

A TAXONOMIC REVISION OF THE CANADIAN NON-*OSMIA*
OSMIINI
(HYMENOPTERA: MEGACHILIDAE)

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Abstract

The Osmiini (Hymenoptera: Megachilidae) is a tribe whose species encompass much of the biological diversity seen among bees (Michener 2007), and is one that contains many polytypic species in several genera. I use a molecular approach to taxonomy to test current morphological assessments of species-level diversity in the group, and herein examine all polytypic Canadian non-*Osmia* osmiine species. The analyses resulted in the following taxonomic considerations: **1)** the separation of *Atoposmia copelandica copelandica* and *Atoposmia copelandica arefacta* into two distinct species: *Atoposmia copelandica* and *Atoposmia arefacta*, respectively; **2)** the separation of the *Ashmeadiella gillettei* complex into two distinct species—*Ashmeadiella gillettei* and *Ashmeadiella rubra*, the latter species is considered synonymous with *Ashmeadiella gillettei rufiventris*; **3)** the potential addition of a new species to *Ashmeadiella* that is closely related to *Ashmeadiella buconis*—*Ashmeadiella spA* sp. nov. In addition, I present an up-to-date revision of Canadian non-*Osmia* Osmiini (Hymenoptera: Megachilidae). A key to the seven genera of Canadian Osmiini is provided and the 29 species of Canadian non-*Osmia* Osmiini are keyed, in dichotomous format for each genus, with all key features illustrated and full redescriptions of all species provided. Summaries of biogeographic distributions and life histories are included for each genus and its Canadian species.

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CHAPTER 1: INTRODUCTION

1.1 Bees and the Osmini (Hymenoptera: Megachilidae)

With over 20 000 described species, in seven families (Ascher & Pickering 2016), and on all continents but Antarctica (Michener 2007), bees represent one of the planet's major pollinators in both natural and agricultural ecosystems (Klein et al. 2007; Ollerton et al. 2011). Disease, malnutrition, exposure to pesticides, intrinsic genetic mechanisms, a shifting climate and habitat loss are all elements that have been used to explain the global drop in the abundance of wild pollinators (e.g. Meeus et al., 2011; Williams & Kremen 2007; van der Sluijs et al. 2013; Zayed & Packer 2005; Goulson et al. 2015; Larsen et al., 2005, respectively). Considered one of the most economically important groups of organisms (Gallai et al. 2008), a reduction in the abundance of these wild pollinators threatens the health of ecosystems and the viability of many of our food crops (Klein et al. 2007). Conservation efforts for most bee communities continue to be hindered by a lack of understanding of the composition of natural populations, their dynamics and their individual requirements (e.g. Colla & Packer 2008; Potts et al. 2010; Goulson et al., 2015). Protection and conservation of these pollinators must begin with a thorough exploration of the individual species themselves, through taxonomy, as this essentially forms the framework upon which we begin to understand the components of biodiversity (Keogh 2010).

Bees arose from among the crabronid wasps (Branstetter et al. 2017), which, together with the other families of apoid wasp, form the Apoidea (Comstock 1924; Michener 1944; Brothers 1975; Lomholdt 1982; Prentice 1998; Melo 1999; Michener 2007). Bees are thought to have undergone simultaneous radiations alongside the angiosperms, a notion that is supported both by the reliance of bees on angiosperm pollen, and by the fundamental role bees play in angiosperm reproduction (Litman et al. 2011). Today, bees maintain a variety of floral relationships in that they display oligolecty, those who forage from one particular plant taxa only, or polylecty, those who forage on a wide variety of floral taxa (Cane & Sipes 2006). The reproduction of many flowering plant species (nearly 75% of all angiosperm species) is directly dependent on pollination by bees (Mitchell et al. 2009), and many self-pollinating plants require pollination by bees to increase fruit set, a vital food source in many ecosystems (Al-Ghzawi et al. 2007). It has been suggested that roughly 80% of our food crops are pollinated by bees (Allsopp

et al. 2008) and their ecosystem services in this regard have been valued at US\$226 billion (Gemmill-Herren 2016). Bees are very sensitive to changing environmental conditions (e.g. Torchio 1990; Kevan et al. 1997; Banaszak 2000; Kremen & Ricketts 2000; Steffan-Dewenter et al. 2002; Kerr et al., 2015) and to many of the pesticides that are readily applied to commercial food crops (eg. Abbott et al. 2008; Pettis et al. 2013; Arena & Sgolastra 2014). Many cavity-nesting solitary bees have been established as manageable pollinators (Torchio 1991; Bosch & Kemp 2002; Freitas & Pereira 2004) thanks to the suitability of artificial nesting sites for many species (Krombein 1967; Sheffield et al. 2008), but they often remain excluded from commercial crops due to continued pesticide use (Park et al. 2015). Recent declines in managed pollinators at a global scale concurrent with an increase in demand for insect-pollinated crops has reemphasized the importance of wild bee communities in maintaining healthy ecosystems (Kevan & Phillips 2001; Aizen & Harder 2009).

The family Megachilidae represents the second largest family among the bees with respect to number of described species (>4000; Sheffield et al. 2011) and genera (Ascher & Pickering 2016) and is traditionally divided into two subfamilies—Megachilinae and Fideiinae (for different views see—Gonzalez et al. 2012, Litman et al. 2011). It is one of two families of long-tongued bees, the other being Apidae (Michener 2007). Megachilid bees have the pollen-carrying scopa restricted to the metasomal sterna (with few exceptions among the cleptoparasitic genera, Pararhophitini and the genus *Aspidosmia* (Gonzalez et al. 2012)) and are easily recognizable as robust bees with head widths usually as wide as, or wider than, the mesosoma (Banaszak & Romashenko 1998; Michener 2007), and a labrum that is broadest at the very base (Michener 2007; Packer & Ratti 2009). Otherwise, it is only characters of the proboscis (see Michener 2007 for details) that unite the Megachilidae since the inclusion of two taxa—the Fideiinae and the Pararhophitini—make the Megachilidae less easy to define morphologically (see Michener 2007 for details). The inclusion of the Fideiinae and the Pararhophitini among the Megachilidae, though limiting the characters that define the family, has been supported both among adult forms (Rozen 1970, 1973a; McGinley & Rozen 1987; Roig-Alsina & Michener 1993; Gonzalez et al. 2012) and larval forms (McGinley & Rozen 1987; Rozen 1973b). Most Megachilinae have the distal margin of the mandible elongate because the pollex is expanded to

form two to several teeth (Michener & Fraser 1978), often making these bees easily recognizable.

One of the five tribes among the Megachilinae is the Osmiini; bees with such biological diversity that they are considered to encompass all the diversity seen among bees (Gonzalez et al. 2012). Osmiine bees vary in size (from 3.4mm to 18mm), are usually either black or brown and non-metallic usually with pale pubescence, or, are green to blue metallic, with pale to black pubescence (Michener 2007). These bees also display diverse nesting strategies and floral relationships. Most osmiine bees nest in pre-existing cavities, usually holes in wood, stems or in the ground (Michener 2007). Like most of the Megachilidae (not Lithurgini, and some cleptoparasitic genera of the Megachilini), osmiines almost always construct their nests using foreign materials, a strategy they share with some bees of the Apinae (Michener 2007). These materials are diverse and found alone or in any number of combinations, and include masticated leaf and/or flower pieces and/or pulp, mud, sand and pebbles, nectar, gum and resin (e.g. Krombein 1967; Parker 1975; Rozen 1987; Yanega 1994; Rozen & Eickwort 1997; Michener 2007; Müller 2013). Many species of osmiine bees, most notably those of *Chelostoma*, display what is considered the ancestral state in being oligolectic on particular floral taxa, at least on the level of plant family or genus (Sedivy et al. 2008), however, the majority of osmiines are generalists (Michener 2007).

Globally the tribe is represented by 13 genera (Praz et al. 2008; Gonzalez et al. 2012) and nearly 1200 described species (Ascher & Pickering 2016). Members of the Osmiini can be recognized among the Megachilinae, by the following combination of characters: episternal groove absent; forewing with two submarginal cells and with second recurrent vein basal to second submarginal crossvein; arolia present; all other tribes having one or more alternative combinations (Michener 2007). Osmiines have a univoltine life cycle and are thought to have originated in the Palaearctic, the Earth's largest ecozone, where they are most diversified (Müller 2013). Nesting strategies in the group are thought to have allowed for their dispersal across oceans inside buoyant flotsam such as logs or stems (Praz et al. 2008; Gonzalez et al. 2012). Osmiines inhabit all continents except Australia and Antarctica (Praz et al. 2008), but have only recently been collected in South America (see Gonzalez & Griswold 2011). As is the case for a great majority of bees, osmiines are most diverse in mediterranean and xeric climates (Michener

1979). In the Nearctic, the Osmiini is represented by eight genera and over 320 species, with seven genera and about 108 species comprising the Canadian fauna (Michener 2007; Ascher & Pickering 2016).

The first molecular phylogeny of the Osmiini was provided by Praz et al. (2008). Their results concluded that the core genera of the Osmiini form a monophyletic group but that four small genera—*Afroheriades*, *Noteriades*, *Ochreriades* and *Pseudoheriades*—referred to as ‘problem taxa’ by Michener (2007), render the tribe paraphyletic (Praz et al. 2008). These conclusions were somewhat inconsistent with the results of a more recent morphology-based cladistic analysis (Gonzalez et al. 2012) that suggested the inclusion of *Ochreriades*, *Afroheriades* and *Pseudoheriades* among the Osmiini. However, both studies supported the removal of *Noteriades* from the tribe, and Gonzalez et al. (2012) supported placement of the small genus among the Megachilini, as was suggested initially by Griswold (1985; as cited in Gonzalez et al. 2012).

Sexual dimorphism and highly speciose genera make species recognition in the Osmiini somewhat difficult. Furthermore, many genera in the Osmiini contain polytypic species. For taxonomists, this confuses matters, and a lack of understanding regarding the classification of many osmiines hinders our ability to make sound judgments in conserving biodiversity within the tribe. This biodiversity is often held within what we often refer to as a subspecies, but in reality what we are potentially observing are real time speciation events (Phillimore & Owens 2006; Müller et al. 2007; Cacho & Baum 2012). Analyses using molecular data are often thought now to be necessary to help determine proper classifications for such taxa, and to help uncover new paths to recovering a rigorous phylogeny for the tribe.

Many controversies with respect to the evolutionary history of the group remain (Michener 2007), and although advances in scientific thought have caused paradigm shifts in the field of systematics, current analyses of the evolutionary history of the Osmiini remain unresolved (e.g. Praz et al. 2008; Litman et al. 2011; Gonzalez et al. 2012). From the traditional morphological analyses to new integrative approaches that combine morphological and molecular analyses, an understanding of the phylogeny of the Osmiini is, and has been, rather poor since it was first examined in the mid-20th century (Michener 1941). Continued efforts in all

areas of systematics are necessary to progress to a clearer understanding of the composition of and the position of (in terms of relationships and function within a community) the Osmiini in all regions of the world.

1.2 Taxonomy and Systematics

Taxonomy is the practice of naming and classifying living things into their natural groupings. Modern day taxonomy began with Carl Linnaeus' *Systema Naturæ* (1735 [1964 edition]), and has since reflected more and more the theory of evolution by natural selection introduced by Darwin in *On the Origin of Species* (1859). Taxonomy is fundamental to many areas of biology (Mallet & Willmott 2003) and is a branch of the discipline of systematics. The latter is devoted to deciphering the relationships, both past and present, among living things. These relationships are often visualized using phylogenies, usually in the form of phylogenetic trees, where branching patterns reflect evolutionary relationships among taxa. Phylogenetics was introduced as a Tree of Life by Darwin in a field notebook that later was included in *On the Origin of Species* to help explain his theory of evolution (Darwin 1859). Since Darwin, biological diversity has become understood as the result of a dynamic process rather than as a static picture. This has created the need for up-to-date records that build upon past works in ever-more creative ways.

Today we find ourselves with an urgent need for reliable taxonomy when there is a lack of formally trained and experienced taxonomists (e.g. Wilson 1985; Winston 1999; Godfray 2002). In the midst of the biodiversity crises in which we are losing species and habitat at an alarming rate (Wilson 1992), conservation efforts are in vain where biodiversity has not first been described, mapped and measured by taxonomists (Winston 1999). A global lack of funding and a reduction in the number of job posts demanding taxonomic expertise (Ebach et al. 2011; Packer et al. 2009) has resulted in incomplete species accounts in studies in ecology and conservation biology, making formal conclusions difficult to reach. In an era that demands sound advice for conserving biodiversity on a global scale, a better understanding of the systematics of populations and of species is necessary (Ryder 1986; Vernon et al. 2017).

The definition of a species has long been a topic of controversy in all fields of biology (Richards 2010). No consensus on how to delineate a species has been reached since its introduction as a biological unit in Carl Linnaeus' *Systema Naturæ* (1735 [1964 edition]), and many of the nearly two dozen definitions in use today are incompatible (de Queiroz 1998). In his chapter on species concepts, de Queiroz (1998) proposes a means to unify the multitude of contemporary species concepts that have led to “the species problem”—wherein one species concept cannot be agreed upon by all groups of biologists. He suggests that each species concept is in fact nothing more than a slight modification to, or special case of, the general lineage concept, but that each concept makes use of different tools that can be applied to more specific fields of biology. While all definitions have their own associated advantages and disadvantages, modern day taxonomists are continuously trying to find more empirical approaches to defining a species, and recently some have suggested that genetic data serve to better delineate a species since this information may be better at detecting genetically discrete units in populations than is morphology (Hebert et al. 2003a, 2003b; Packer et al. 2009;).

Subspecies is a below species-level taxonomic rank and is a level of classification surrounded by much contention (Mayr 1982), only to be made worse with the introduction of molecular studies that were often incongruent with the delineations of subspecific taxa set forth by traditional taxonomy (Phillimore & Owens 2006). Subspecies are essentially taxa that vary by characters that are less distinct than those that separate species, but more important than those that characterize ordinary intraspecific variation. If these differences in phenotypic traits are sufficient enough to permit subspecies identification, we need to consider whether they are sufficiently diagnostic to suggest species level taxonomy for those units (Laurence Packer, personal communication). Though discontinuities in the distribution of phenotypic traits can provide insight into patterns of intraspecific genetic diversity which can be extrapolated to estimate evolutionary divergence (Mayr & Ashlock 1991; Phillimore & Owens 2006), they do not necessarily signify adaptive variation and thus, may not remain in the population in the long term (Ryder 1986). Confusion over the meaning of the term subspecies continues to hinder progress in taxonomy, evolutionary biology and conservation studies by not always accurately reflecting evolutionary diversity (Zink 2004), or simply by being incomplete and/or inaccurate.

