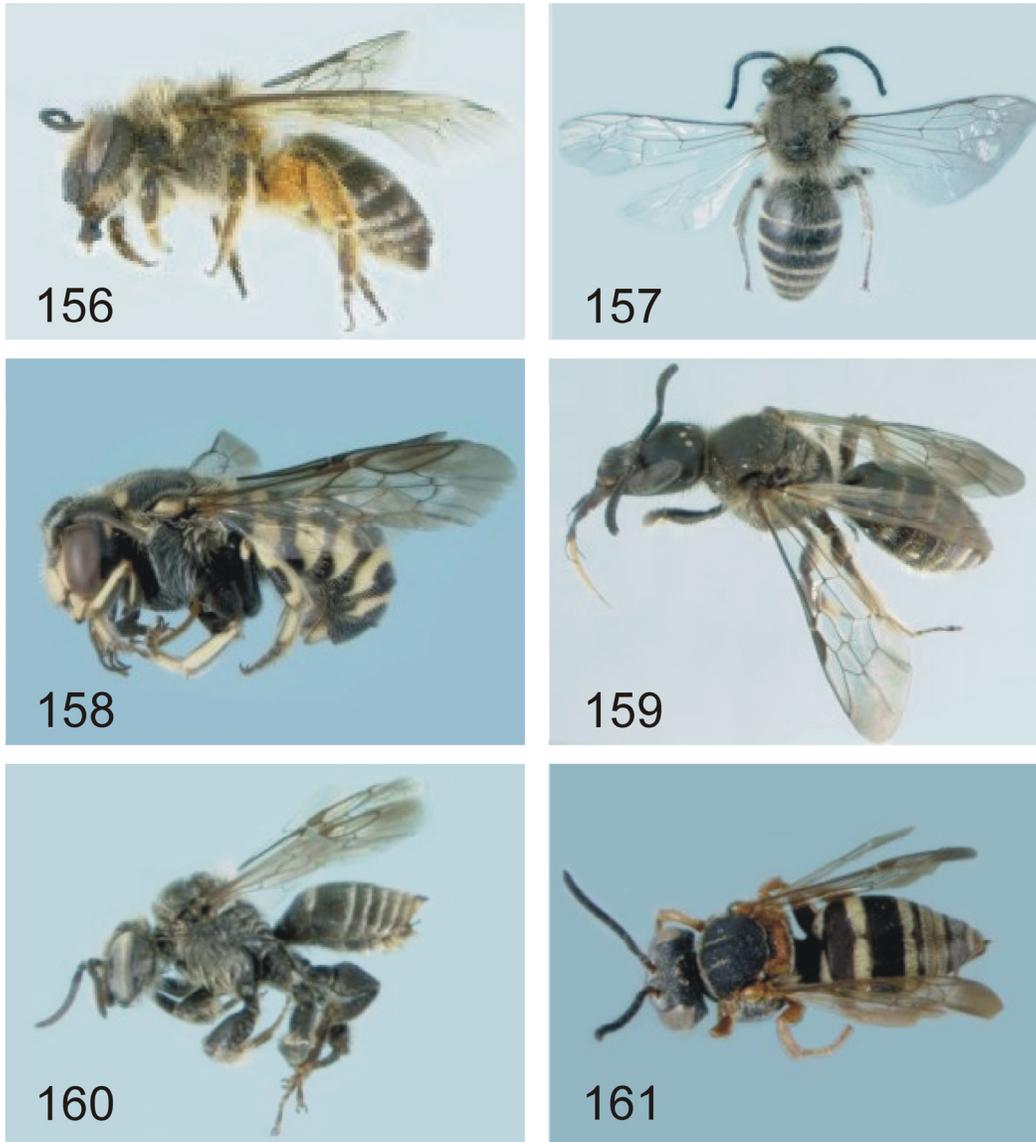
The species can be distinguished using the keys of Miller et al. (2002) or Romankova (2003a).

5. *Anthophora*. (Figs. 142, 143). These are robust long-tongued bees, with hairless forewing cells and with the outer region of the forewing papillate. Most species nest in the ground, but one, *A. terminalis* Cresson, excavates nests in pithy stems, and can be found commonly at tomato flowers in urban areas in southern Ontario. These are solitary species. Mitchell (1962) can be used to identify the eastern Canadian species, although *A. plumipes* (Pallas), a recently introduced European form, is not included in that work and may extend its range into eastern Canada. However, some of

the species names in Mitchell (1962) are now considered subspecies or integrades of *A. bomboides* (Kirby) (see Brooks (1983) for clarification).

6. *Apis*. (Fig. 144). Readily identified by lacking hind tibial spurs, but also by overall appearance, the well known domesticated honey bee, *Apis mellifera* L., is common throughout the warmer regions of Canada. This introduced species is the only bee in Canada to winter as a colony; all others have a solitary stage in their life history.

7. *Augochlora*. (Fig. 145). These are bright green bees with an acute epistomal lobe. There is only one species of this genus in Canada, *A. pura*



Figs. 156-161. Eastern Canadian bees. 156. *Colletes* female. 157. *Colletes* male. 158. *Dianthidium* male. 159. *Dufourea* male. 160. *Epeoloides* male. 161. *Epeolus* female.

(Say), a bright bluish-green bee that nests solitarily in rotting wood. It can be found through much of the summer and is common in southern Ontario, less so in the Atlantic provinces.

8. *Augochlorella*. (Figs. 146, 147). These are also bright green or bronze bees with a right-angled epistomal lobe, rounded tegula and lacking a carina surrounding the posterior surface of the propodeum. This genus also has only one species in eastern Canada, *A. aurata* (Smith) (previously known as *A. striata* (Provancher)). It is a greenish-bronze

species, somewhat smaller than *A. pura*. This eusocial species (Mueller, 1997; Packer, 1990) that nests in the ground, forming small turrets at the nest entrance. *Augochlorella* is common in southern parts of eastern Canada.

9. *Augochloropsis*. (Fig. 148). A third genus of bright green bee with only one species occurs in our area. *Augochloropsis metallica* (Smith) is a bluish-green species, more robust than either of the preceding species. It can easily be identified by the shape of the tegula. It is a moderately common



Figs. 162-167. Eastern Canadian bees. 162. *Halictus* female. 163. *Heriades* female. 164. *Heriades* male. 165. *Holcopasites* male. 166. *Hoplitis* females. 167. *Hylaeus* male.

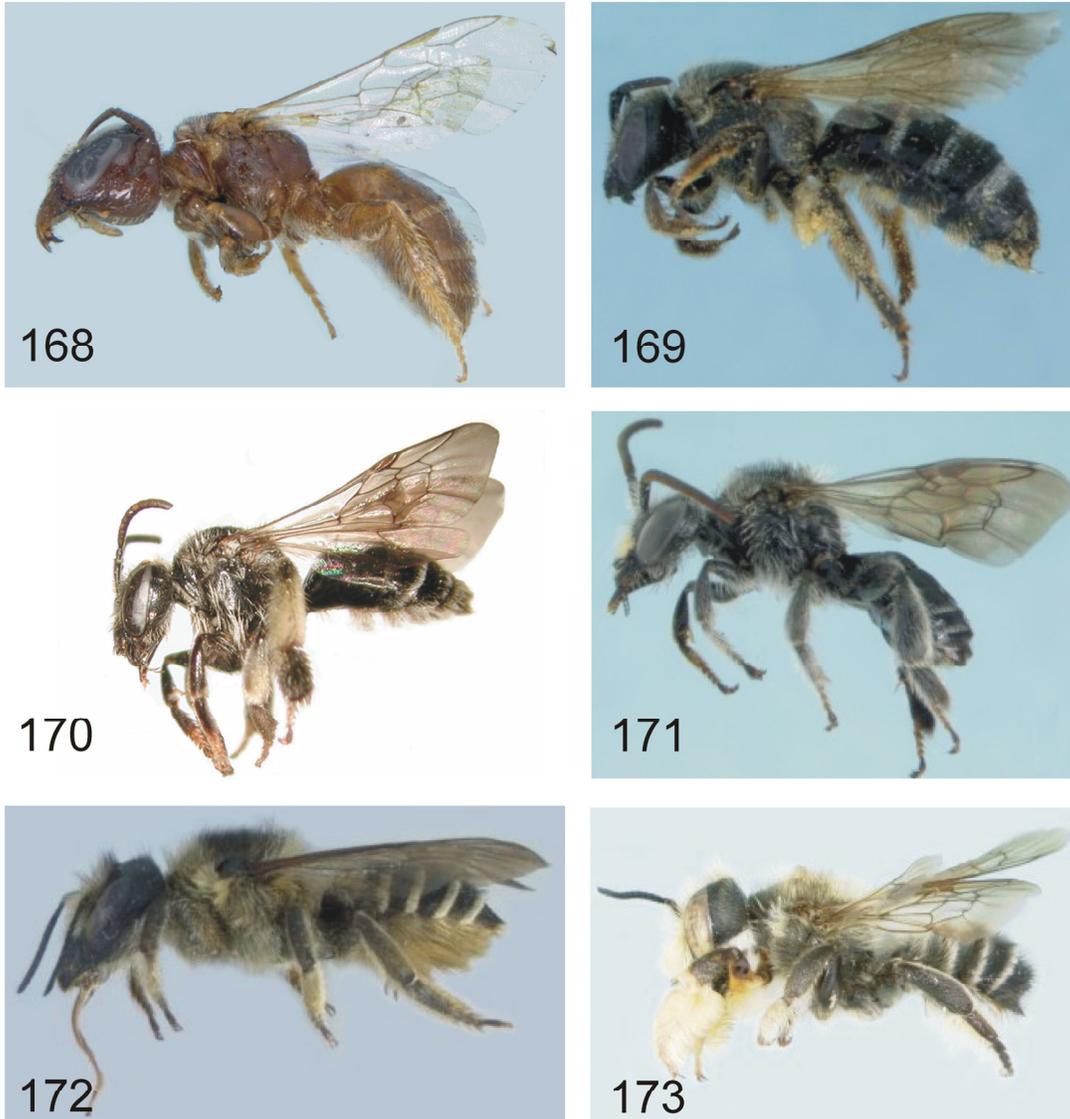
species in southern Ontario. This species is a ground-nester and it is probable that at least some nests contain multiple females.

10. *Bombus*. (Fig. 149). The common and easily recognized bumble bees are large and furry corbiculate bees with no jugal lobe to the hind wing. All species are eusocial except for the subgenus *Psithyrus*, which are social parasites that invade host bumble bee nests and replace the queen's ovipositional activities while relying on her workers to feed their offspring (Fisher, 1987). An additional species not of this subgenus, *B. hyperboreus* Schönherr, adopts a similar invasion strategy in the far north, but is not a social parasite further south (Richards, 1973). Bumble bees are found throughout our area, and occur even in the

arctic where they can forage for 24 hours a day under conditions of continual sunlight. Identification of the 27 eastern species is comparatively easy and mostly based upon details of colouration (Lavery and Harder, 1988).

11. *Calliopsis*. (Figs. 150, 151). The only species in eastern Canada, *C. andreniformis* Smith, is easily identified by the pattern of white markings on the face of the female and the entirely yellow legs of the male. These bees nest in flat, sandy soil and are locally abundant in suitable areas from southern Ontario to Cape Breton, Nova Scotia, in summer. The biology of this species was discussed in detail by Shinn (1967).

12. *Ceratina*. (Fig. 152). The three species of small carpenter bees found in eastern Canada are all



Figs. 168-173. Eastern Canadian bees. 168, 169. *Lasioglossum* females. 170. *Macropis* female. 171. *Macropis* male. 172. *Megachile* female. 173. *Megachile* male.

dark metallic blue with ivory markings on the face and/or legs. They nest in dead, pithy stems and, as they overwinter as adults, are among the few Canadian bees that can be collected in midwinter. Although males and females overwinter together, nests that are actively being provisioned house only a single adult female. These bees are active throughout the summer and are found throughout the southern regions of eastern Canada. Mitchell's (1962) key works well for males, but female identification has recently been improved upon by Rehan et al. (in preparation), available on the Discover Life website.

13. *Chelostoma*. (Fig. 153). Easily recognized as very narrow and cylindrical Megachilidae, as

noted in the key. Three species are known from eastern Canada, two of them introduced from Europe and found in Ontario; the indigenous species, *C. philadelphi* (Robertson), is known from Ontario and Quebec. One of the introduced species, *C. campanularum* (Kirby), is a tiny, narrow black bee which commonly visits *Campanula* (Campanulaceae) flowers in urban areas. These are solitary bees that nest in stems. Buck et al. (2005) provide a key to the species in eastern Canada.

14. *Coelioxys*. (Figs. 154, 155). In our area, these are black bees with bands and/or spots of short dense white hairs. The males have multiple spines at the end of the metasoma, whereas the females' metasoma ends in a narrow point; these



Figs. 174-179. Eastern Canadian bees. 174. *Melissodes* female. 175. *Melissodes* male. 176, 177. *Nomada* females. 178. *Osmia* female. 179. *Osmia* male.

characteristics make this genus easy to recognize. They are found in summer throughout most of eastern Canada and are cleptoparasites that lay eggs in the nests of *Megachile* species. The ten eastern Canadian species can be identified using Mitchell (1962).

15. *Colletes*. (Figs. 156, 157). The S-shaped recurrent vein is diagnostic for this genus, as is the combination of a concave apex of the tongue and three submarginal cells. These bees have a densely

pubescent head and mesosoma, usually orange-brown, sometimes dull brown, less commonly blackish or grey. The metasoma is entirely covered in hair in one rare species, *C. solidaginis* Swenk, but in other species is usually distinctly banded, with the bands at the apex of the terga. These are solitary bees that nest in the ground and line their tubular nests with a cellophane-like secretion that waterproofs the brood cells to prevent both waterlogging from rain and leakage of the rather



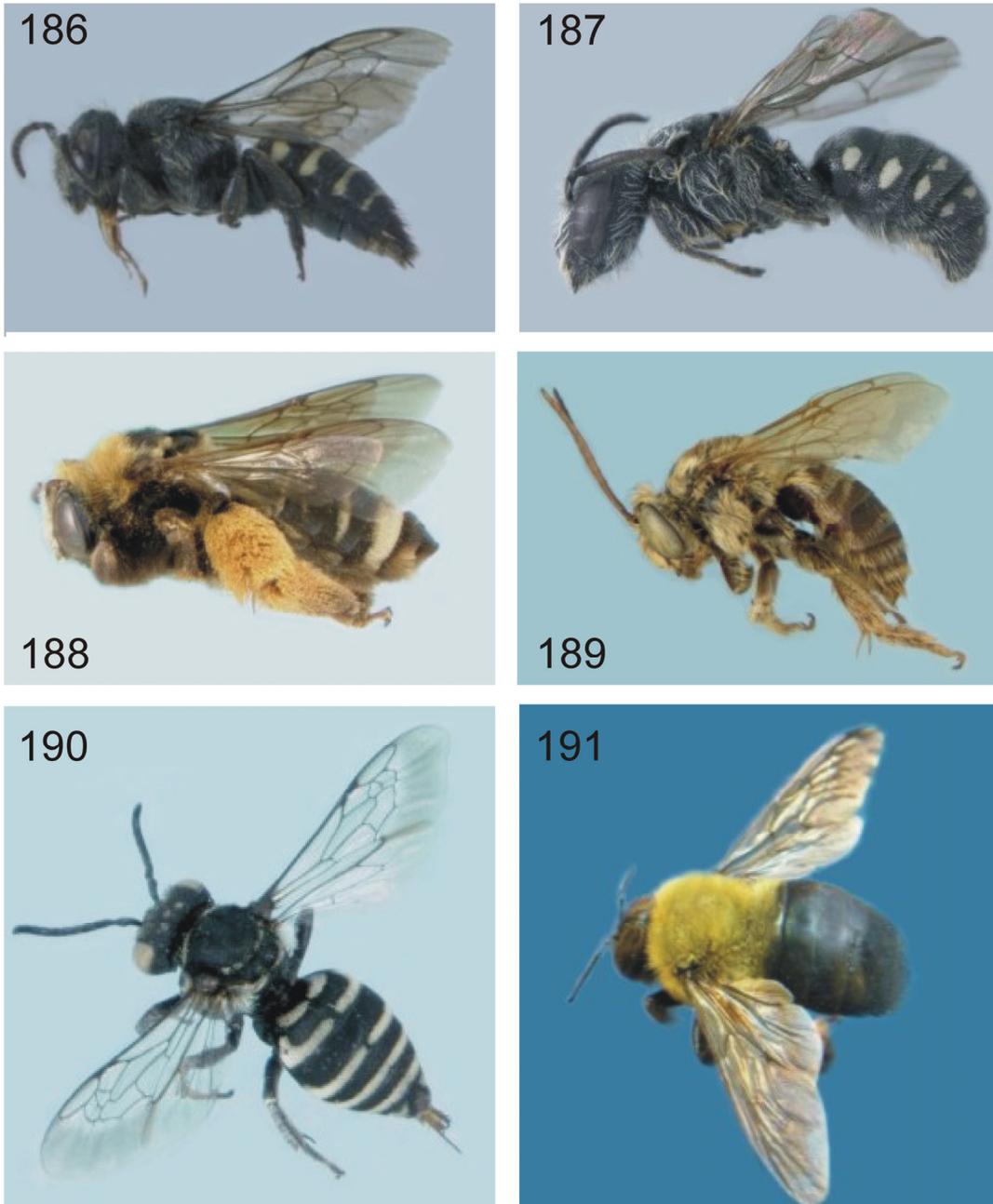
Figs. 180-185. Eastern Canadian bees. 180. *Paranthidium* male. 181. *Peponapis* male. 182. *Perdita* female. 183. *Protandrena* female. 184. *Protandrena* male. 185. *Sphecodes* female.

watery provisions provided for the larvae (Torchio et al., 1988). Different species are active at different times of year such that the genus can be found from early spring (mostly on maple flowers, *Acer*) to late autumn (mostly on goldenrod, *Solidago*, Asteraceae). *Colletes* is common throughout eastern Canada. Romankova (2003b) keyed the Ontario species, but several additional ones have been discovered since, so Mitchell's (1960) key remains useful for the approximately 17 species.