As outlined in Winston (1999), a species description is a detailed account of an organism and follows a general formatting guideline depending on the taxon in question. It is primarily based on morphology but must be supplemented by geographic data and will sometimes include genetic data (Dayrat 2005). In a taxonomic revision, arguably the most useful of works that includes species descriptions, these data update the taxonomy of a group which facilitates identification and/or describes new species (Maxted 1992). Revisions update and improve the taxonomic understanding of a particular group, and make the information available to a wider audience. The examination of large numbers of specimens, usually across vast geographic areas, is required in order to capture the composition of, and variability within, a group that is being revised. Furthermore, each holotype—the single specimen upon which the description of a species is based — must be examined as it provides the benchmark from which intraspecific variation can be observed (International Commission on Zoological Nomenclature 1999). The holotype is designated by the author at the time of description (Winston 1999). When possible, the author further designates a group of conspecifics as a paratype series, and from this series, an individual as the allotype—the opposite sex of the holotype. Increasingly, revisions today involve integrative taxonomy.

In integrative taxonomy, species boundaries are delineated using multiple, complementary lines of evidence—distributional, morphological and molecular (Dayrat 2005). Molecular evidence, though more recently developed than other lines of evidence, has become a useful tool in testing morphological assessments of species identity (Gibbs 2009a, 2009b), and has often helped to discover cryptic species (for example: Packer & Taylor 1997; Danforth et al. 1998; Hebert et al. 2004; Gibbs 2009a, 2009b; Williams et al. 2012). Molecular datasets, perhaps especially those from DNA barcoding, can help discern the true identity of an organism, and is becoming part of the framework upon which species identification is now based (Kuhlmann et al. 2007; Gibbs 2009a, 2009b; Williams et al. 2012).

DNA barcoding is based on the premise that all species have their own diagnostic sequence with less variation within, than between them: this is termed the ‘barcode gap’; and this variation can be used to infer population structure at many levels (Dayrat 2005; Kuhlmann et al. 2007; Groom et al. 2013). Its usefulness has been shown in many areas of taxonomy including the sorting of new collections into taxonomic units, aiding in the assignment of damaged or

misleading specimens to particular taxa, associating males and females in sexually dimorphic taxa and supplementing other taxonomic datasets (e.g. Hebert et al. 2004; Schindel & Miller 2005; Gibbs 2009a, 2009b; Sheffield et al. 2009; Sheffield & Rehan 2011). It employs a 658 base pair fragment of the mitochondrial cytochrome oxidase subunit I (COI), the established standard for animals (e.g. Hebert et al. 2003a; Gibbs 2009b) which usually exhibits low intraspecific diversity (e.g. Hebert et al. 2003a, 2003b; Kim et al. 2009; Murray et al. 2008). The advantages to using mitochondrial DNA are that this genetic material is found in high numbers in most cells, and, barring mutation, it remains identical from parent (mother) to offspring (Ivanova et al. 2006). DNA barcoding has been met with much controversy in the past (Trewick 2008; Packer et al. 2009; Goldstein & DeSalle 2011), but because these data detect and define genetically discrete units within populations, they lie at the heart of any species concept, and are thus invaluable evidence when delineating species boundaries (Hebert et al. 2003b; Packer et al. 2009). Where morphological information is unreliable, molecular datasets have been, and are being, used to aid in the diagnosis of new species (e.g. Kuhlmann et al. 2007; Sheffield et al. 2009).

1.3 Research Focus

For my MSc thesis I have completed a taxonomic revision of the Osmiini (Hymenoptera: Megachilidae) of Canada (Table 1; excluding *Osmia*, a highly speciose genus currently being explored in depth by Molly Rightmyer). In conducting a taxonomic revision of these genera I have provided a more complete taxonomic understanding of the osmiine bees occurring in Canada, and have produced user-friendly identification keys that encompass all of the Canadian non-*Osmia* species of the tribe. I have used an integrative approach to taxonomy that incorporated both genetic data (mtDNA barcoding) and traditional morphological studies. My research efforts have also assessed the validity of numerous named subspecies in the non-*Osmia* osmiines south of the Canadian/US border for which one or more subspecies are found in Canada.

1.4 References

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CHAPTER 2: DNA BARCODING UNCOVERS HIDDEN DIVERSITY WITHIN THREE GENERA OF CANADIAN NON-*OSMIA* OSMIINI (HYMENOPTERA:MEGACHILIDAE)

2.1 Introduction

Theodosius Dobzhansky eloquently stated that “nothing in biology makes sense except in the light of evolution” (Dobzhansky 1973), and so, taxonomy, or the ability to accurately separate distinct taxonomic units, is an essential practice that lies at the base of most biological sciences because without it, one cannot accurately reconstruct paths of evolution (Dayrat 2005). For many bees, including those of the Osmiini (Megachilidae), taxonomic knowledge is incomplete and often obscured by a lack of understanding of relationships within the tribe (Michener 2007). Nearly 1200 species (Ascher and Pickering 2016) of osmiine bees are currently recognized globally in 16 genera (Gonzalez et al. 2012), on all continents except Antarctica and Australia (Praz et al. 2008; only recently found in South America with a single species known from Colombia (Gonzalez & Griswold 2011)). Taxonomic changes for the tribe have been proposed many times, especially recently (Praz et al. 2008; Sedivy et al. 2008; Gonzalez et al. 2012; Sedivy et al. 2013) when molecular strategies began to offer a means to test morphological assessments. Sexual dimorphism and highly speciose genera makes species recognition in the Osmiini somewhat difficult (Michener 2007), and polytypic species have been described in most genera, the subspecies representing a taxonomic level whose definition and utility is debated (eg. Mayr 1982; Will et al. 2005; Zink 2004).

Molecular evidence has become a useful tool in testing morphological assessments of species identity (Page et al. 2005; Gibbs 2009), and has helped to elucidate cryptic species many times (e.g. Carman & Packer 1997; Packer & Taylor 1997; Danforth et al. 1998; Hebert et al. 2004; Witt et al. 2006; Gibbs 2009a; 2009b; Williams et al. 2012). Molecular datasets, perhaps especially those from DNA barcoding efforts, can help discern the true identity of an organism, and have become part of the framework upon which species identification is now based (e.g. Kuhlmann et al. 2007; Gibbs 2009a; 2009b; Williams et al. 2012). DNA barcoding has been met with much controversy in the past (Trewick 2008; Goldstein & DeSalle 2011), but because these

genetic data are able to detect the absence of gene flow in populations, it forms the basis of any species concept and is thus invaluable evidence when delineating species boundaries. Where morphological information is unreliable, molecular datasets have been, and are being, used to aid in the diagnosis of new species (e.g. Hebert et al. 2003a; Will et al. 2005; Kuhlmann et al. 2007; Gibbs 2009a; 2009b; Packer et al. 2009).

In order to get a better understanding of the composition of the Canadian non-*Osmia* Osmiini, and to test current morphological assessments of species-level diversity in the group, I herein examine all polytypic Canadian species in the tribe¹. The composition of Canadian non-*Osmia* Osmiini has not yet been specifically assessed, and classifications of many species within it are outdated. I sampled species and subspecies as part of a review of the current composition of the tribe (excluding *Osmia*²). I clarify the classification of described subspecies within a subset of Nearctic Osmiini (including all those with representatives in Canada), and report the existence of cryptic species.

2.2 Methods

DNA extraction, PCR and sequencing of tissue samples—a single midleg from pinned specimens (less than ten years old)—were performed at the Canadian Centre for DNA Barcoding at Guelph University (Guelph, Ontario) using standard protocols described in Hebert et al. (2003b). One of two universal primers for amplifying the DNA barcode sequence for insects [(LCO1490 and HCO2198; Folmer et al. 1994) or the variants LepF1 and LepR1 (Hebert et al. 2004)] were used. DNA barcodes were generated for at least one specimen (where available) for each described subspecies for those polytypic species with at least one subspecies known from Canada (excludes *Chelostoma* and *Heriades*, see Table 2.1) and from as great a geographic range as possible. DNA barcode sequences were uploaded to BOLD: the **B**arcode of **L**ife **D**ata system (Ratnasingham & Hebert 2007). Only high quality sequences (those greater than 630 base pairs and without contamination/damage evident in the trace files) were considered in the analyses.

¹ A thorough examination of *Heriades* was not completed because the genus is in need of a complete revision at a North American scale. Several high quality sequences for all polytypic species in the genus (see Table 1) were obtained throughout their ranges, but extreme morphological variation in the specimens made it impossible to ascertain which subspecies were represented by each sequence. An initial examination of the DNA barcode data did not suggest species-level divergence/species complexes in any of the species clusters.

² In depth analysis of this speciose genus is under way by Molly Rightmyer.

The analytical system within BOLD was used in two ways: 1) to generate a neighbour-joining tree based on a Kimura-2 parameter (K2P) distance model of base substitution (Kimura 1980) to provide a graphic representation of the patterning of divergences (%) among species (Saitou & Nei 1987; Sheffield et al. 2009); and 2) the BINning system (Ratnasingham & Hebert 2013) was applied in order to quantify the strength of cohesion of barcode sequences at various taxonomic levels. The latter model examines the strength of association among lineages at each level in the taxonomic hierarchy based on COI sequence similarity, and then assigns a unique BIN number to each putative species level cluster (Ratnasingham & Hebert 2013). Sequence data were then downloaded from BOLD for further analyses.

Three further tree-building methods were used in order to determine if the patterns observed in the neighbour-joining tree built in BOLD were robust to more rigorous methods. COI barcode sequences (excluding primer sequences) were aligned by ClustalW (a general purpose alignment program for DNA or protein sequences) in MEGA: **M**olecular **E**volutionary **G**enetics **A**nalysis version 7 (Tamura et al. 2013), to allow the quantification and visualization of genetic distances between taxa (Sheffield et al. 2009). A neighbour-joining tree based on the *p*-distance model (with pairwise deletion of missing data) was created for each genus where polytypic species were assessed, and a phylogeny was generated using 1000 bootstrap replicates. Estimates of evolutionary divergence between sequences were subsequently quantified in MEGA by the number of nucleotide and amino acid base differences per site (represented herein as a proportion) (Nei & Kumar 2000). All ambiguous positions were removed for each sequence pair. A parsimony analysis was performed in TNT: **T**ree **A**nalysis Using **N**ew **T**echnology version 1.1 (Goloboff, Farris & Nixon 2008) following a driven search using default settings except for ratchet (10,000 iterations; up/down weight probabilities set to 10), drift (20 cycles) and ‘find minimum length’ set to 100. Characters were non-additive and equally weighted. A strict consensus was applied to all equally parsimonious trees and symmetric resampling (Goloboff et al., 2002) was performed for 100 replicates using a 33% probability of up and down weighting of each character. Results from TNT were visualized using WinClada version 1.0000 (Nixon 1999). A Bayesian analysis was performed using MrBayes version 3.2 (Ronquist, Huelsenbeck & Teslenko 2011), using the GTR: **G**eneralized **T**ime **R**eversible substitution evolutionary model with gamma-distributed rate variation across sites (Gibbs 2009a; Ronquist, Huelsenbeck &

Teslenko 2011). The analysis was run until an acceptable average standard deviation of split frequencies was obtained (i.e. below 0.01) (e.g. Gibbs 2009a; Ronquist, Huelsenbeck & Teslenko 2011). Results from the Bayesian analysis were visualized using FigTree version 1.4.3 (Rambaut 2016). Overall we included 107 DNA barcode sequences from Osmiini specimens collected throughout North America in the analyses.

2.3 Results

High levels of intraspecific divergence were noted among several polytypic species in the Canadian Osmiini (Table 2.1) denoting species complexes within three genera—*Ashmeadiella*, *Atoposmia* and *Hoplitis*. A total of 107 high quality DNA barcode sequences for polytypic North American Osmiini were obtained representing a total of 20 BINs in BOLD (Ratnasigham & Hebert 2013) for the three genera. Putative species identified from polytypic species previously described formed discrete clusters in the neighbour-joining trees in many cases. DNA barcoding revealed patterns in the sequences consistent with morphological assessments of species delineation but has also provided evidence of the need for taxonomic changes within a few genera among the Osmiini.

2.3.i *Ashmeadiella*

Phylogenetic analyses of the DNA barcode data for *Ashmeadiella* (Table 2.2) showed distinct clusters, but clusters did not correspond to existing patterns in morphology in all cases. Forty-one sequences were full length, another four were slightly shorter (Table 2.2), all were used in the analysis and represented nine BINs in BOLD. The analysis of the 45 sequences performed in MEGA (Fig. 2.1; Table 2.3) showed **1**) minimal intersubspecific divergences between the following subspecies: *A. b. buconis* and *A. b. denticulata*; *A. c. cactorum* and *A. c. basalis*; *A. c. cubiceps* and *A. c. clypeata*; and *A. c. californica* and *A. c. florissantensis* and *A. c. sierraensis*; **2**) divergences between subspecies in the *A. gillettei* complex were well above the 2% species delineation boundary with *A. g. rubra* and *A. g. rufiventris* clustering together while sequences for *A. g. gillettei* clustered as a separate putative species; **3**) a sequence, “AB sp. novo.”, closely related to the *A. buconis* complex shows a deep divergence from the *A. buconis*

cluster consistent with species level differentiation; 4) a sequence, ‘NM A c cactorum’, closely related to the *A. cactorum* complex shows a deep divergence from its nearest cluster.

The intrasubspecific divergences in the nucleotide p-distances within the *A. buconis* cluster have a maximum of 1.9 while the minimum divergence between the unique sequence (“AB sp. novo.”) and those within the *A. buconis* cluster is 2.3 (Table 2.3). One sequence ‘NM A c cactorum’ shows a divergence of over 2% from the nearest sequence in its cluster in the NJ tree (Fig. 2.1), but, this divergence represents less than 0.011 when nucleotide p-distance divergences are calculated (Table 2.3). The cluster containing only *A. g. gillettei* (Fig. 2.1, Box B) shows a divergence of over 2% from the cluster containing the other described subspecies—*A. g. rubra* and *A. g. rufiventris* (Fig. 2.1, Box A). The remaining putative species clusters, *A. buconis*, *A. californica* and *A. cubiceps*, show low intrasubspecific divergence.

The parsimony analysis in TNT yielded 27 trees. The consensus tree (Fig. 2.2) resulted in the same clusters as were obtained in MEGA (Fig. 2.1), and symmetric resampling showed strong support values in most instances throughout the tree (Fig. 2.2). In contrast to the NJ tree obtained using MEGA (Fig. 2.1), but concurrent with the nucleotide and amino acid distances calculated using MEGA (Table 2.3), the sequence ‘NM A c cactorum’ shows little divergence from other sequences in the ‘A c cactorum S’ complex. Also in contrast to the NJ tree, there does not appear to be strong support to split *A. gillettei* into two species according to their subspecific designations (Fig. 2.2). Results from the Bayesian analysis are congruent with those of the parsimony analysis with each of the putative species forming monophyletic groups with high posterior probabilities (Fig. 2.3). However, the analysis suggests that, like in the NJ tree, *A. gillettei* represents two distinct species clusters (Fig. 2.3). The analysis was run for 854100 generations after reaching a standard deviation of split frequencies below 0.01 (0.009952).