16. *Dianthidium*. (Fig. 158). One species, *D. simile* (Cresson), occurs in Ontario.

This is a robust, yellow and black marked bee that can be separated from the other anthidiine genera using the characteristics noted in the key. *Dianthidium* are mason bees that construct nests of resin and gravel on a surface.

17. *Dufourea*. (Fig. 159). These are small brownish or black bees which have the antennal bases located low on the face, and a scopa which is most strongly developed on the hind tibia. There are three species in southern parts of eastern Canada, each is oligolectic on different plant species. The only moderately common species is *D. novaeangliae* (Robertson), which forages solely



Figs. 186-191. Eastern Canadian bees. 186. *Stelis* female. 187. *Stelis* male. 188. *Svastra* female. 189. *Svastra* male. 190. *Triepeolus* female. 191. *Xylocopa* male.

on pickerel weed (*Pontederia*, Pontederiaceae), an aquatic plant. As such, it is one of the few bees most easily collected while canoeing! The other two species have rarely been seen in our area. These are solitary, ground-nesting bees (Eickwort et al., 1986). Mitchell (1960) identifies the species easily enough.

18. *Epeoloides*. (Fig. 160). This bee is easily identified as a long-tongued cleptoparasite

(therefore lacking a scopa) that has no discrete patches or bands of appressed, pale-coloured hairs. The one North American species, *E. pilosula* (Cresson), was thought to be extinct until rediscovered in Nova Scotia (Sheffield et al., 2004). *Epeoloides* attacks the nests of *Macropis* and flies in July, but is extremely rare.

19. *Epeolus*. (Fig. 161). These are robust bees with bands and/or spots of white or creamy

appressed hairs. The integument is black, sometimes marked with orange or red, especially on the legs. It is only likely to be confused with species of *Triepeolus* from which it can be separated by the short pseudopygidial area in females and posteriorly convergent margins of the pygidial plate in males. These are cleptoparasitic bees that attack *Colletes*, and they can often be found flying low over the ground looking for host nests. Mitchell (1962) keyed the 11 species in our area.

20. *Halictus*. (Fig. 162). These are common ground-nesting bees easily identified as halictines by the strongly arched basal vein, strong apical wing venation, and apical hair bands on the metasomal terga. One species (*H. confusus* Smith) is dull metallic green, the other three are brownish-black. These are socially variable bees. *Halictus rubicundus* (Christ) is known to be solitary in shorter summer habitats and eusocial in warmer environments (Eickwort et al., 1996) and *H. ligatus* is one of the best studied social sweat bees (e.g. Richards et al., 1995). *Halictus* species can be found throughout eastern Canada except in the far north. The four species can be easily identified using Mitchell (1960).

21. *Heriades*. (Figs. 163, 164). These are small, black, coarsely sculptured Megachilidae with a short horizontal portion of the propodeum that is made up of a single row of large pits. They fly in the summer and accept trap-nests. The biology of our most common species, *H. carinata* Cresson, which occurs as far east as Nova Scotia (Sheffield, 2006), was discussed by Matthews (1965). The three species in our area can be identified with Mitchell (1962).

22. *Holcopasites*. (Fig. 165). The only species in our area, *H. calliopsidis* (Linsley), is easily identified as a small black and red bee with many spots of white, appressed hairs, giving a checkerboard appearance to the metasoma. It is a cleptoparasite that attacks the nests of *Calliopsis andreniformis*. It occurs as far east as Nova Scotia (Sheffield, 2006).

23. *Hoplitis*. (Fig. 166). These are small to relatively large, black Megachilidae (a metallic green species occurs in western Canada), similar in appearance to black *Osmia*, but distinguishable by the elongate parapsidial line on the scutum, and the more elongate metasoma. These summer-flying bees are common throughout our area, some species ranging into the sub-arctic regions (Michener, 2000). Most species can be trap-nested in drilled wood blocks or hollow stems, but a recently recorded species (Buck et al., 2005), *H. anthocopoides* (Schenck) is a mason which

constructs exposed nests out of small pebbles. The eight species in our area (excluding *H. anthocopoides*) are identifiable using Mitchell (1962).

24. *Hylaeus*. (Fig. 167). Unlike most comparatively glabrous (hairless) species, *Hylaeus* are not cleptoparasites; rather, they carry pollen and nectar internally and therefore do not possess a scopa. *Hylaeus* are shiny black bees with white/yellow markings on the face (although females of one species, *H. basalis* (Smith), are completely black) and with pale banded legs. One species, *H. nelumbonis* (Robertson), has the basal few metasomal segments red. There are usually a few patches of white hairs on the mesosoma, and on the apicolateral portions of the more basal metasomal terga in some subgenera. *Hylaeus* are small bees common in the summer, and most nest in stems (and trap-nests) but a few species nest in the ground and, like *Colletes*, they line their nest with cellophane-like material. The best account of the nesting biology of any *Hylaeus* species is that of Torchio (1984). *Hylaeus* in our area can be identified using Mitchell (1960), although *H. hyalinatus* Smith, an introduced species, was only recently recorded in Ontario (Buck et al., 2005).

25. *Lasioglossum*. (Figs. 168, 169). These are halictines with reduced apical wing venation. The numerous species are classified in four subgenera in eastern Canada: *Lasioglossum*, *Evylaeus*, *Dialictus* and *Sphecodogastra*. Most nest in the ground, although a few species of the subgenus *Dialictus* are known to nest in soft wood. This is the most socially diverse genus of bees in the world, with many solitary, a few communal and many eusocial species known. A few species are cleptoparasitic (previously placed in genus or subgenus *Paralictus* but now considered to be *Dialictus* – Fig. 176). *Lasioglossum* are very common throughout temperate and boreal Canada, less so in the subarctic, and often make up a large proportion of all specimens collected in surveys (e.g. MacKay and Knerer, 1979; Grixti and Packer, 2006). Larger species (those of the subgenus *Lasioglossum*) are readily identified using McGinley (1986). The single Eastern Canadian species in the subgenus *Sphecodogastra* – *L. oenotherae* (Stevens) is found from Ontario to New Brunswick and is a common early morning visitor to the flowers of evening primroses and sundrops, *Oenothera* (Onagraceae) (Knerer and MacKay, 1969). The other subgenera, which are typically smaller bees (and many are dull metallic), can be identified, with some difficulty, using Mitchell (1960) although he raised several subgenera to generic rank, incorrectly associated the sexes of several species and made several other

mistakes with this group. Ongoing molecular work reveals that there are numerous cryptic species in this difficult group.

26. *Macropis*. (Figs. 170, 171). This is the only genus of Melittidae in Canada. These are uncommon, relatively small, ground-nesting bees that are completely dependent on their floral hosts, *Lysimachia* (Primulaceae), from which they collect pollen and oils. The oils are used both as a larval food source and as part of the nest cell lining (Cane et al., 1983). *Macropis* is found in the southern part of our area as far east as Nova Scotia. Mitchell (1960) can be used to separate our two species.

27. *Megachile*. (Figs. 172, 173). The leafcutting bees are readily identified by the combination of metasomal sternal scopa, lack of arolia and lack of yellow integumental markings. All our species use cuttings from leaves or floral petals to line their brood cells which are usually in pre-existing holes in wood (they commonly accept trap-nests), although some species nest in the ground. One species, the alfalfa leafcutter bee, *M. rotundata* (Fabricius), was accidentally introduced into North America prior to the 1950's, and is now managed for alfalfa pollination, although it visits many other flowers and has become widely established and is commonly collected. *Megachile* are common throughout eastern Canada as far north as the sub-arctic zone. The 18 species can be identified using Mitchell (1962), although the key uses characteristics of the mandibles, primarily the teeth and cutting edge shape, and identification of specimens with closed mandibles or badly worn teeth, may be difficult.

28. *Melissodes*. (Figs. 174, 175). These are robust, solitary ground-nesting, long-tongued bees. The males have extremely long antennae, in Eastern Canada shared only with *Svastra obliqua* (Say), which is much less common and rarely collected in our area. *Melissodes* can be separated by the narrowed anterior portion of the tegula. Mitchell (1962) can be used to separate the ten species in our area; *M. rustica* (Say) now known as *M. druriella* (Kirby).

29. *Nomada*. (Figs. 176, 177). *Nomada* are wasp-like bees with narrow bodies marked with yellow, orange or red (or combinations of these colours), lacking discrete hair patches and without a strongly curved basal vein. These are mostly cleptoparasites of *Andrena* and can be easily found flying low above the ground looking for host nests. They are found throughout our area to the arctic circle with different species active at different times of year, although they are most dominant in the early spring. *Nomada* are often difficult to identify, and numerous species are known from only one

sex. Mitchell (1962) can be used to identify the 37 named species in our area and some taxa can be identified using the Discover Life website.