2.3.ii Atoposmia

Phylogenetic analysis of the DNA barcode data for *Atoposmia* (Table 2.4) showed distinct clusters which corresponded well with patterns in morphology. Nine 658bp DNA sequences representing three BINs in BOLD were used in the analyses. A neighbour-joining tree (Fig. 2.4) of the nine *Atoposmia* sequences showed minimal intraspecific divergence within the

A. abjecta complex while divergences between subspecies in the *A. copelandica* complex were high (intrasubspecific divergences in nucleotide p-distances were below 0.009 while intersubspecific divergencies between the clusters for *A. c. copelandica* and *A. c. arefacta* were a minimum of 0.083) and indicative of different BINs (Fig. 2.4; Table 2.5).

The parsimony analysis in TNT yielded only one tree, with each putative species resolved as a distinct monophyletic unit (Fig. 2.5). Symmetric resampling showed strong support (GC value= 100) for all three putative species of *Atoposmia*. The results of the Bayesian analysis are congruent with those from the parsimony analysis. Each of the putative species forms a distinct monophyletic group with a high posterior probability (100) for all clusters (Fig. 2.6). The analysis was stopped after 7000 generations reaching a standard deviation of split frequencies below 0.01 (0.005612).

2.3.iii *Hoplitis*

Distinct clustering was evidenced in the *Hoplitis* species complexes, but again, the clustering did not necessarily correspond to patterns of morphology in current taxonomy. Fifty-three 658bp sequences (Table 2.6) were used to elucidate putative species within the *Hoplitis* species complexes. The analyses of the 53 sequences performed both in MEGA (Fig. 2.7; Table 2.6) and in TNT (Fig. 2.8) showed **1**) minimal intrasubspecific divergences in clusters for *H. fulgida* and *H. albifrons* (Fig. 2.7c); **2**) some divergence between sequences across subspecies for *H. grinnelli*, but clusters did not support a monophyly for either subspecies (Fig. 2.7 b); **3**) relationships within the *H. producta* complex remain unclear following these analyses (Fig. 2.7a). Within the *H. producta* complex there are relatively well supported clusters (Fig. 2.7a and Fig 2.8), but these clusters contain more than one subspecies and thus, show no monophyly at the level of subspecies. Moreover, results from the Bayesian analysis are congruent with those of the parsimony analysis with each of the species, as defined by morphology, forming monophyletic groups with relatively high posterior probabilities (Fig. 2.9) and no evidence for monophyly at the level of subspecies. The analysis in MrBayes was run for 384000 generations reaching an average standard deviation of split frequencies of 0.009964.

2.4 Discussion/Taxonomic Considerations

The literature is replete with evidence to suggest that the inclusion of DNA barcoding data is invaluable in aiding in the discovery of species boundaries (e.g.s Hebert et al. 2003a; 2003b; 2004; Dayrat 2005; Gibbs 2009a; 2009b; Goldstein & DeSalle 2011). As is often the case with insects, the distinguishing characters of closely related adult forms are usually subtle and blurred by intraspecific variation (e.g. Meyer & Paulay 2005). This is no exception among the Osmiini wherein species differ by subtle morphological characters that can easily be, and have been, mistaken for intraspecific variation, or have been entirely overlooked. The same observations have been made on a number of occasions. For example, the same is true of other bee taxa, notably among the Halictidae wherein studies in integrative taxonomy for the genus *Lasioglossum* represent an example where DNA barcoding has been an invaluable tool in uncovering cryptic diversity in a group in which adult morphologies differ from species to species by subtle morphological characters at best (e.g.s Gibbs 2009a; 2009b). Burns et al. (2008) discuss the utility of DNA barcoding in delineating species of skipper butterflies in which distinguishing characters in adults are also blurred by intraspecific variation but are more notable among pupal and larval life stages.

The inability of the DNA barcoding system to resolve taxonomic classification in many instances in this study does not come as a surprise when one considers the scope of the analysis. Because DNA barcoding has been shown to perform poorly in assisting in species/subspecies delineation where groups are incompletely sampled (e.g. Meyer & Paulay 2005) the lack of sound results may yet represent another example where a larger dataset is required in order to elucidate boundaries where intraspecific and interspecific variation diverge. In many cases, especially within *Hoplitis*, the results illustrate a high degree of cryptic diversity within well-defined species that does not support the subspecies-level classification as it is currently understood through traditional taxonomy. For example, in the case of *Hoplitis*, many populations have become somewhat reproductively isolated in many parts of North America (Michener 1947) and thus, the high levels of intraspecific divergence in this genus is to be expected (Porco et al. 2012). The results presented here suggest that there is potential to greatly increase the number of well-supported clusters in COI sequencing with broader sampling efforts (Meyer & Paulay 2005) and that, even amid mismatch between morphological and molecular species- and

subspecies-level identification, DNA barcoding here shows, once again, its utility in disclosing hidden biodiversity that traditional approaches to taxonomy may be unable to detect.

In the context of this analysis, DNA barcoding has allowed both for the lumping together of subspecies and the splitting of species. Molecular data supports some taxonomic changes among Canadian non-*Osmia* Osmiini. First, *Ashmeadiella* appears to have two new species. The first arises from the splitting of the *Ashmeadiella gillettei* complex into two distinct species—*A. gillettei* and *A. rubra*, the latter species clustering with sequences for *A. g. rufiventris* thus further suggesting a synonymy of the subspecies *rubra* and *rufiventris*. The second appears to represent a new species that is closely related to *Ashmeadiella buconis*—*Ashmeadiella* spA sp. nov.

Secondly, the results obtained herein are evidence enough to suggest that *A. copelandica* represents two species rather than two subspecies, and thus, *A. c. arefacta* is raised to species level **stat. nov.** The deep intersubspecific divergences are in stark contrast to the subtle intrasubspecific divergencies. In the absence of DNA barcode data for *A. c. albomarginata* no decision can yet be made related to its taxonomic status. The molecular evidence suggests that the subtle morphological differences between subspecies of *A. abjecta* are but intraspecific variation—there is no molecular evidence to support the splitting of the subspecies into two species.

Lastly, the classification of, and relationships within, *Hoplitis* remain unclear following molecular analyses. Though clustering and deep divergences were noted within some polytypic species, it did not correspond to existing morphological assessments in any case, nor did it remain consistent across analyses.

2.5 TABLES

Table 1- Canadian non-*Osmia* Osmiini.

Genus	Subgenus	Species and Subspecies *
<i>Ashmeadiella</i>	<i>Ashmeadiella</i> s. str.	<i>Ashmeadiella buconis buconis</i> (Say)
		<i>Ashmeadiella buconis denticulata</i> (Cresson)
		<i>Ashmeadiella cactorum cactorum</i> (Cockerell)
		<i>Ashmeadiella cactorum basalis</i> Michener +
		<i>Ashmeadiella californica californica</i> (Ashmead)
		<i>Ashmeadiella californica florissantensis</i> Michener +
		<i>Ashmeadiella californica sierraensis</i> Michener +
		<i>Ashmeadiella cubiceps cubiceps</i> (Cresson)
		<i>Ashmeadiella cubiceps clypeata</i> Michener +
		<i>Ashmeadiella gillettei gillettei</i> Titus
		<i>Ashmeadiella gillettei cismontanica</i> Michener +
		<i>Ashmeadiella gillettei rubra</i> Michener +
		<i>Ashmeadiella gillettei rufiventris</i> Michener +
<i>Atoposmia</i>	<i>Atoposmia</i> s. str.	<i>Atoposmia abjecta abjecta</i> (Cresson)
		<i>Atoposmia abjecta alta</i> (Michener) +
	<i>Hexosmia</i>	<i>Atoposmia copelandica copelandica</i> (Cockerell)
		<i>Atoposmia copelandica albomarginata</i> (Cockerell) +
		<i>Atoposmia copelandica arefacta</i> (Cockerell) +
<i>Chelostoma</i>	<i>Foveosmia</i>	<i>Chelostoma campanularum</i> (Kirby)
		<i>Chelostoma minutum</i> (Crawford)
		<i>Chelostoma phaceliae</i> Michener
	<i>Prochelostoma</i>	<i>Chelostoma philadelphi</i> (Robertson)
	<i>Gyrodromella</i>	<i>Chelostoma rapunculi</i> (Lepelletier)
<i>Heriades</i>	<i>Neotrypetes</i>	<i>Heriades carinata</i> Cresson
		<i>Heriades cressoni</i> Michener
		<i>Heriades leavitti leavitti</i> Crawford
		<i>Heriades leavitti crawfordi</i> (Graenicher) +
		<i>Heriades variolosa variolosa</i> (Cresson)
		<i>Heriades variolosa purpurascens</i> Cockerell +
<i>Hoplitis</i>	<i>Alcidamea</i>	<i>Hoplitis albifrons albifrons</i> (Kirby)
		<i>Hoplitis albifrons argentifrons</i> (Cresson)
		<i>Hoplitis albifrons maura</i> (Cresson) +
		<i>Hoplitis fulgida fulgida</i> (Cresson)
		<i>Hoplitis fulgida platyura</i> (Cockerell) +
		<i>Hoplitis grinnelli grinnelli</i> (Cockerell) +
		<i>Hoplitis grinnelli septentrionalis</i> (Michener)
		<i>Hoplitis hypocrita</i> (Cockerell)
		<i>Hoplitis louisae</i> (Cockerell)
		<i>Hoplitis pilosifrons</i> (Cresson)
		<i>Hoplitis producta producta</i> (Cresson)

Tbl. 1 cont.

	<i>Hoplitis producta bernardina</i> Michener +
	<i>Hoplitis producta gracilis</i> (Michener) +
	<i>Hoplitis producta interior</i> Michener
	<i>Hoplitis producta panamintana</i> Michener +
	<i>Hoplitis producta subgracilis</i> Michener
	<i>Hoplitis sambuci</i> Titus
	<i>Hoplitis spoliata</i> (Provancher)
	<i>Hoplitis truncata truncata</i> (Cresson)
	<i>Hoplitis truncata mescalerium</i> Cockerell +
<i>Formicapis</i>	<i>Hoplitis robusta</i> (Nylander)
<i>Hoplitis</i> s. str.	<i>Hoplitis anthocopoides</i> (Schenck)
<i>Protosmia</i> <i>Chelostomopsis</i>	<i>Protosmia rubifloris</i> (Cockerell)

* Where subspecies have been described.

+ Suspecies not known to occur in Canada.

Table 2.1-A complete list of the polytypic Canadian species of non-*Osmia* Osmiines as defined prior to the addition of molecular data, and reference to whether or not a representative of each has been barcoded.
There are no polytypic Canadian *Chelostoma*.

Genus	Subgenus	Species	Subspecies	Barcoded?
<i>Ashmeadiella</i>	<i>Ashmeadiella</i>	<i>bucconis</i>	<i>bucconis</i>	Yes
		<i>bucconis</i>	<i>denticulata</i>	Yes
<i>Ashmeadiella</i>	<i>Ashmeadiella</i>	<i>cactorum</i>	<i>basalis</i>	Yes
		<i>cactorum</i>	<i>cactorum</i>	Yes
<i>Ashmeadiella</i>	<i>Ashmeadiella</i>	<i>californica</i>	<i>californica</i>	Yes
		<i>californica</i>	<i>florissantensis</i>	Yes
		<i>californica</i>	<i>sierraensis</i>	Yes
<i>Ashmeadiella</i>	<i>Ashmeadiella</i>	<i>cubiceps</i>	<i>clypeata</i>	Yes
		<i>cubiceps</i>	<i>cubiceps</i>	Yes
<i>Ashmeadiella</i>	<i>Ashmeadiella</i>	<i>gillettei</i>	<i>gillettei</i>	Yes
		<i>gillettei</i>	<i>rubra</i>	Yes
		<i>gillettei</i>	<i>rufiventris</i>	Yes
		<i>gillettei</i>	<i>cismontanica</i>	No *
<i>Atoposmia</i>	<i>Atoposmia</i>	<i>abjecta</i>	<i>abjecta</i>	Yes
		<i>abjecta</i>	<i>alta</i>	Yes
<i>Atoposmia</i>	<i>Hexosmia</i>	<i>copelandica</i>	<i>albomarginata</i>	No *
		<i>copelandica</i>	<i>arefacta</i>	Yes
		<i>copelandica</i>	<i>copelandica</i>	Yes
<i>Heriades</i>	<i>Neotrypetes</i>	<i>leavitti</i>	<i>crawfordi</i>	?
		<i>leavitti</i>	<i>leavitti</i>	?
<i>Heriades</i>	<i>Neotrypetes</i>	<i>variolosa</i>	<i>purpurascens</i>	?
		<i>variolosa</i>	<i>variolosa</i>	?
<i>Hoplitis</i>	<i>Alcidamea</i>	<i>albifrons</i>	<i>albifrons</i>	Yes
		<i>albifrons</i>	<i>argentifrons</i>	Yes

Table 2.1 cont.

		<i>albifrons</i>	<i>maura</i>	Yes
<i>Hoplitis</i>	<i>Alcidamea</i>	<i>fulgida</i>	<i>fulgida</i>	Yes
		<i>fulgida</i>	<i>platyura</i>	Yes
<i>Hoplitis</i>	<i>Alcidamea</i>	<i>grinnelli</i>	<i>grinnelli</i>	Yes
		<i>grinnelli</i>	<i>septentrionalis</i>	Yes
<i>Hoplitis</i>	<i>Alcidamea</i>	<i>producta</i>	<i>bernardina</i>	Yes
		<i>producta</i>	<i>gracilis</i>	Yes
		<i>producta</i>	<i>interior</i>	Yes
		<i>producta</i>	<i>panamintana</i>	Yes
		<i>producta</i>	<i>producta</i>	Yes
		<i>producta</i>	<i>subgracilis</i>	Yes
<i>Hoplitis</i>	<i>Alcidamea</i>	<i>truncata</i>	<i>mescalerium</i>	Yes
		<i>truncata</i>	<i>truncata</i>	No*

* Material not available for barcoding and/or barcoding attempts were unsuccessful.

? Inconclusive—See Chapter 2, footnote 1.

Table 2.2- *Ashmeadiella* specimens used in the subspecies analysis of Canadian non-*Osmia* Osmini.