30. *Osmia*. (Figs. 178, 179). These are robust bees, with a dull metallic blue-green integument in most species, a sternal metasomal scopa, and punctiform parapsidal lines. This is the only megachilid genus to overwinter as an adult, and they are thus common in spring and early summer throughout our area, north to the arctic circle. Some individuals in short summer climates skip a year entirely and fly almost two years after their mother laid the egg (Tepedino and Frohlich, 1984). They mostly nest in pre-formed cavities; holes in walls, door locks, and have even been found in stethoscopes in field hospitals! These species commonly accept trap nests. A few species, such as *O. inermis* (Zetterstedt), build nests under rocks. A variety of extraneous materials are used to line the brood cells, including grass blades, mud, chewed leaves, and gravel. Most of the 23 species can be identified using Mitchell (1962), although additional species have been recorded in our area since that time (Discover Life), and some species are notoriously difficult to identify (Rust, 1974).

31. *Paranthidium*. (Fig. 180). The one uncommon species found in our area, *P. jugatorium* (Say), can readily be told from all other genera (except *Anthidiellum*, *Anthidium* and *Dianthidium*) by having a sternal scopa, yellow markings on the body, and from these three anthidiine genera by the presence of arolia, a rounded anterior profile to the mesoscutum, and the anterior portion of the mesopleuron which is not separated from the lateral surface by a sharp carina. It nests in sandy soil and lines the brood cells with resin (Evans, 1993).

32. *Peponapis*. (Fig. 181). One species is known in the east, *P. pruinosa* (Say), the Hoary Squash Bee. This species is most easily identified through its host association: it is oligolectic on cucurbits (*Cucurbita*, Cucurbitaceae) and readily found in gardens in southern Ontario. This is a solitary ground-nesting bee found from mid to late summer. Information on this species from Ontario was presented by Kevan et al. (1989).

33. *Perdita*. (Fig. 182). *Perdita* are small, rather flat bees with body mostly dull metallic and with pale markings on the face and metasoma. These are solitary or communal ground-nesting species and are locally common in southern parts of eastern Canada in the summer and autumn. The nesting biology of the three species found in eastern Canada was reviewed by Michener and Ordway (1963) and Eickwort (1977). The species can be identified using Mitchell (1960).

34. *Protandrena*. (Figs. 183, 184). These are small, black bees with two subantennal sutures and glabrous facial foveae. Species in our area have two submarginal cells. Males have yellow face maculations, including the entire clypeus, though not as extensive as in *Calliopsis*. These are summer and autumn-flying bees that can often be collected on goldenrod (*Solidago*) and black-eyed susan (*Rudbeckia*, Asteraceae). Mitchell (1960) can be used to identify the six species in our area (as the genus *Pseudopanurgus*).

35. *Sphecodes*. (Fig. 185). This is our only genus of cleptoparasitic halictines (strongly arched basal vein), which are also shiny, usually coarsely sculptured and with the metasoma largely red (but entirely black in males of a few species). These bees, which mostly attack the nests of other halictines, are common throughout our area south of the arctic circle. There are 24 species recorded from our area, and they can be identified with difficulty using Mitchell (1960). One reason for their taxonomic complexity is that species attacking a single eusocial host with strong size dimorphism between queens and workers, or a species attacking multiple hosts of different sizes, will exhibit marked size variation according to which caste or species of host the parasite female laid eggs on.

36. *Stelis*. (Fig. 186, 187). Identifiable as cleptoparasitic Megachilidae with yellow markings on the metasoma. These bees attack Megachilidae, primarily *Heriades* and *Hoplitis*, but possibly

*Osmia* and *Chelostoma* as well. The ten species can be identified using Mitchell (1962).

37. *Svastra*. (Figs. 188, 189). One species is found in our area: *S. obliqua* (Say). It can be separated from other bees, except *Melissodes*, by the enormously long antennae in the male, and from *Melissodes* (and all other bees) by the spatulate hairs on some parts of the body (see the key for details). It is rare, known in eastern Canada only from southern Ontario and Quebec.

38. *Triepeolus*. (Fig. 190). Readily identified from all other genera except *Epeolus* as a long-tongued cleptoparasitic bee with appressed patches/bands of white or yellowish hairs, giving a strongly patterned appearance. It is separated from *Epeolus* by the longer pseudopygidial area in females and sinuate lateral margin to the pygidial plate in males. These are cleptoparasites, mostly of *Melissodes*. Ten species are found in southern parts of eastern Canada. They can be identified using Mitchell (1962) or Rightmyer (2006).

39. *Xylocopa*. (Fig. 191). One species is found in eastern Canada: *Xylocopa virginica* (L.). These large carpenter bees nest in wood and can be pests of outdoor wooden structures. Nest sharing by females is known and they are comparatively long-lived as adults. These bees are becoming increasingly common in southern Ontario and seem to be spreading north.

**Key to separate the bee genera of eastern Canada.**

The sexes in bees can be differentiated by counting the number of metasomal terga – 6 in females, 7 in males, or the number of apparent segments of the antennae – 12 in females, 13 in males. The second antennal segment is sometimes largely retracted within the first, particularly in some wasp-like bees.

- 1 Forewing with three submarginal cells (Fig 1)..... 2
- Forewing with two submarginal cells (Fig 2)..... 22
- 2 Hind tibial spurs absent (Fig 3)..... *Apis mellifera* L
- Hind tibial spurs present (Fig 4)..... 3
- 3 Female usually with hind basitarsus very strongly expanded and with corbicular structure on hind tibia (Fig 5); jugal lobe of hind wing absent (Fig 7)..... *Bombus*
- Female lacking strongly expanded hind basitarsus, hind tibia without corbicula (Fig 6); jugal lobe of hind wing present (Fig 8) ..... 4
- 4 Forewing with posterior portion of second recurrent vein arcuate outwardly making it somewhat S-shaped on the right wing (backwards S on the left wing) (Fig 9)..... *Colletes*
- Forewing with posterior portion of second recurrent vein not outwardly arcuate (Fig 10)..... 5
- 5 Forewing with basal vein strongly arched (Fig 11); female usually with narrow pseudopygidial area on T5 (Fig 13) [females lacking this area are usually shiny and black with red on metasoma (Fig 185) and lack a scopa on the hind leg (Fig 15)] ..... 6

- Forewing with basal vein not strongly arched though it may be slightly curved (Fig 12), but not strongly towards the base; T5 usually without pseudopygidial area, but IF present THEN body broad with pattern of white appressed pubescence (Figs 14, 161, 190) ..... 12
- 6 Female with pseudopygidial area divided by a deep cleft (Fig 17) (may need verification by prodding area with a pin); male with genital opening at extreme apex of metasoma, T7 not recurved anteroventrally (Fig 19); body in both sexes entirely bright metallic green or bronze (Figs 145, 148); posterior surface of propodeum lacking distinct carinate rim (Fig 21) ..... 7
- Female with pseudopygidial area entire (Fig 18) (sometimes appearing cleft due to orientation of minute hairs on surface, this can be checked by prodding with a pin); IF female entirely bright metallic, THEN posterior surface of propodeum entirely surrounded by a strong carina (Fig 22); male with apex of T7 recurved anteroventrally so that genital opening is slightly in front of the apex (Fig 20); male never entirely bright metallic, but IF head and thorax of male bright green THEN metasoma with yellow transverse bands (Fig 132)..... 9
- 7 Tegula with inner posterior angle somewhat produced inwardly (Fig 23); female with basitibial plate very short, barely extending beyond apex of femur (Fig 25); T1 and T2 with apical row of simple bristles ..... *Augochloropsis metallica* (F.)
- Tegula evenly rounded posteriorly (Fig 24); female with basitibial plate extending well beyond apex of femur (Fig 26); T1 and T2 without bristles ..... 8
- 8 Face with paraocular lobe forming an acute, but rounded angle projecting onto clypeus (Fig 27); female with clypeus evenly convex in profile with narrow apical non-metallic area (Fig 27); female S1 with a median keel (Fig 29); male S4 with a straight margin (Fig 31)..... *Augochlora pura* (Say)
- Face with paraocular lobe forming at most a right angle onto clypeus (Fig 28); female clypeus with a more extensive non-metallic apical portion that in profile is at a slight angle to the rest of the clypeus (Fig 28); female S1 without median keel (Fig 30); male S4 with a concave margin (Fig 32) ..... *Augochlorella aurata* (Smith)
- 9 Head and mesosoma (and often metasoma) brilliant metallic green; male with yellow bands on metasoma; outer wing veins all strong (Fig 33); posterior surface of propodeum encircled by a strong carina (Fig 35); body moderately large, at least 10mm in length (Figs 132, 133)..... *Agapostemon*
- Entire body either black (Fig 169), brown (Fig 168) or dull metallic. IF dull metallic (Fig 162), then body smaller, <7mm and EITHER posterior surface of propodeum not encircled by strong carina (Fig 36) OR one or more apical wing veins weakened (Fig 34) (note that the wing vein character does not always work well for all males)..... 10
- 10 Metasoma with hair bands on apical portion of each tergum (Fig 37), the bands may be effaced in older specimens in which they are generally more easily detected laterally ..... *Halictus*
- Metasoma either with hair bands on basal portions of terga, (Fig 38) (more apical segments may be entirely covered in pale appressed hairs in some species) or hair bands almost entirely absent (Fig 39) ..... 11
- 11 Apical wing veins weakened (Fig 34); female with scopa on hind leg (Fig 16) and distinct subapical mandibular tooth (Fig 42) [IF metasoma with reddish markings (uncommon) THEN body neither shiny nor with coarse sculpture] ..... *Lasioglossum*
- Apical wing veins strong (Fig 41); female lacking scopa (Fig 15) and sometimes lacking subapical mandibular tooth (Fig 43); metasoma usually with bright red markings, sometimes entirely red (Fig 185), IF entirely black THEN body shiny and usually with coarse sculpture ..... *Sphcodes*
- 12 Axilla produced into a rounded lobe or an angle or spine, clearly not continuing outline of scutellum (Fig 44); body mostly black with bands or spots of pale appressed pubescence (Figs 44, 161, 190) ... 13
- Axilla not produced, continuing outline of scutellum (Fig 45); body variously coloured or patterned ..... 14
- 13 Female with pseudopygidial area of T5 at least half as long as greatest breadth (Fig 46); S6 with disk reduced to a transverse bar that connects a pair of elongate processes that are almost forceps-like and with coarse spine-like setae at apex (Fig 48) (IF S6 not extruded, the spines at its apex may still be