Species	Subspecies	Unique identifier/ BOLD process ID	BOLD Bin number	Sequence length (base pairs)	State or province (*)
<i>bucconis</i>	<i>bucconis</i>	BOWGF2785-13 CCDB-19990 C06	AAD8457	658	NM 1
		BOWGF2784-13 CCDB-19990 C05	ACE4780	658	NM 2
		BOWGF2796-13 CCDB-19990 D05	AAD8457	658	CA
		BEECB863-07 03-TX-1580	ACE4780	651	TX 1
		BOWGF3335-14 CCDB-22789 E10	AAD8457	658	TX 2
		BOFWM623-10 HM905464 04744E05-MEX	ACE4780	658	MEX
<i>bucconis</i>	<i>denticulata</i>	BOWGF3088-14 CCDB-22792 A01	ACM2172	658	AB
		BOWGF2786-13 CCDB-19990 C07	AAD8457	658	NV
		BWTWO728-09 GU708326 CCDB-03775 F03	AAD8457	658	BC 1
		BCLRB13-10 HM406770 LRBBC327	AAD8457	658	BC 2
		BCLRB406-10 HM406763 LRBBC320	AAD8457	658	BC 3
		BOWGF3099-14 CCDB-22792 A12	AAD8457	658	BC 4
<i>cactorum</i>	<i>cactorum</i>	BCLRB410-10 HM406767 LRBBC324	ABY9591	658	BC 1
		BCLRB411-10 HM406768 LRBBC325	ABY9591	658	BC 2
		BCLRB412-10 HM406769 LRBBC326	ABY9591	658	BC 3
		BEECB425-07 04-NV-1144	AAC8041	658	NV
		TOBEE054-14 CCDB-22002 E6	AAC8041	658	NM
		BWTWO1120-10 HQ558143 06732G03-WY	AAC8041	658	WY
		TOBEE059-14 CCDB-22002 E11	AAC8041	658	UT
<i>cactorum</i>	<i>basalis</i>	TOBEE065-14 CCDB-22002 F5	AAC8041	658	CA
		TOBEE060-14 CCDB-22002 E12	AAC8041	658	CA 2
<i>californica</i>	<i>californica</i>	BCLRB404-10 HM406761 LRBBC318	AAE6519	658	BC 1

Tbl. 2.2 cont.

		BOWGF3102-14 CCDB-22792 B03	AAE6519	658	BC 2
		BEECB426-07 04-NV-1145	AAE6519	658	NV
		BEECB711-07 07-ID-1334	AAE6519	658	ID
<i>californica</i>	<i>florissantensis</i>	BOWGF2792-13 CCDB-19990 D01	AAE6519	637	WY
		BOWGF2793-13 CCDB-19990 D02	AAE6519	632	WY 2
<i>californica</i>	<i>sierraensis</i>	BOWGF2791-13 CCDB-19990 C12	AAE6519	630	CA
<i>cubiceps</i>	<i>cubiceps</i>	BOWGF2794-13 CCDB-19990 D03	ABW4555	658	CA 1
		BOWGF2795-13 CCDB-19990 D04	ABW4555	658	CA 2
<i>cubiceps</i>	<i>clypeata</i>	BOWGF2797-13 CCDB-19990 D06	ABW4555	658	UT
<i>gillettei</i>	<i>gillettei</i>	BEECE969-10 JF865785 CCDB-09665 B07	AAJ9333	658	SK 1
		BEECE967-10 JF865783 CCDB-09665 B05	AAJ9333	658	SK 2
		BEECE968-10 JF865784 CCDB-09665 B06	AAJ9333	658	SK 3
		BOWGF3104-14 CCDB-22792 B05	AAJ9333	658	AB
		BOWGF3131-14 CCDB-22792 D08	AAJ9333	658	SD
		BOWGF3447-14 CCDB-22791 G03	AAJ9333	658	UT 1
		BOWGF3457-14 CCDB-22791 H01	AAJ9333	658	UT 2
		BOWGF3463-14 CCDB-22791 H07	AAJ9333	658	UT 3
		BOWGF3466-14 CCDB-22791 H10	AAJ9333	658	CO
		BOWGF3453-14 CCDB-22791 G09	AAJ9333	658	WY
<i>gillettei</i>	<i>rubra</i>	BOWGF2799-13 CCDB-19990 D08	AAJ3024	658	AZ
		BOWGF2798-13 CCDB-19990 D07	AAJ3024	658	NM
<i>gillettei</i>	<i>rufiventris</i>	BOWGF3444-14 CCDB-22791 F12	AAJ3024	658	CA
		BOWGF2800-13 CCDB-19990 D09	AAJ3024	658	NV

*Unique identifier to distinguish between duplicate sequences for a given species/subspecies. Unique identifiers are found in the figures, and represent the state or province where the specimen was collected.

Table 2.3- Pairwise sequence divergence of DNA barcodes from putative species of *Ashmeadiella*. Column headings correspond to numbered species in column one. Numbers above the diagonal are the minimum interspecific nucleotide *p*-distances. The diagonal gives the maximum within-species nucleotide *p*-distance followed by the maximum amino acid *p*-distance. Numbers below the diagonal are the minimum proportion of amino acid differences per site between sequences. The coding data was translated assuming a standard genetic code table.

Species	1	2	3	4	5	6	7	8
1 <i>A. buconis</i>	0.019; 0.010	0.060	0.044	0.047	0.049	0.070	0.061	0.023
2 <i>A. californica</i>	0.019	0.015; 0.005	0.067	0.060	0.043	0.064	0.050	0.074
3 <i>A. cactorum BC*</i>	0.014	0.014	0.005; 0.005	0.018	0.057	0.070	0.061	0.054
4 <i>A. cactorum S*</i>	0.014	0.014	0.005	0.011; 0.010	0.060	0.066	0.054	0.058
5 <i>A. cubiceps</i>	0.019	0.010	0.014	0.014	0.015; 0.010	0.058	0.058	0.058
6 <i>A. gillettei</i>	0.044	0.034	0.029	0.039	0.024	0.015; 0	0.023	0.074
7 <i>A. rubra</i>	0.034	0.024	0.029	0.029	0.014	0.010	0.014; 0.005	0.068
8 <i>A. sp. novo</i>	0.020	0.039	0.034	0.034	0.039	0.065	0.055	NA; NA

NA- Only one sequence obtained, comparison not available.

* See Fig.2.1 for sequences contained under this heading.

Table 2.4- *Atoposmia* specimens used in the subspecies analysis of Canadian non-*Osmia* Osmini.

Species	Subspecies	Unique identifier/ BOLD process ID	BOLD Bin number	Sequence length (base pairs)	State or province (*)
<i>Abjecta</i>	<i>alta</i>	TOBEE062_14_CCDB-22002_F2	AAM5524	658	CA
<i>abjecta</i>	<i>abjecta</i>	TOBEE061_14_CCDB-22002_F1	AAM5524	658	CA
<i>copelandica</i>	<i>arefacta</i>	BOWGF2764_13_CCDB_19990_A09	ABW4512	658	CA (1)
		BOWGF2765_13_CCDB_19990_A10	ABW4512	658	CA (2)
<i>copelandica</i>	<i>copelandica</i>	BCLRB39_10_HM406755_LRBBC312	AAD2967	658	BC (5)
		BCLRB394_10_HM406751_LRBBC308	AAD2967	658	BC (3)
		BCLRB396_10_HM406753_LRBBC310	AAD2967	658	BC (4)
		BCLRB395_10_HM406752_LRBBC309	AAD2967	658	BC (1)
		BCII220_10_HQ553742_LRBBC1319	AAD2967	658	BC (1)

*Unique identifier to distinguish between duplicate sequences for a given species/subspecies. Unique identifiers are found in the figures, and represent the state or province where the specimen was collected.

Table 2.5- Pairwise sequence divergence of DNA barcodes from putative species of *Atoposmia*. Numbers above the diagonal are the minimum interspecific nucleotide *p*-distances. The diagonal gives the maximum within-species nucleotide *p*-distance followed by the maximum amino acid *p*-distance. Numbers below the diagonal are the minimum proportion of amino acid differences per site between sequences. The coding data was translated assuming a standard genetic code table.

Species	<i>A. a. abjecta</i>	<i>A. a. alta</i>	<i>A. c. arefacta</i>	<i>A. c. copelandica</i>
<i>A. a. abjecta</i>	N/A	0.006	0.132	0.143
<i>A. a. alta</i>	0.00	N/A	0.134	0.146
<i>A. c. arefacta</i>	0.068	0.068	0.005; 0	0.078
<i>A. c. copelandica</i>	0.058	0.058	0.024	0.009; 0

NA- Only one sequence obtained, comparison not available.

Table 2.6- *Hoplitis* specimens used in the subspecies analysis of Canadian non-*Osmia* *Osmini*.

Species	Subspecies	Unique identifier/ BOLD process ID	BOLD Bin number	Sequence length (base pairs)	State or province (*)
<i>albifrons</i>	<i>albifrons</i>	BOWGF800-09 GU708048 CCDB-01565 D4	AAB7508	658	YT 1
	<i>albifrons</i>	BWTWO1147-10 HQ937912 06717A07-YT	AAB7508	658	YT 2
	<i>argentifrons</i>	BCII214-10 HQ553737 LRBBC1313	AAB7508	658	BC 1
	<i>argentifrons</i>	BCIII027-11 JF865273 LRBBC2126	AAB7508	658	BC 2
	<i>argentifrons</i>	BCIII447-11 JF865572 LRBBC2636	AAB7508	658	BC 3
	<i>argentifrons</i>	BOFTW630-10 HQ937223 3770F02-BC	AAB7508	658	BC 4
	<i>argentifrons</i>	BEECB665-07 07-ID-1476	AAB7508	658	ID
	<i>argentifrons</i>	BUSA535-12 CCDB-15263-D02	AAB7508	658	OR 1
	<i>argentifrons</i>	BEECB580 07-OR-1297	AAB7508	658	OR 2
	<i>argentifrons</i>	BEECB332-07 04-WA-1050	AAB7508	658	WA 1
	<i>argentifrons</i>	BEECB331-07 04-WA-1049	AAB7508	658	WA 2
	<i>argentifrons</i>	BEECB333-07 04-WA-1051	AAB7508	658	WA 3
	<i>maura</i>	BOWGF2777-13 CCDB-19990 B10	AAB7508	650	CA
<i>fulgida</i>	<i>fulgida</i>	BCIII908-10 HQ932277 LRBBC2007	AAC5432	658	BC 1
	<i>fulgida</i>	BEECB661-07 07-ID-1472	AAC5432	658	ID 1
	<i>fulgida</i>	BOWGF831-09 GU708045 CCDB-01565 F11	AAC5432	658	YT 1
	<i>platyura</i>	BOWGF2776-13 CCDB-19990 B09	AAC5432	658	CA
<i>grinnelli</i>	<i>grinnelli</i>	BOWGF3449-14 CCDB-22791 G05	ACF0035	658	CA 1
	<i>grinnelli</i>	BOWGF3461-14 CCDB-22791 H05	ACF0035	658	CA 2
	<i>grinnelli</i>	TOBEE063-14 CCDB-22002 F3	ACF0035	658	CA 3
	<i>grinnelli</i>	TOBEE066-14 CCDB-22002 F6	ACM2350	658	NV 1
	<i>grinnelli</i>	BOWGF3437-14 CCDB-22791 F05	ACM2350	658	NM 1
	<i>grinnelli</i>	BOWGF3443-14 CCDB-22791 F11	ACM2350	658	NM 2

Tbl. 2.6
cont.

	<i>grinnelli</i>	BOWGF3439-14 CCDB-22791 D07	ACM2350	658	CA 4
	<i>septentrionalis</i>	BCIII102-11 JF865333 LRBBC2506	ACF0033	658	BC 1
	<i>septentrionalis</i>	BCIII101-11 JF865332 LRBBC2505	ACF0033	658	BC 2
	<i>septentrionalis</i>	BCIII096-11 JF865327 LRBBC2500	ACF0033	658	BC 3
	<i>septentrionalis</i>	BCIII100-11 JF865331 LRBBC2504	ACF0033	658	BC 4
	<i>septentrionalis</i>	BEECB729-07 07-WA-1352	ACF0033	658	WA 1
	<i>septentrionalis</i>	BEECB669-07 07-WA-1480	AAD0303	658	WA 2
	<i>septentrionalis</i>	BEECB668-07 07-WA-1479	AAD0303	658	WA 3
	<i>septentrionalis</i>	TOBEE050-14 CCDB-22002 E2	AAD0303	658	OR 1
	<i>septentrionalis</i>	TOBEE051-14 CCDB-22002 E3	AAD0303	658	MT 1
<i>producta</i>	<i>bernardina</i>	BOWGF3464-14 CCDB-22791 H08	AAA7118	658	CA 1
	<i>bernardina</i>	BOWGF3448-14 CCDB-22791 G04	AAA7118	658	CA 2
	<i>bernardina</i>	BOWGF3460-14 CCDB-22791 H04	AAA7118	658	CA 3
	<i>bernardina</i>	BOWGF3462-14 CCDB-22791 H06	AAA7118	658	CA 4
	<i>gracilis</i>	BOWGF3438-14 CCDB-22791 F06	AAX1127	658	CA 1
	<i>gracilis</i>	BOWGF3433-14 CCDB-22791 F01	AAX1127	658	CA 2
	<i>gracilis</i>	BOWGF3436-14 CCDB-22791 F04	AAX1127	658	CA 3
	<i>interior</i>	BOWGF3452-14 CCDB-22791 G08	AAA7118	658	CO 1
	<i>interior</i>	BOWGF3454-14 CCDB-22791 G10	AAA7118	658	CO 2
	<i>interior</i>	BOWGF3450-14 CCDB-22791 G06	AAA7118	658	ID
	<i>panamintana</i>	BOWGF3434-14 CCDB-22791 F02	AAA7118	658	NV
	<i>producta</i>	BANT210-10 HQ927997 CCDB-06734 B08	AAA7118	658	ON 1
	<i>producta</i>	BANT203-10 HQ927990 CCDB-06734 B01	AAA7118	658	ON 2
	<i>producta</i>	BANT211-10 HQ927998 CCDB-06734 B09	AAA7118	658	ON 3

Tbl 2.6
cont.