- visible) (Fig 46); male pygidial plate with lateral margins parallel posteriorly, widened anteriorly (Fig50)..... ***Triepeolus***
- Female with pseudopygidial area of T5 usually less than half as long as greatest breadth (Fig 47); S6 with disk broad and lateral process spatulate with triangular teeth (Fig 49) (IF S6 not extruded but the apex is visible THEN it does not have spines); male pygidial plate with lateral margins convergent posteriorly (Fig 51)..... ***Epeolus***
- 14 Body shiny dark blue or dark green-blue, female clypeus with vertical white stripe (Fig 52), and male clypeus with larger white mark (Fig 53); female with weak scopa on hind leg and apex of metasoma pointed and lacking pygidial plate (Fig 55)..... ***Ceratina***
- Body not shiny blue or dark green-blue, female clypeus without a white median stripe (Fig 54); female with scopa of hind leg present or absent: IF metasoma appearing pointed in female, THEN pygidial plate present (Fig 56); male clypeal colouration variable..... 15
- 15 Face with two subantennal sutures (Fig 57); female with facial foveae shallow and entirely covered in short dense velvety hairs (Fig 59), and with propodeal corbicula (Fig 60) ..... ***Andrena***
- Face with one subantennal suture (Fig 58); female without facial foveae and without propodeal corbicula (Fig 61)..... 16
- 16 Integument of metasoma (Fig 62), and often mesosoma, marked with yellow, orange, white or red, sometimes entirely reddish (Figs 176, 177); female scopa absent (Fig 62); female S6 with specialized bristles (Fig 64) ..... ***Nomada***
- Integument of metasoma not marked with yellow, orange or red (Fig 63); female with scopa present (Fig 63) (except in one very rare species which has no markings on integument); female S6 without specialized bristles (Fig 65)..... 17
- 17 Forewing without stigma, marginal cell slender, about 7 times as long as wide (Fig 66); metasoma lacking distinct pale hair bands (Fig 191) ..... ***Xylocopa virginica*** (L.)
- Forewing with stigma, marginal cell at most 6 times as long as wide (Figs 67, 68); usually with metasomal hair bands (Figs 174, 175)..... 18
- 18 Wings with most closed cells hairless and apical regions strongly papillate; the papillae not giving rise to hairs (Fig 67) ..... ***Anthophora***
- Wings with closed cells with hairs, apical regions not usually strongly papillate (Fig 68)..... 19
- 19 Male antenna short (Fig 160); female scopa absent (Fig 15) ..... ***Epeoloides pilosula*** (Cresson)
- Male antenna long (Fig 181) to very long (Figs 175, 189); female with scopa (Figs 174, 188) ..... 20
- 20 Tegula narrowed anteriorly (Fig 69) ..... ***Melissodes***
- Tegula not narrowed anteriorly (Fig 70) ..... 21
- 21 Both sexes with some shiny, spatulate hairs most easily visible on base of T2 (Figs 71-72) or ... arising from suture between mesoscutum and scutellum (Figs 71-72) ..... ***Svastra oblique*** (Say)
- Both sexes lacking modified hairs as above ..... ***Peponapis pruinosa*** (Say)
- 22 Distance from stigma to distal end of marginal cell little if any longer than stigma, AND, second submarginal cell less than 2/3 as long as first (Fig 73); body small with metallic colouration and pale maculations on metasoma (Fig 182)..... ***Perdita***
- Marginal cell or submarginal cells not as above (Fig 74) ..... 23
- 23 Second submarginal cell much shorter than first, usually only half as long; first recurrent vein received by first submarginal cell or meeting first transverse cubital vein (Fig 75), IF second submarginal cell is 2/3 as long as first, THEN first recurrent vein clearly in first submarginal cell (Fig 75); female without scopa (Figs 165, 167, 176, 177) ..... 24
- Second submarginal cell at least 2/3 as long as first and usually receiving first recurrent vein (Fig 76); female with scopa present or absent..... 26

- 24 Jugal lobe of hind wing about  $\frac{3}{4}$  as long as vannal lobe (Fig 77); glossa truncate or bilobed (Fig 79); body black and usually with white or yellow markings on legs and face (Fig 79) but lacking white or yellow integument on metasoma (metasoma occasionally red basally)..... ***Hylaues***  
 - Jugal lobe of hind wing less than  $\frac{1}{4}$  as long as vannal lobe (Fig 78); glossa pointed (Fig 80); body with yellow, orange or red markings on metasoma (Figs 83, 165, 176, 177)..... 25
- 25 Apex of marginal cell on wing margin (Fig 81); metasoma lacking discrete patches of pale appressed pubescence, IF metasoma appears spotted, THEN spots are made of coloured integument and not appressed hairs (Fig 83) ..... ***Nomada***  
 - Apex of marginal cell curved away from wing margin (Fig 82); metasoma with discrete patches of pale appressed pubescence giving a checkered appearance (Fig 84) ..... ***Holcopasites calliopsidis*** (Linsley)
- 26 Axilla produced to a lobe, angle or spine lateral to scutellum (Fig 85)..... ***Coelioxys***  
 - Axilla not produced into a lobe, angle or spine lateral to scutellum (Fig 86)..... 27
- 27 At least female with facial fovea (Fig 87); both sexes with two subantennal sutures (Fig 89), except rarely in males of shiny black species with yellow on face and legs (Fig. 184)..... 28  
 - Both sexes without facial fovea (Fig 88) and with one subantennal suture (Fig 90)..... 30
- 28 Female with facial fovea covered in short velvety hairs (Fig 91); both sexes usually with long dense hairs especially on the face of male (Fig 91) and the lateral surface of propodeum with long hairs forming a corbicula in the female (Fig 93)..... ***Andrena***  
 - Female with facial fovea lacking hairs (Fig 92); male without face covered in long hairs (Figs 96, 98); female without corbicula on lateral surface of propodeum (Fig 94) ..... 29
- 29 Female with whitish marks on face (Fig 95); male with most of face below facial foveae (Fig 98) and all legs bright yellow (Fig 151); male with hind tibia without carina along upper margin .....  
 ..... ***Calliopsis andreniformis*** (Smith)  
 - Female with face black (Fig 97); male with yellow on face (Fig 98) and yellow markings on legs much reduced to absent (Fig 184); male with hind tibia with dentate carina along upper margin .....  
 ..... ***Protandrena***
- 30 Metasoma with white, yellow or red markings (Fig 99) ..... 31  
 - Metasoma lacking white, yellow or red markings (Fig 100)..... 35
- 31 Female metasomal scopa absent (Fig 101); male metasoma lacking spines or protuberances near apex (Fig 103)..... ***Stelis***  
 - Female metasomal scopa present (Fig 102); male metasoma with apical spines or processes.. (Fig.104)  
 ..... 32
- 32 Female mandible with at least 5 distinct teeth (Fig 105); arolia absent (Fig 107)..... ***Anthidium***  
 - Female mandible with 3 or 4 teeth (Figs 106, 113); arolia present (Fig 108) ..... 33
- 33 Anterior margin of mesoscutum angularly produced so that there is a sharp edge running from one pronotal lobe to the other (Fig 109); both sexes with 3 mandibular teeth (Figs 111, 112).....  
 ..... ***Dianthidium simile*** (Cresson)  
 - Anterior margin of mesoscutum rounded (Fig 110); female with 4 mandibular teeth (Fig 113), male with 3 (Fig 112)..... 34
- 34 Mesopleuron divided into transverse anterior and longitudinal lateral portions by a sharp carina (Fig 114) ..... ***Anthidiellum notatum*** (Latreille)  
 - Mesopleuron not sharply divided into anterior and lateral portions (Fig 115) .....  
 ..... ***Paranthidium jugatorium*** Say
- 35 Mesopleura with episternal groove present below scrobal groove (Fig 116)..... ***Dufourea***  
 - Mesopleura with episternal groove absent below scrobal groove (Fig 117) ..... 36