<i>producta</i>	BANT206-10 HQ927993 CCDB-06734 B04	AAA7118	658	ON 4
<i>producta</i>	BEECB1076-07 07-MB-1697	AAA7118	658	MB 1
<i>subgracilis</i>	TOBEE053-14 CCDB-22002 E5	AAA7118	658	WA 1
<i>subgracilis</i>	TOBEE058-14 CCDB-22002 E10	AAA7118	658	OR 1
<i>subgracilis</i>	BCII897-10 HQ932269 LRBBC1996	AAA7118	658	BC 1
<i>subgracilis</i>	BCLRB401-10 HM406758 LRBBC315	AAA7118	658	BC 2

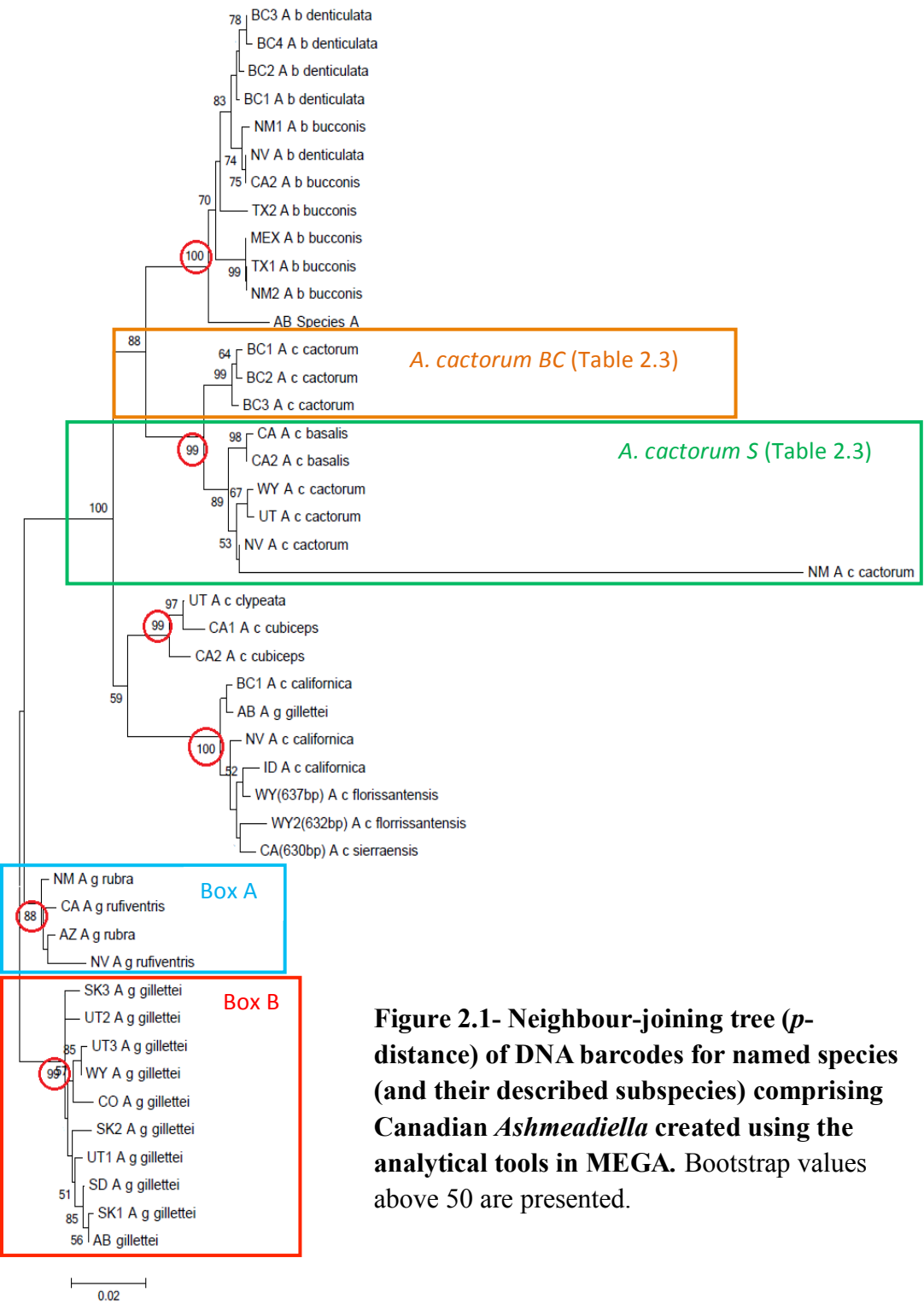
*Unique identifier to distinguish between duplicate sequences for a given species/subspecies. Unique identifiers are found in the figures, and represent the state or province where the specimen was collected.

Table 2.7- Pairwise sequence divergence of DNA barcodes from putative species of *Hoplitis*. Column headings correspond to numbered species in column one. Numbers above the diagonal are the minimum interspecific nucleotide *p*-distances. The diagonal (in bold) gives the maximum within-species nucleotide *p*-distance followed by the maximum amino acid *p*-distance. Numbers below the diagonal are the minimum proportion of amino acid differences per site between sequences. The coding data was translated assuming a standard genetic code table.

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 <i>H.a.albifrons</i>	0.014; 0.009	0.002	0.005	0.052	0.058	0.087	0.084	0.084	0.090	0.084	0.084	0.092	0.084	0.093
2 <i>H.a.argentifrons</i>	0.005	0.017; 0	0.003	0.050	0.057	0.084	0.084	0.083	0.089	0.084	0.084	0.090	0.084	0.092
3 <i>H.a.maura</i>	0.005	0	NA; NA	0.051	0.057	0.083	0.085	0.083	0.090	0.085	0.085	0.091	0.085	0.093
4 <i>H.f.fulgida</i>	0.019	0.014	0.014	0.003; 0.014	0.011	0.086	0.087	0.086	0.087	0.089	0.090	0.095	0.089	0.093
5 <i>H.f.platyura</i>	0.019	0.014	0.014	0	NA; NA	0.090	0.092	0.093	0.090	0.093	0.095	0.098	0.093	0.098
6 <i>H.g.grinnelli</i>	0.053	0.048	0.049	0.043	0.043	0.021; 0.019	0.014	0.046	0.044	0.041	0.046	0.044	0.044	0.047
7 <i>H.g.septentrionalis</i>	0.048	0.040	0.044	0.038	0.038	0.005	0.018; 0.009	0.041	0.038	0.040	0.043	0.046	0.040	0.049
8 <i>H.p.bernardina</i>	0.068	0.061	0.064	0.058	0.058	0.024	0.014	0.018; 0.019	0.021	0.009	0.017	0.015	0.008	0.050
9 <i>H.p.gracilis</i>	0.073	0.066	0.069	0.063	0.063	0.029	0.019	0.005	0.002; 0	0.024	0.029	0.029	0.024	0.052
10 <i>H.p.interior</i>	0.058	0.061	0.064	0.058	0.058	0.024	0.019	0.009	0.014	0.017; 0.009	0.014	0.014	0.003	0.046
11 <i>H.p.panamintana</i>	0.068	0.071	0.074	0.068	0.068	0.034	0.024	0.009	0.014	0.009	NA; NA	0.024	0.014	0.055
12 <i>H.p.producta</i>	0.073	0.066	0.069	0.063	0.063	0.019	0.019	0.014	0.009	0.014	0.024	0.003; 0	0.011	0.055
13 <i>H.p.subgracilis</i>	0.058	0.061	0.064	0.058	0.058	0.024	0.019	0.009	0.014	0	0.009	0.014	0.015; 0.009	0.047
14 <i>H.t.mescalerium</i>	0.068	0.061	0.064	0.048	0.048	0.019	0.019	0.029	0.034	0.029	0.038	0.034	0.029	NA; NA

NA- Only one sequence obtained, comparison not available.

2.6 FIGURES



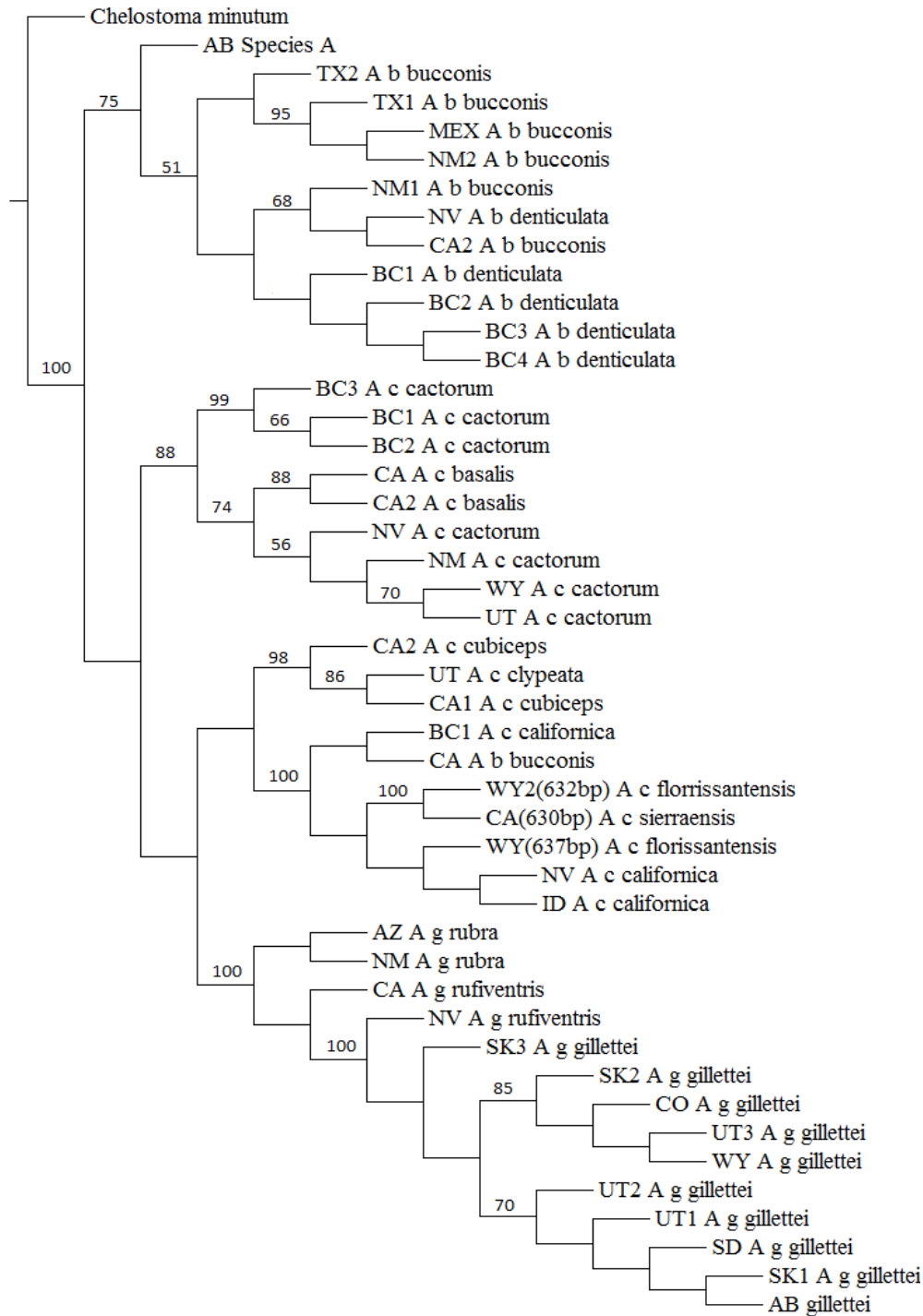


Figure 2.2- Most parsimonious tree based on DNA barcodes for the *Ashmeadiella* species group with *Chelostoma minutum* as the outgroup. Numbers at nodes indicate GC values (%) above 50 from symmetric resampling (Goloboff, Farris & Nixon 2003). L= 747; Ci= 56; Ri= 88.

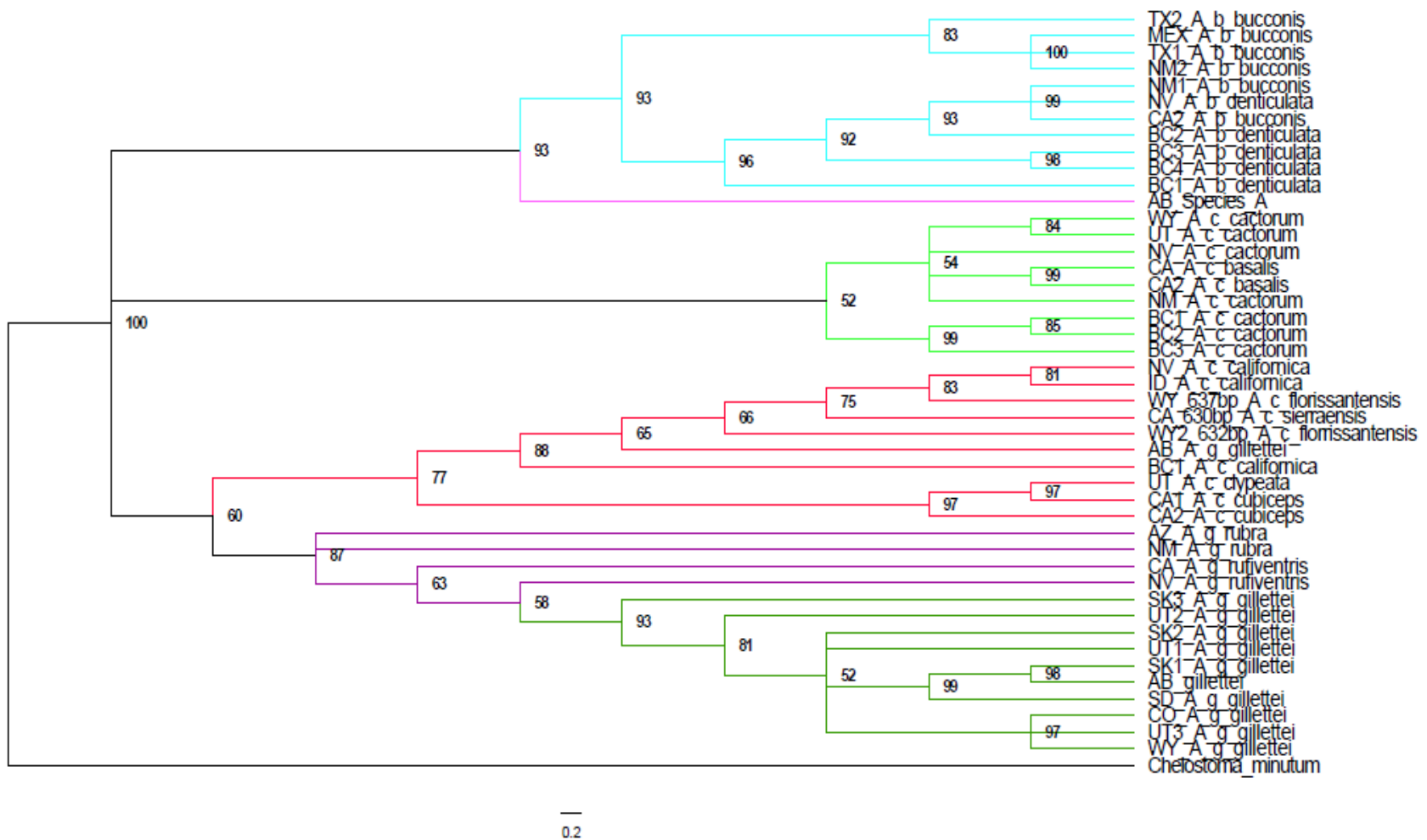


Figure 2.3- Most probable tree based on Bayesian analysis of DNA barcodes from *Ashmeadiella* with *Chelostoma minutum* as the outgroup. Numbers at the basal node of each species cluster indicate posterior probabilities (%) above 50.