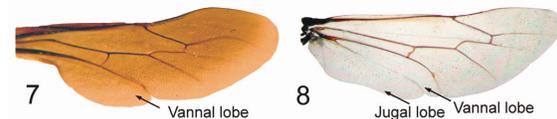
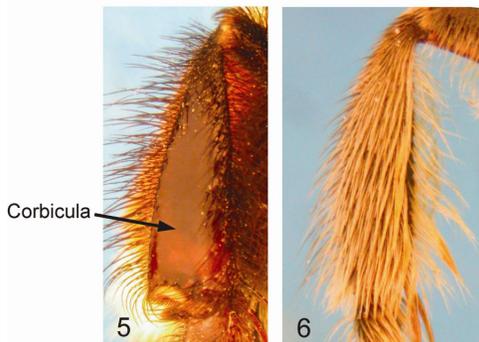
- 36 Female with well developed scopa on hind tibia (Fig 118) and less well developed scopa on metasomal sterna; male with yellow clypeus (Fig 120)..... **Macropis**
- Female with scopa entirely absent on hind tibia but very well developed on metasomal sterna (Fig 119); male with black clypeus (Fig 121)..... 37
- 37 Arolia absent (Fig 122)..... **Megachile**
- Arolia present (Fig 123) ..... 38
- 38 Dorsal surface of propodeum horizontal, short and made up of pits, separated from posterior surface by a carina (Fig 124) ..... **Heriades**
- Dorsal surface of propodeum not as above, EITHER sloping OR not made up of pits OR not separated from posterior surface by a carina (Fig 125) ..... 39
- 39 Mesoscutum with parapsidal lines not much longer than broad (Fig 126)..... **Osmia**
- Mesoscutum with parapsidal lines elongate (Fig 127) ..... 40
- 40 Mesosoma elongate (Fig 128); imaginary line tangential to anterior margins of tegulae at mid length of mesoscutum (Fig 130)..... **Chelostoma**
- Mesosoma not so elongate (Fig 129); imaginary line tangential to anterior margins of tegulae in anterior half of mesoscutum (Fig 131) ..... **Hopliti**



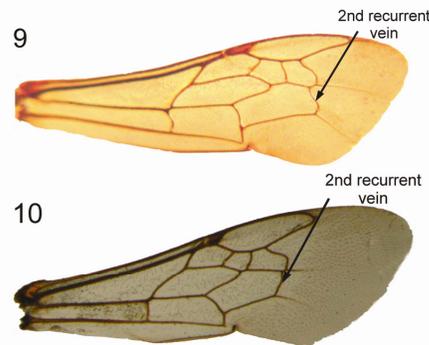
Figs. 1-2. Fore wings. 1. With three submarginal cells. 2. With two submarginal cells.



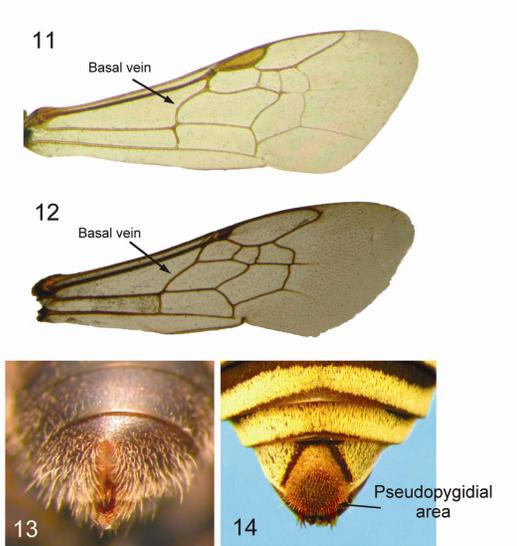
Figs. 3-4. Hind tibia. 3. Hind tibial spurs absent. 4. Hind tibial spurs present.



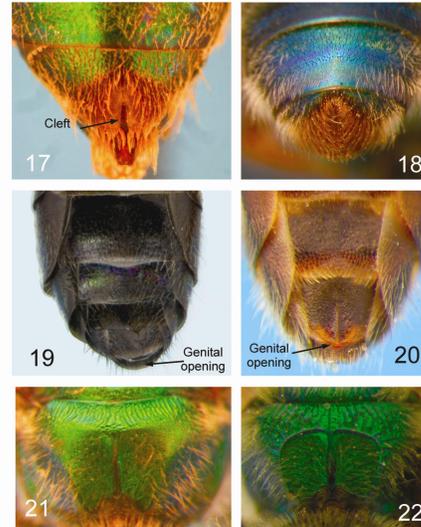
Figs. 5-8. 5. Hind tibia with corbicula. 6. Hind tibia without corbicula. 7. Hind wing without jugal lobe. 8. Hind wing with jugal lobe.



Figs 9-10. Fore wing. 9. Posterior portion of second recurrent vein arcuate. 10. Posterior portion of second recurrent vein not outwardly arcuate.



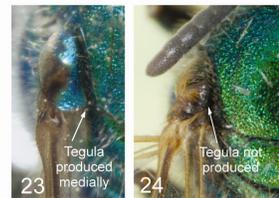
Figs. 11-14. 11. Fore wing with basal vein strongly arched. 12. Fore wing with basal vein not strongly arched. 13. Narrow pseudopygidial area of female. 14. Broad pseudopygidial area of female.



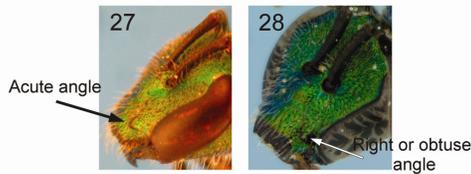
Figs. 17-22. 17. Pseudopygidial area of female divided by a deep cleft. 18. Pseudopygidial area of female entire. 19. Male with genital opening at extreme apex of metasoma. 20. Male with genital opening slightly in front of the apex of metasoma. 21. Posterior surface of propodeum lacking distinct carinate rim. 22. Posterior surface of propodeum entirely surrounded by a strong carina.



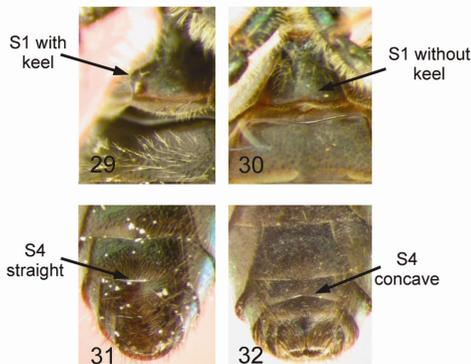
Figs 15-16. Hind leg. 15. Without scopa. 16. With scopa.



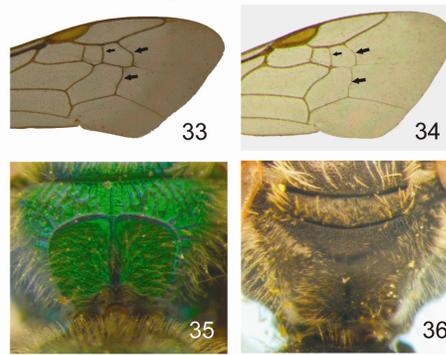
Figs. 23-26. 23. Tegula with inner posterior angle somewhat produced inwardly. 24. Tegula evenly rounded posteriorly. 25. Basitibial plate of female short, barely extending beyond apex of femur. 26. Basitibial plate of female extending well beyond apex of femur.



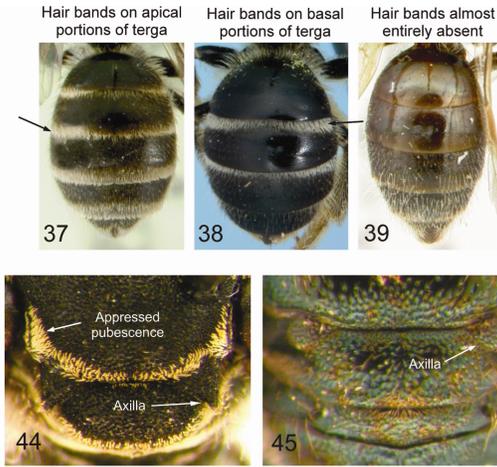
Figs. 27-32. 27. Face with paraocular lobe forming an acute, but rounded angle projecting onto clypeus. 28. Face with paraocular lobe forming at most a right angle onto clypeus. 29. Female S1 with a median keel. 30. Female S1 without a median keel. 31. Male S4 with a straight margin. 32. Male S4 with a concave margin.



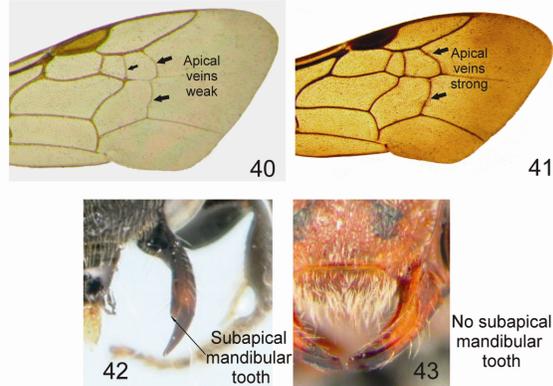
Figs. 27-32. 27. Face with paraocular lobe forming an acute, but rounded angle projecting onto clypeus. 28. Face with paraocular lobe forming at most a right angle onto clypeus. 29. Female S1 with a median keel. 30. Female S1 without a median keel. 31. Male S4 with a straight margin. 32. Male S4 with a concave margin.



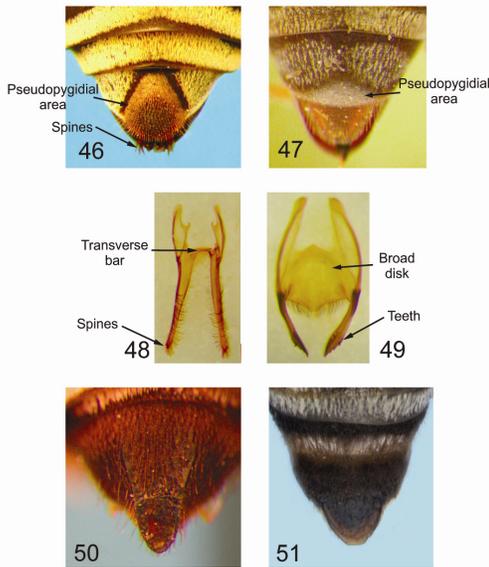
Figs. 33-36. 33. Fore wing with outer veins all strong. 34. Fore wing with one or more apical veins weakened. 35. Posterior surface of propodeum encircled by a strong carina. 36. Posterior surface of propodeum not encircled by a strong carina.



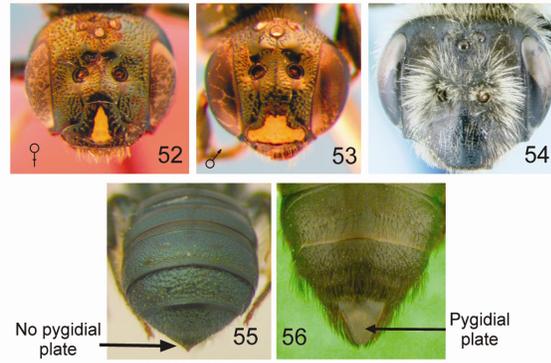
Figs. 44-45. Axillae. 44. Produced into a rounded lobe, angle or spine, not continuing outline of scutellum. 45. Not produced, continuing outline of scutellum.



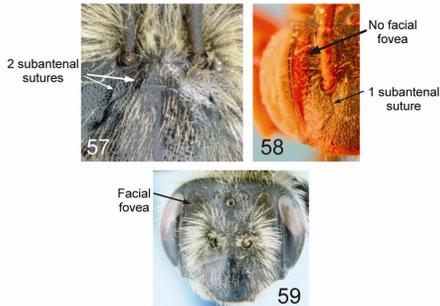
Figs. 40-43. 40. Fore wing with apical veins weakened. 41. Fore wing with apical veins strong. 42. Mandibles of female with subapical tooth. 43. Mandibles of female without subapical tooth.



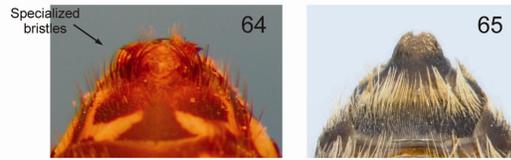
Figs. 46-51. 46. Pseudopygidial area of female at least half as long as greatest breadth. 47. Pseudopygidial area of female less than half as long as greatest breadth. 48. S6 of female with disc reduced to a transverse bar connecting a pair of slender processes. 49. S6 of female with large disc and a pair of shorter processes. 50. Pygidial plate of male with lateral margins parallel posteriorly, widened anteriorly. 51. Pygidial plate of male with lateral margins convergent posteriorly.



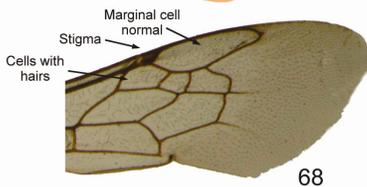
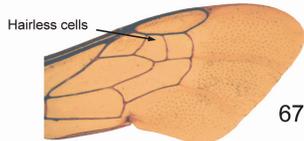
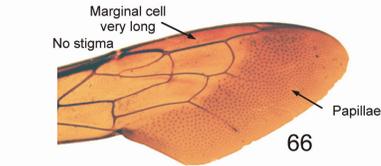
Figs. 52-56. 52. Frontal view of female head showing stripe on clypeus. 53. Frontal view of male head showing larger mark on clypeus. 54. Frontal view of female head showing clypeus without markings. 55. Apex of metasoma of female pointed and lacking pygidial plate. 56. Apex of metasoma of female with pygidial plate.



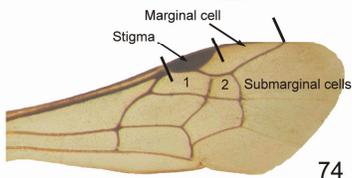
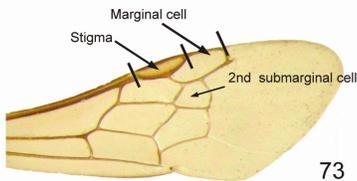
Figs. 57-61. 57. Face with two subantennal sutures. 58. Face with one subantennal sutures. 59. Face of female showing facial foveae shallow and entirely covered in short dense velvety hairs. 60. Lateral view of mesosoma of female showing propodeal corbicula. 61. Lateral view of mesosoma of female without propodeal corbicula.



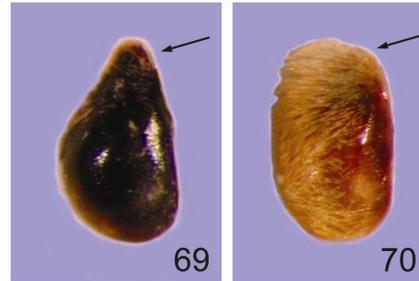
Figs. 62-65. 62. Integument of metasoma marked with white; scopa absent in female. 63. Integument of metasoma without colour marks; scopa present in female. 64. S6 of female with specialized bristles. 65. S6 of female without specialized bristles.



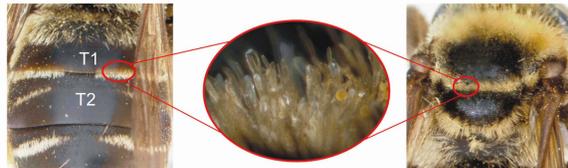
Figs. 66-68. Fore wing. 66. Without stigma, marginal cell very long. 67. With most closed cells hairless, apical regions papillated. 68. With closed cells with hairs and stigma.



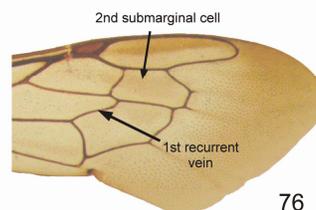
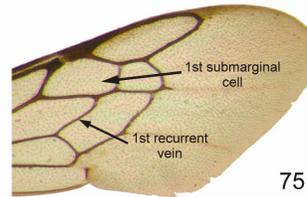
Figs. 73-74. Fore wing. 73. With shorter distance from stigma to distal end of marginal cell. 74. With longer distance from stigma to distal end of marginal cell.



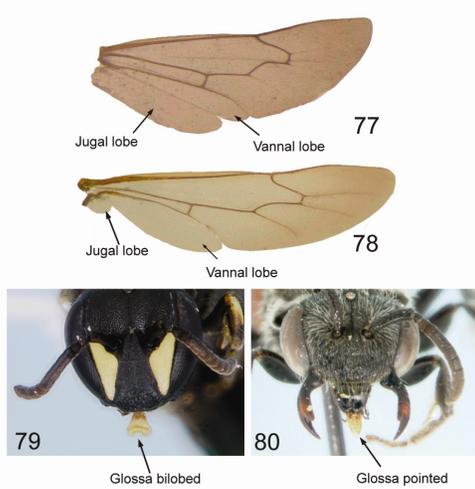
Figs. 69-70. Tegulae. 69. Narrowed anteriorly. 70. Not narrowed anteriorly.



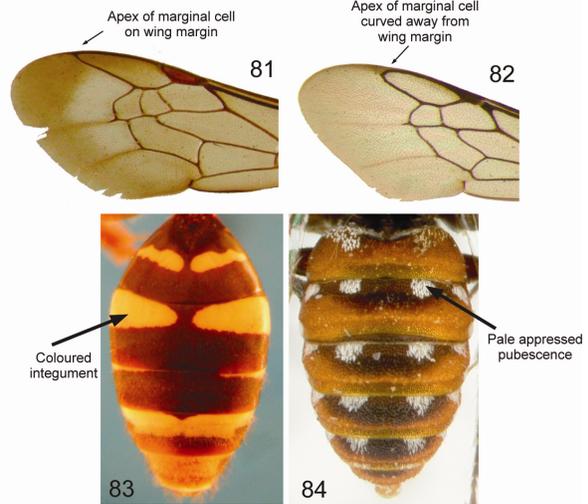
Figs. 71-72. Spatulate hairs on base of T2 and arising from suture between mesoscutum and scutellum.