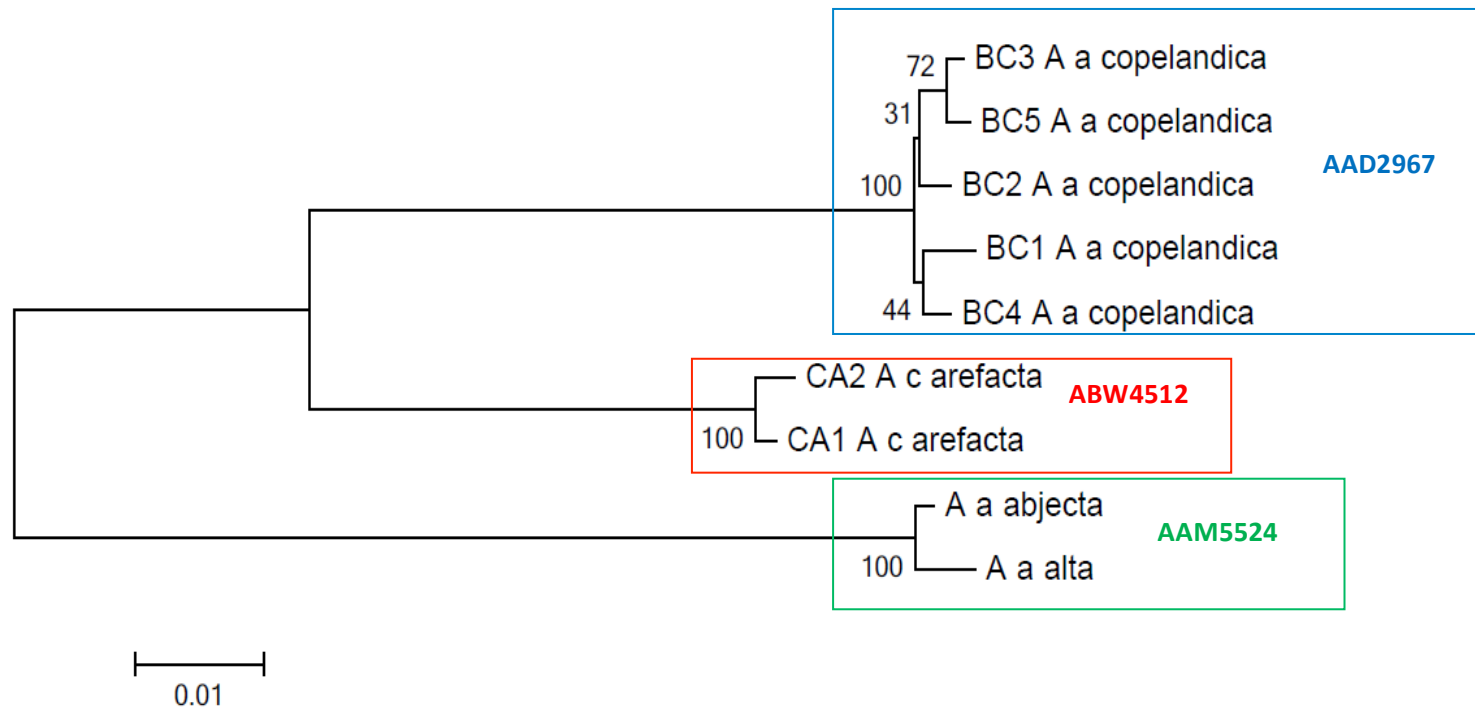


Figure 2.4- Neighbour-joining tree (p -distance) of DNA barcodes for named species (and their described subspecies) comprising Canadian *Atoposmia* created using the analytical tools in MEGA. Bootstrap values are presented. BIN numbers (from BOLD) are presented for each cluster.

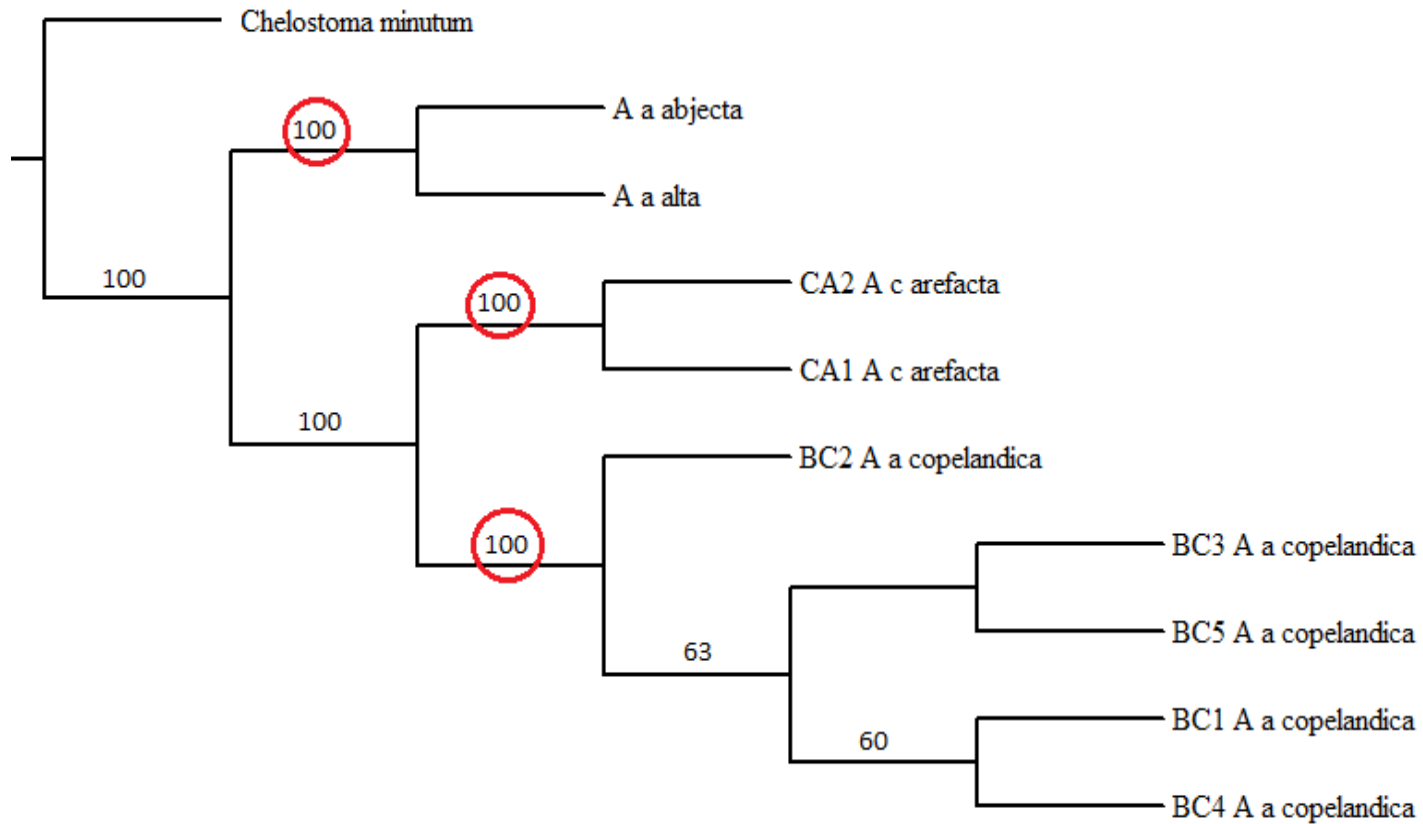


Figure 2.5- Most parsimonious tree based on DNA barcodes for the *Atoposmia* species group with *Chelostoma minutum* as the outgroup. Numbers at nodes indicate GC values (%) above 50 from symmetric resampling (Goloboff, Farris & Nixon 2003). L= 478; Ci= 88; Ri= 89.

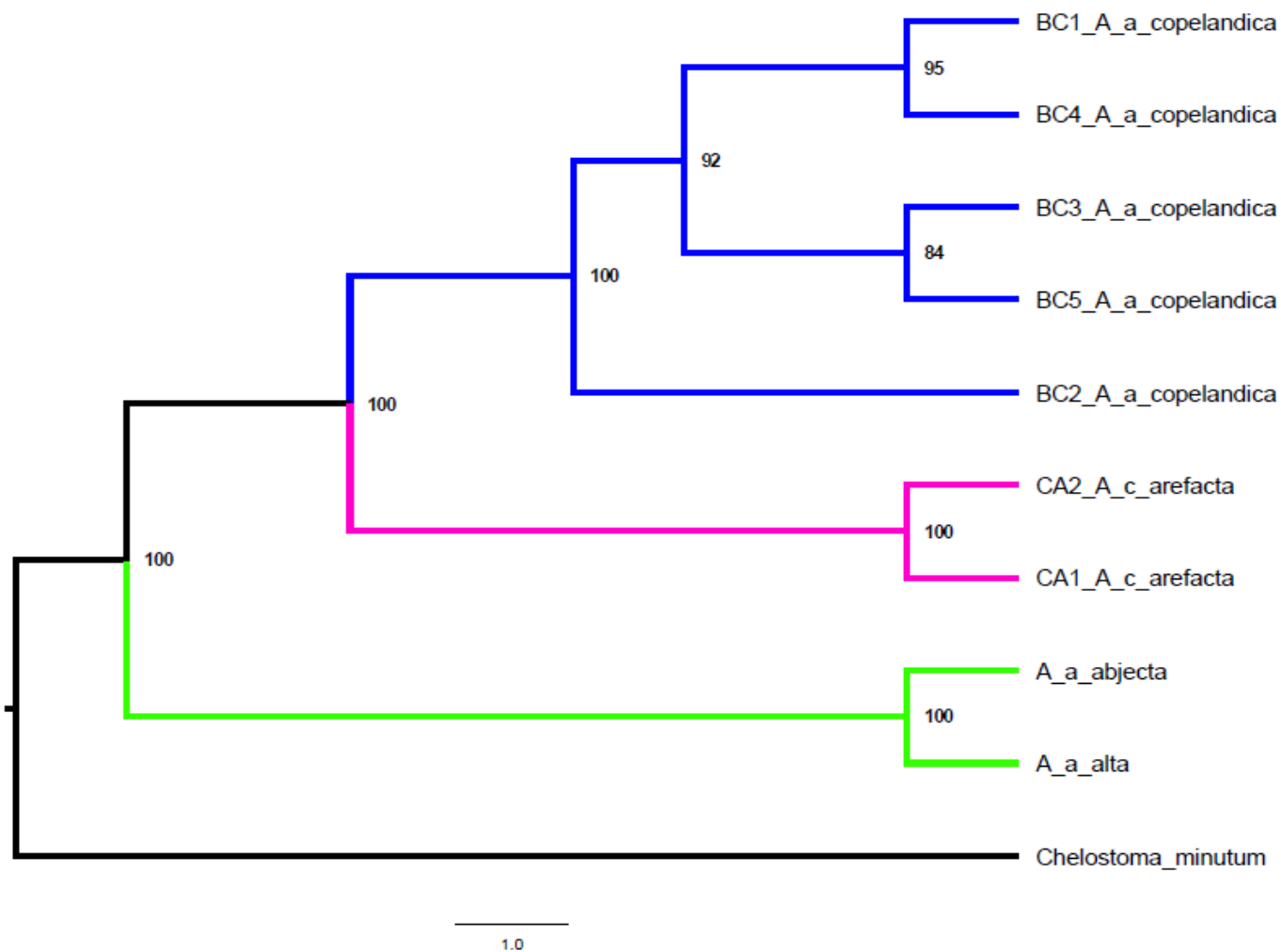


Figure 2.6- Most probable tree based on Bayesian phylogenetic analysis of DNA barcodes from *Atoposmia* with *Chelostoma minutum* as the outgroup. Numbers in bold at the basal node of each species cluster indicate posterior probabilities (%) above 50.

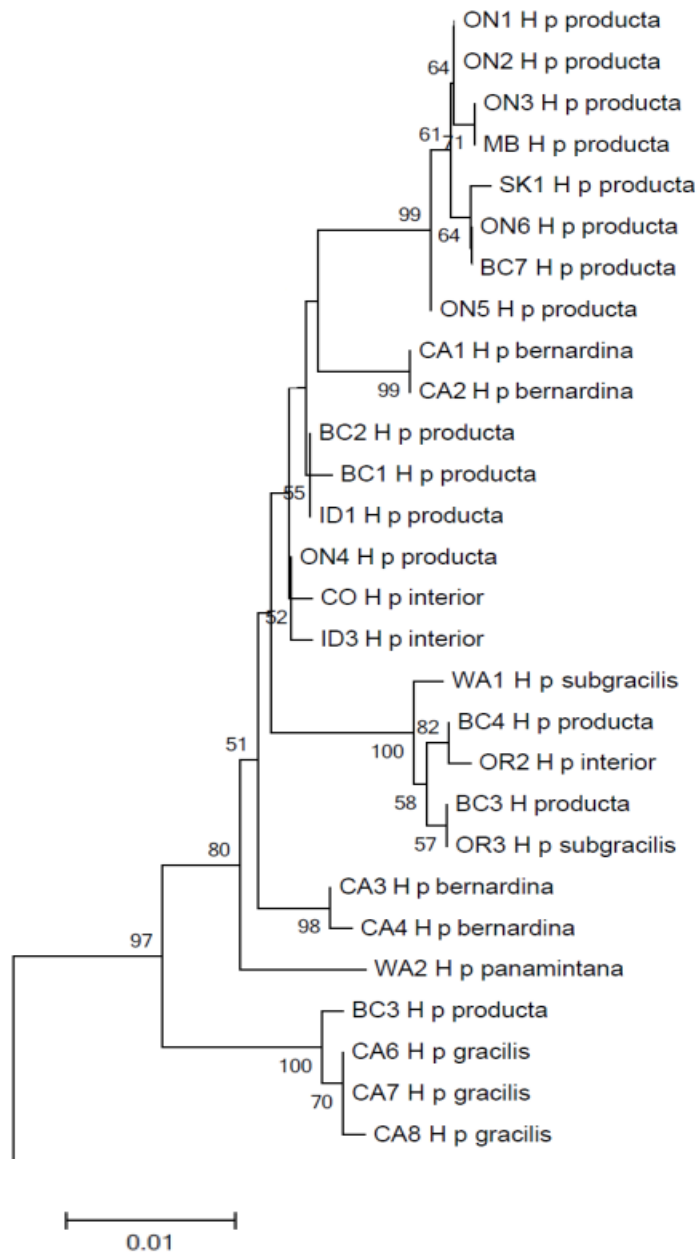


Figure 2.7a- Neighbour-joining tree (p-distance) of DNA barcodes for named species (and their described subspecies) comprising the Canadian *Hoplitis producta* complex created using the analytical tools in MEGA. Remaining polytypic Canadian *Hoplitis* are presented in Fig. 2.7b and Fig. 2.7c. Bootstrap values above 50 are presented.

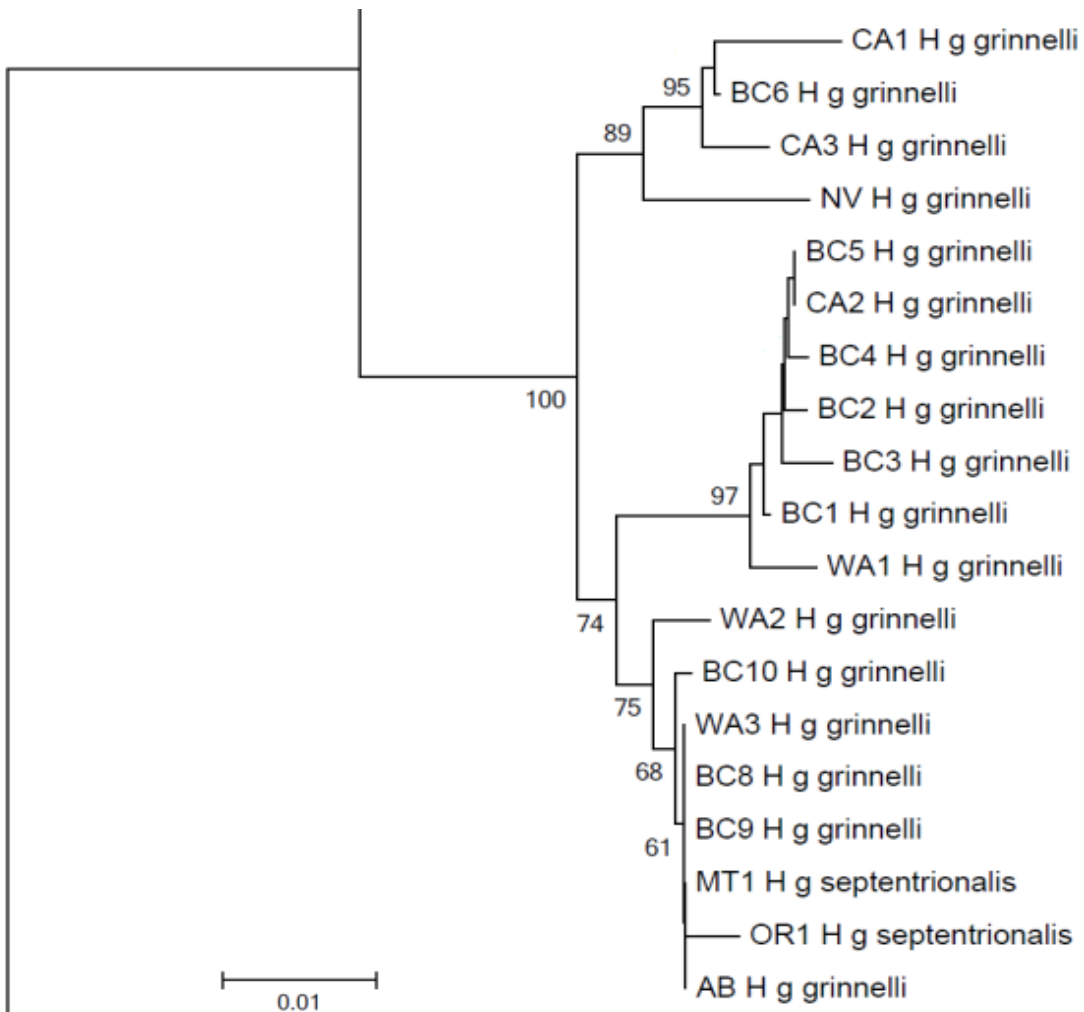


Figure 2.7b- Neighbour-joining tree (p-distance) of DNA barcodes for named species (and their described subspecies) comprising the Canadian *Hoplitis grinnelli* complex created using the analytical tools in MEGA. Remaining polytypic Canadian *Hoplitis* are presented in Fig. 2.7a and Fig. 2.7c. Bootstrap values above 50 are presented.

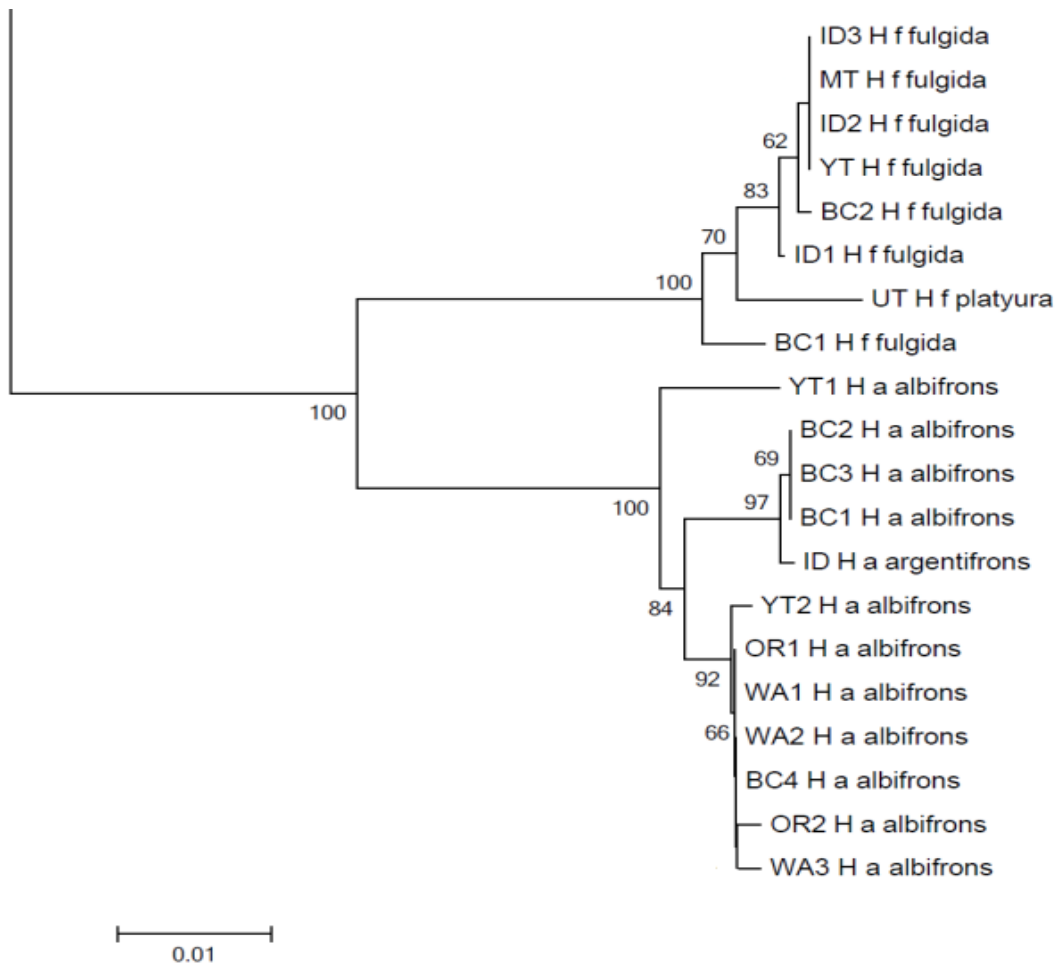


Figure 2.7c- Neighbour-joining tree (p-distance) of DNA barcodes for named species (and their described subspecies) comprising the Canadian *Hoplitis albifrons* and *Hoplitis fulgida* complexes created using the analytical tools in MEGA. Remaining polytypic Canadian *Hoplitis* are presented in Fig. 2.7a and Fig. 2.7b. Bootstrap values above 50 are presented.

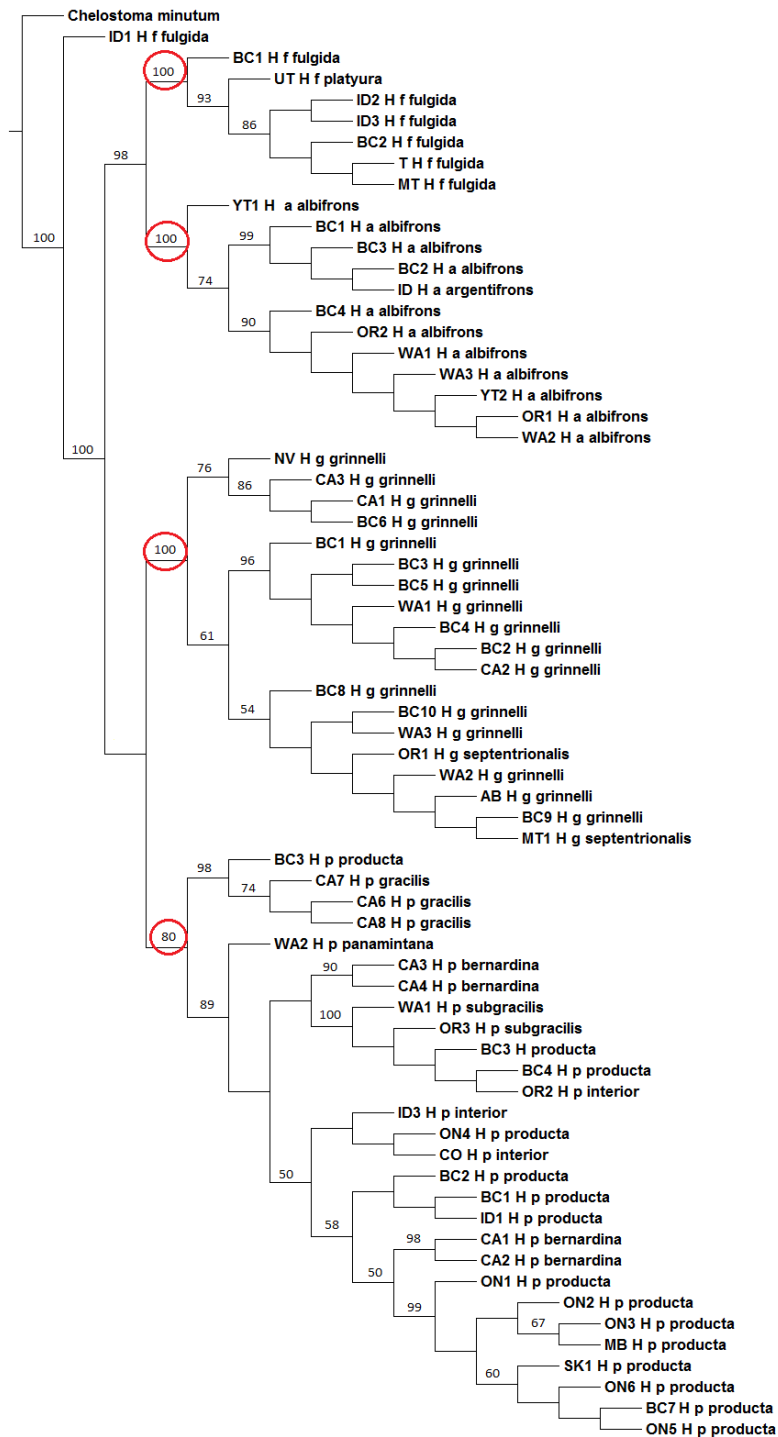


Figure 2.8-Most parsimonious tree based on DNA barcodes for the *Hoplitis* species group with *Chelostoma minutum* as the outgroup. Numbers at nodes indicate GC values (%) above 50 from symmetric resampling (Goloboff, Farris & Nixon 2003) after 100 replicates using default setting traditional searches in TNT for each replicate (Goloboff, Farris & Nixon 2003). L= 1494; Ci= 77; Ri= 91.

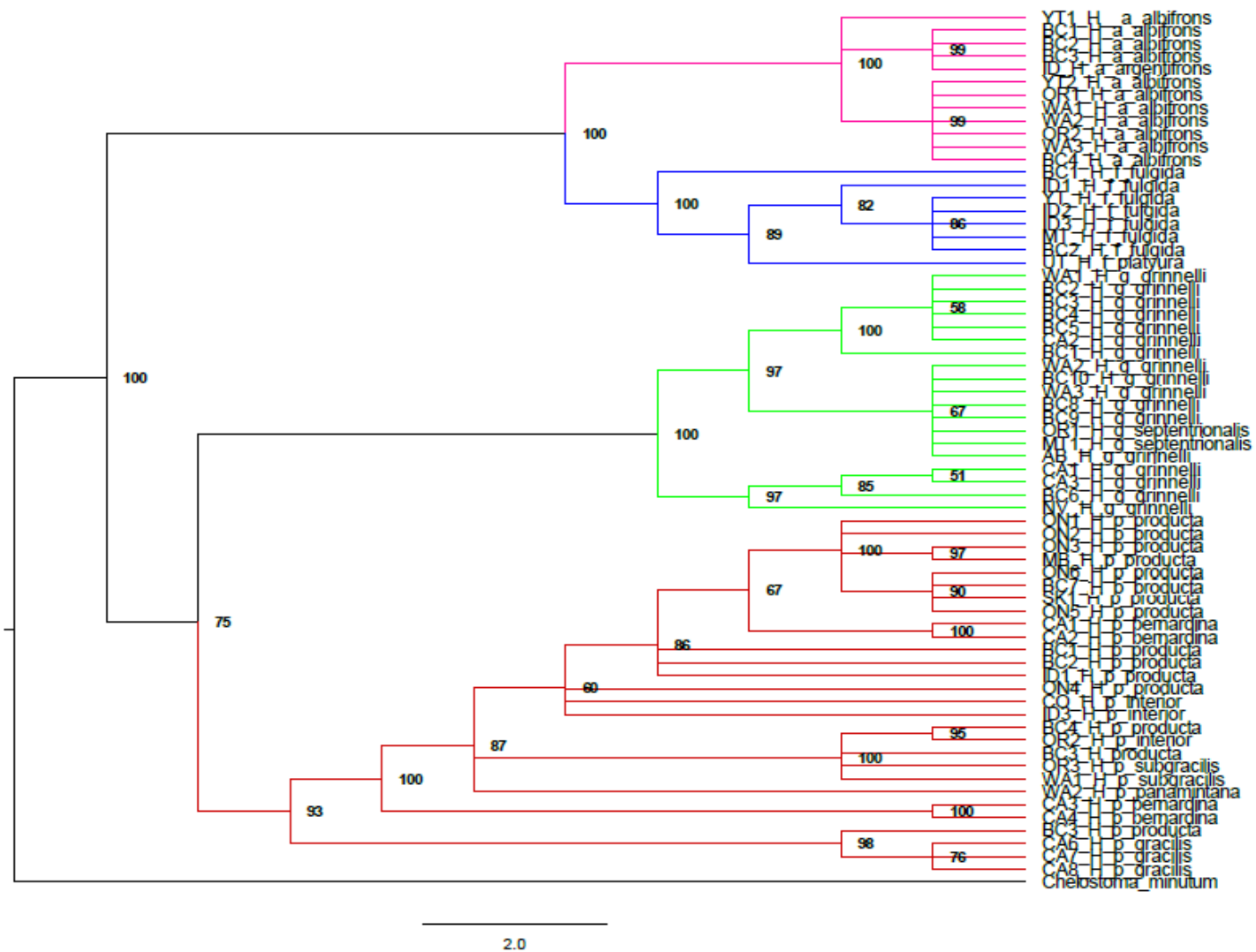


Figure 2.9- Most probable tree based on Bayesian phylogenetic analysis of DNA barcodes from *Hoplitis* with *Chelostoma minutum* as the outgroup. Numbers at the basal node of each species cluster indicate posterior probabilities (%) above 50.

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CHAPTER 3: A REVISION OF CANADIAN NON-*OSMIA* OSMIINES (HYMENOPTERA:MEGACHILIDAE)

3.1 Introduction

Nested within the large subfamily the Megachilinae (Gonzalez et al. 2012), osmiine bees (Tribe: Osmiini) represent a very biologically diverse group of solitary bees (Michener 2007). Roughly 1200 species (Ascher & Pickering 2016) of osmiine bees are currently recognized globally in 16 genera (Gonzalez et al. 2012), on all continents except Antarctica and Australia (Praz et al. 2008; only recently found in South America, see Gonzalez & Griswold 2011). These bees, like most others, are especially diverse in mediterranean and other semi-arid climates (Michener 2007), and are considered important pollinators in both wild and managed ecosystems (Praz et al. 2008). With 29 described species in six recognized genera in Canada, non-*Osmia* osmiines represent an important group of wild pollinators in Canadian ecosystems.