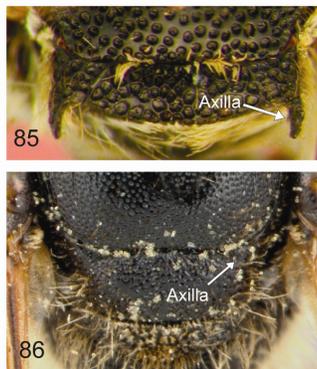
Figs. 75-76. Fore wing. 75. First recurrent vein received by first submarginal cell. 76. First recurrent vein received by second submarginal cell.



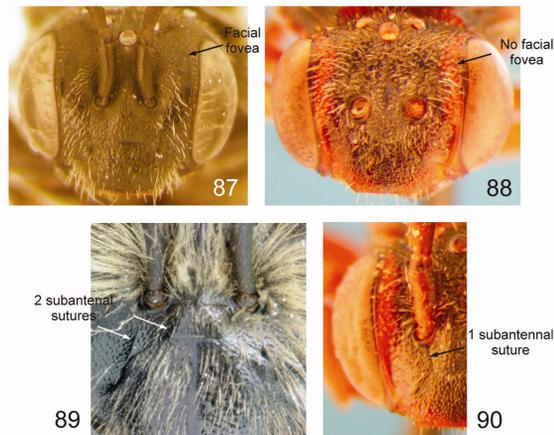
Figs. 77-80. 77. Jugal lobe of hind wing about 3/4 as long as vannal lobe. 78. Jugal lobe of hind wing less than 1/4 as long as vannal lobe. 79. Face with pale marks, and glossa bilobed. 80. Glossa pointed.



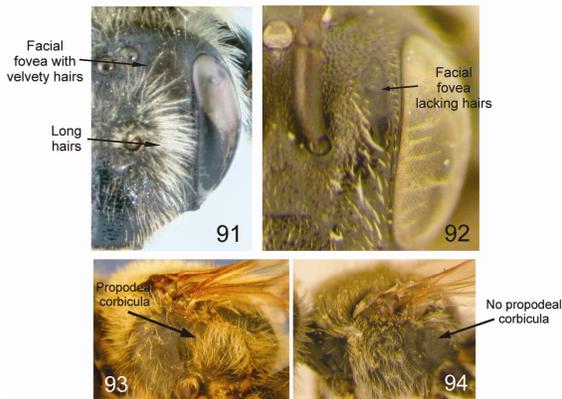
Figs. 81-84. 81. Apex of marginal cell on fore wing margin. 82. Apex of marginal cell curved away from fore wing margin. 83. Dorsal view of metasoma showing spots of coloured integument. 84. Dorsal view of metasoma showing patches of appressed pubescence.



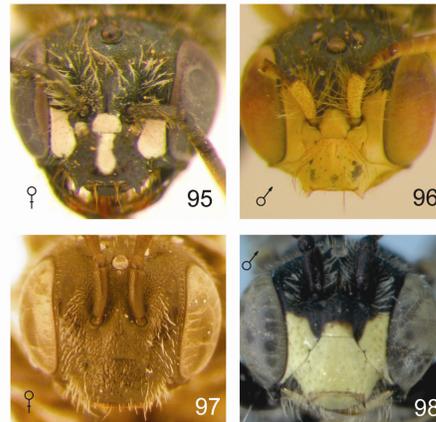
Figs. 85-86. Axillae. 85. Produced into a spine lateral to scutellum. 86. Not produced into a lobe, angle or spine lateral to scutellum.



Figs. 87-90. Frontal view of head. 87. With facial fovea. 88. Without facial fovea. 89. With two subantennal sutures. 90. With one subantennal suture.



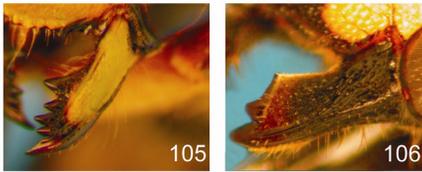
Figs. 91-94. 91. Face of female showing facial fovea covered in short velvety hairs. 92. Face of female with facial fovea lacking hairs. 93. Lateral surface of propodeum of female with long hairs forming a corbicula. 94. Lateral surface of propodeum of female without corbicula.



Figs. 95-98. Face. 95. With whitish marks in female. 96. Without covered in long hairs in male. 97. Black in female. 98. With most covered of bright yellow in male.



Figs. 99-100. Dorsal view of metasoma. 99. With yellow markings. 100. Without markings.



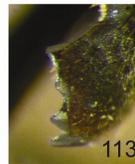
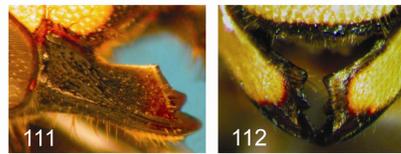
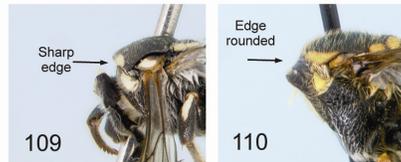
Figs. 105-108. 105. Mandible of female with five teeth. 106. Mandible of female with three teeth. 107. Legs without arolia. 108. Legs with arolia.



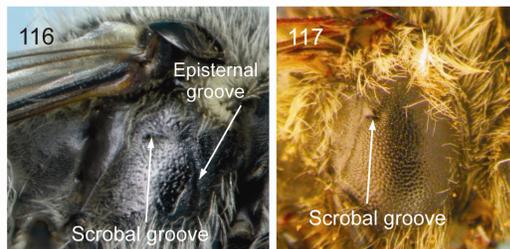
Figs. 114-115. 114. Mesopleuron divided by a sharp carina. 115. Mesopleuron not divided by a sharp carina.



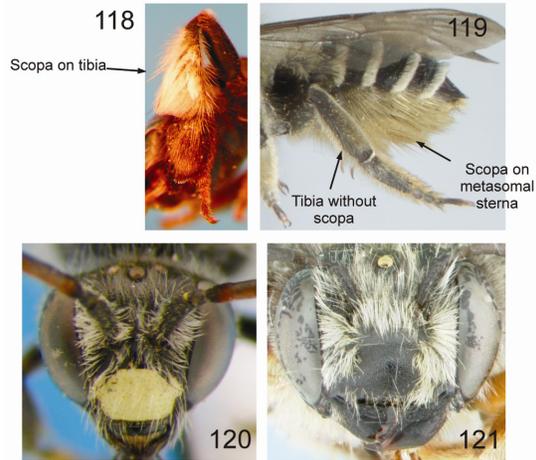
Figs. 101-104. 101. Female metasomal scopa absent. 102. Female metasomal scopa present. 103. Metasoma of male lacking spines or protuberances near apex. 104. Metasoma of male with spines or processes near apex.



Figs. 109-113. 109. Anterior margin of mesoscutum angularly produced so that there is a sharp edge. 110. Anterior margin of mesoscutum rounded. 111. Mandible with three teeth. 112. Mandible of male with three teeth. 113. Mandible of female with four teeth.



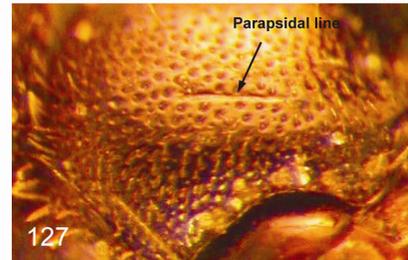
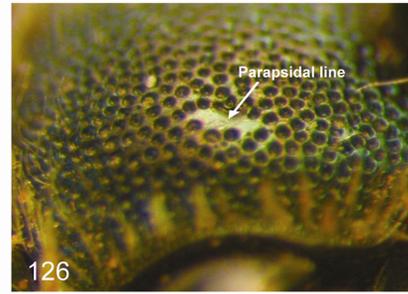
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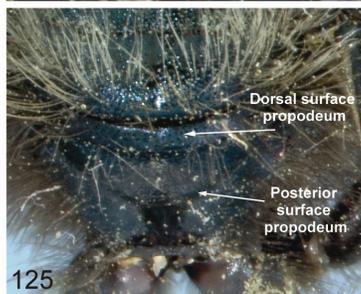
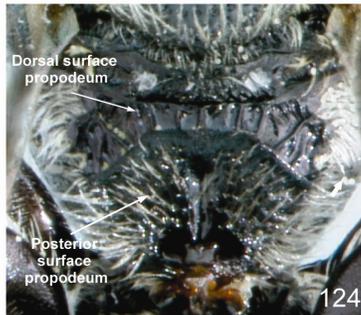
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Figs. 126-127. Mesoscutum. 126. With parapsidal lines not much longer than broad. 127. With parapsidal lines elongate.



Figs. 124-125. Dorsal surface of propodeum. 124. Horizontal, short, made up of pits, separated from posterior surface by a carina. 125. Sloping, not made up of pits, not separated from posterior surface by a carina.



Figs. 128-131. 128. Mesosoma elongate. 129. Mesosoma not so elongate. 130. Imaginary line tangential to anterior margins of tegulae at mid length of mesoscutum. 131. Imaginary line tangential to anterior margins of tegulae in anterior half of mesoscutum.

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