Though complete accounts for the majority of the North American genera have previously been published (Griswold 1985; 1994; Griswold & Michener 1998; Hurd & Michener 1955; Michener 1936a; 1936b; 1938a; 1938b; 1939; 1941; 1947; 2007 and Mitchell 1962), they are out-of-date, do not incorporate the new techniques of genetic approaches, and are not specific to Canada. Here, in conjunction with Chapter 2, I provide an account of Canadian non-*Osmia* Osmiini. Dichotomous keys are presented for each genus with key features imaged. Species redescrptions are provided for all Canadian species along with their corresponding range maps that include Canadian collection localities explicitly marked within wider, estimated North American ranges.

3.2 Methods

Species descriptions were made while using a Nikon SMZ 1500 stereomicroscope. Descriptions follow the format outlined in Toro and Moldenke (1979) and are divided into subsections on colouration, pubescence, surface sculpture and structure, each proceeding from the anterior to posterior of the specimen. Terminology for structures follow Michener (2007), Prentice (1998) and Torre-Bueno (1937), and terminology for mandibles and surface sculpture

follow Michener and Fraser (1978) and Harris (1979), respectively. The following abbreviations are used: **FAL**—frontal area length, measured from the posterior margin of the antennal socket to the anterior margin of the median ocellus, **VAL**—vertexal area length, measured from the posterior margin of the median ocellus to the posterior margin of the vertexal area (these are used in conjunction as a relative measure (FAL:VAL) of the position of the median ocellus); **UOD**—upper ocular distance, a measure of the distance between the upper convexity of the compound eyes; **MID**—maximum ocular distance, a measure of the greatest distance between the compound eyes at the median concavity; **LOD**—lower ocular distance, a measure of the distance between the lower convexity of the compound eyes; **IOC**—interocellar distance, the shortest distance between lateral ocelli; **OV**—ocello-occipital margin, the shortest distance between the posterior margin of the lateral ocellus and the posterior margin of the vertexal area; **OOC**—ocello-ocular distance, the shortest distance between the margin of the lateral ocellus and the nearest margin of the compound eye; **i**—interspace, **d**—puncture diameter, these are used in conjunction to give a relative measure of puncture density, e.g. $i=2d$; **MOD**—median ocellar diameter, the transverse diameter of the median ocellus, a measure primarily used to give a relative measure of length (usually of pubescence); **ITW**—intertegular width, a measure of the shortest distance between the tegulae. Clypeal truncation (Fig. 3.1) is a measure of the extent to which the clypeus is produced anteriorly beyond the base of the labrum. Lateral angles of the clypeal truncation are the point at which the lateral margin of the clypeal truncation ceases to be produced anteriorly. The distance measured between teeth of the mandible is a measure of the distance between the apices of the teeth in question. Individual metasomal terga, sterna and antennal flagellomeres are referred to by the letter T, S, and F, respectively, followed by the appropriate number. The **disc** of any given tergal or sternal segment is defined as all the area within the margins of the gradulus and the premarginal line. Relative size measurements are given in ratios based on eyepiece graticule units. Body length, head width, forewing length and intertegular width were measured for all specimens examined, and ranges for each are presented in parentheses within descriptions. Measurements of the holotypes (where applicable/available) are given before these parentheses. Body length, measured in millimeters (mm), is measured from the most apical point of the clypeus to the apex of the last abdominal segment. Where specimens were curled or distorted, measurements of the head, mesosoma and metasoma were taken separately and summed. In species where much of the metasomal segments were

telescoped or recurved (e.g. Fig. 3.33a, c, g), most notably in *Heriades*, the measurement was taken to the posterior most point of the unstraightened metasoma. The range of measurements across specimens examined is given. Head width is a measure of the greatest distance between the outermost margins of the compound eyes, and head length is a measure of the greatest length of the head from the vertexal area to the most anterior part of the apical margin of the clypeus when both the apical margin of the clypeus and the median ocellus are in focus. The number of female and male specimens, not including the type specimen, is stated at the beginning of each species description as (N= __). Included for each species (where applicable) are sections that summarize and discuss distribution, nesting strategies and floral relationships. Details for intraspecific variation among Canadian specimens are included within the redescrptions. All descriptions, except for the first species (alphabetical) for each genus, have been relegated to the Supplementary Material in order to shorten the thesis.

Images were captured using a Visionary Digital BK Plus imaging system equipped with a Canon EOS 40D digital SLR camera. Images were cropped and sharpened, and scale bars were added, using Adobe Photoshop 12. Scale bars represent 1mm for all images except dissections (specified in figure captions) where they represent 0.5mm. Range maps for individual species were constructed in RStudio (V. 0.97.248) using the following packages installed in R (V.2.15.0): **1)** maptools (Bivand & Lewin-Koh 2014); **2)** raster (Hijmans & Elith 2015); **3)** rgdal (Bivand et al. 2014); and **4)** rgeos (Bivand & Rundel 2014). Maps of Canada and the United States of America were plotted using projected shapefiles obtained from Statistics Canada (2015) and the U.S. Census Bureau (2015), and the map of Mexico was plotted using shapefiles obtained from the GADM database of Global Administrative Areas (V.2.8) (Onuferko 2017). Points of Canadian occurrence for a particular species are based on GPS coordinates accurate to at least two decimal degrees. Continuous ranges throughout North America and Mexico were estimated using georeferenced occurrence records from the literature, museum collections and from specimens examined.

3.3 Key to genera for the Canadian Osmiini

(Adapted from Hurd & Michener 1955; Michener 2007; Mitchell 1962; Packer, Genaro & Sheffield 2007).

Females and Males

- (1) 1 Parapsidal lines punctiform (Fig. 3.67), not more than three times longer than wide (integument usually metallic blue or green, sometimes black) *Osmia*
- 1 Parapsidal lines linear (Fig. 3.18c; 3.21b; 3.45d; 3.55e), at least three times longer than wide (integument usually black or rarely metallic blue, green or blue-green) 2
- (2) 1 Propodeum with narrow basal zone separated into a single transverse row of pits by longitudinal carinae AND delimited from the posterior surface by a distinct ridge (Fig. 3.32e); T1 anterior surface delimited from the dorsal surface by a distinct transverse carina (Fig. 3.32d; 3.32e) *Heriades*
- 1 Propodeum with basal zone sloping AND/OR not separated into pits by carinae AND/OR not delimited from the posterior surface by a distinct ridge (Fig. 3.28e; 3.55c; 3.59d; 3.61c; 3.63e); T1 without a distinct carina separating the anterior and dorsal surfaces, the surfaces delimited either by a sharp line (Fig. 3.18d; 3.21d), a rounded angle or T1 evenly convex in profile (Fig. 3.46a; 3.50a; 3.53e; 3.57a; 3.60a; 3.61a) 3
- (3) 1 Mesosoma elongate anteriorly, an imaginary line drawn tangential to the anterior margins of the tegulae would cross near the middle of the mesoscutum (Fig. 3.24f); forewing, marginal cell hardly curving away from costal margin apically, if at all (Fig. 3.30d) *Chelostoma*
- 1 Mesosoma not especially elongate anteriorly, an imaginary line drawn tangential to the anterior margins of the tegulae would cross the mesoscutum considerably anterior to its midline (Fig. 3.45d; 3.55e); forewing, marginal cell distinctly curving away from costal wing margin apically, usually for at least the last third of the marginal cell (Fig. 3.45f) 4
- (4) 1 Female, clypeus modified, apical margin bearing a long, narrow, dorsoventrally flattened, spatulate median projection (Fig. 3.65a; 3.65b; 3.65c); male, T6, apical margin produced

into three broad lobes, median lobe roughly 2x wider than lateral lobe (Fig. 3.66b)
..... *Protosmia*

1 Female, clypeus without a median projection (Fig. 3.14b; 3.49b; 3.55b; 3.59c) OR with a short, snout-like median projection (Fig. 3.57b; 3.57c) OR with a low carina along the midline (Fig. 3.63b; 3.63c); male, T6 apical margin not produced into three broad lobes, EITHER inconspicuously sinuate laterally (Fig. 3.19b; 3.21e) OR bearing three sharp teeth (Fig. 3.50c) OR quadridentate (Fig. 3.17d) OR bearing sharp teeth at lateral margins (Fig. 3.42c; 3.44c; 3.48f; 3.54c; 3.60b; 3.64d) **5**

(5) 1 Mesepisternum separated by a distinct carina into a mostly glabrate, shiny anterior surface and a pubescent, mostly punctate lateral surface (Fig. 3.9a; 3.9d; 3.15d; 3.16a); male, T6 apical margin quadridentate (Fig. 3.11d; 3.13b; 3.15f; 3.17d) *Ashmeadiella*

1 Mesepisternum without a distinct carina separating the anterior and lateral surfaces, and the anterior surface with at least some punctation, especially adjacent to the angle separating the surfaces (Fig. 3.20c); T6 of the male not quadridentate, EITHER inconspicuously sinuate laterally (Fig. 3.19b; 3.21e) OR rounded (Fig. 3.58c) OR bearing three sharp teeth (Fig. 3.50c) OR bearing sharp teeth laterally (Fig. 3.42c; 3.44c; 3.48f; 3.54c; 3.60b; 3.64d) **6**

(6) 1 T1 with anterior surface flat or broadly concave and delimited from the dorsal surface by a sharp line, the line extending for at least half the width of tergum (Fig. 3.18d; 3.19a; 3.21d); parapsidal lines short, less than half the length of the tegula (Fig. 3.18c; 3.21b)
..... *Atoposmia*

1 T1 with anterior surface not distinctly flat or concave, not delimited from the dorsal surface by a distinct line, convex in profile (Fig. 3.46a; 3.50a; 3.53e; 3.60a; 3.61a); parapsidal lines long, at least half the length of the tegula (Fig. 3.45d; 3.55e) *Hoplitis*

3.4 Genus *Ashmeadiella* Cockerell

The genus *Ashmeadiella* is restricted to the Nearctic region. There are 58 described and several undescribed species that make up the five subgenera (Michener 2007). *Ashmeadiella* is most speciose and abundant in the western part of North America and in the deserts south of the Great Basin (Michener 1941). The genus extends east to the Atlantic coast, south to Yucatan and north to the western half of southern Canada. In Canada *Ashmeadiella* is represented by five described species in one subgenus—*Ashmeadiella* s. str.

Ashmeadiella spp. nest in pre-existing cavities both above and below ground (Michener 2000), and have been recorded nesting in wooden trap nests (Krombein 1967) and abandoned snail shells (Michener 1939; 1941). Cell partitions are made from nectar mixed with soil when nesting underground (Rozen 1987) but usually consist of leaf pulp mixed with nectar, gum or resin (Rozen & Eickwort 1997; Michener 2000). The majority of *Ashmeadiella* are polylectic though some appear to be oligolectic, especially those occupying higher elevations and narrower geographic ranges (Michener 1941). It is a group of rather small (3.5 to 9.5mm), robust, non-metallic bees, generally with short flight seasons beginning in early spring and summer (Hurd & Michener 1955).

Diagnosis: All Canadian species of *Ashmeadiella* (and almost all extralimital ones) can be recognized by the mesepisternum which is divided (at nearly a 90° angle) by a carina into a smooth, nearly impunctate anterior surface, and a hairy, punctate lateral surface (carina absent in the two species of the subgenus *Isosmia*, though change in sculpturing remains evident) (Fig. 3.9a; 3.9d; 3.15d; 3.16a). This angulation and change in sculpture is absent in all other genera of Osmini (Fig. 3.20c). Males of the genus are unique among New World Osmini in having the apical margin of T6 quadridentate (Fig. 3.11d; 3.13b; 3.15f; 3.17d).

3.4.1 Key to the Canadian species of *Ashmeadiella*

(Adapted from Michener 1941, and Hurd & Michener 1955)

Females

- (1) 1 Mandible quadridentate (Fig. 3.14b); clypeus modified, impunctate in longitudinal midline, impunctate area occupying the medial 1/3 the width of the clypeus (Fig. 3.14b) *A. cubiceps*
- 1 Mandible tridentate (Fig. 3.10b); clypeus unmodified, EITHER entirely punctate (Fig. 3.10d) OR narrowly impunctate along apical margin between lateral angles of truncation (Fig. 3.8c; 3.12b; 3.16c) 2
- (2) 1 Compound eye at least 1.5x wider than genal area in lateral view (Fig. 3.10f); vertexal area short, distance from posterior margin of lateral ocellus to posterior margin of vertexal area distinctly less than 1.5x distance between lateral ocelli (Fig. 3.10c; 3.16d) 3
- 1 Compound eye not wide, genal area nearly as wide as, or wider than, compound eye in lateral view (Fig. 3.8b; 3.12d); vertexal area long, distance from posterior margin of lateral ocellus to posterior margin of vertexal area at least 1.5x distance between lateral ocelli (Fig. 3.8d; 3.12c) 4
- (3) 1 Clypeus broadly bilobed, the lateral angles of truncation not well defined, rounded, with the apical margin punctured, somewhat dull (Fig. 3.10d); S6 disc unmodified, without a deep distinct horizontal depression, only feebly depressed or flat (Fig. 3.10e) *A. cactorum*
- 1 Clypeus with distinct lateral angles to the truncation, the angles not broadly rounded, nearly 90°, and with the apical margin between angles impunctate, distinctly shiny (Fig. 3.16c); S6 disc distinctly depressed submarginally, not flat or feebly depressed (Fig. 3.16b) *A. gillettei*
- (4) 1 Vertexal area longer than the frontal area, median ocellus anterior to the midpoint between the antennal socket and the posterior margin of the vertexal area ($FAL < VAL$) (Fig. 3.8b; 3.8d); punctation of supraclypeal area distinctly sparser than punctation of basal area of clypeus, at least medially at anterior margin (Fig. 3.8c); apical margin of clypeus feebly undulate between lateral angles of truncation (Fig. 3.8c) *A. buconis*

- 1 Vertexal area not longer than frontal area, median ocellus at, or behind, the midpoint between the antennal socket and the posterior margin of the vertexal area ($FA \geq VA$) (Fig. 3.12c; 3.12d); punctation of supraclypeal area not especially sparse, at least as dense as in basal area of clypeus (Fig. 3.12b); apical margin of clypeus feebly concave between lateral angles of truncation, not undulate (Fig. 3.12b) *A. californica*

Males

- (1) 1 T6, median teeth longer than their basal breadth (Fig. 3.13b); T6, median teeth nearer to lateral teeth than to one another (Fig. 3.13b) *A. californica*
- 1 T6, median teeth shorter than, or only as long as basal breadth (Fig. 3.9f; 3.11d; 3.15f; 3.17d); T6, median teeth not closer to lateral teeth than to one another, evenly spaced or closer to one another than to lateral teeth (Fig. 3.9f; 3.11d; 3.15f; 3.17d) 2
- (2) 1 Vertexal area longer than frontal area (Fig. 3.9b; 3.15g); distance between lateral ocelli distinctly shorter than distance from posterior margin of lateral ocellus to posterior margin of vertexal area (Fig. 3.9g; 3.15b) 3
- 1 Vertexal area shorter than frontal area (Fig. 3.11b); distance between lateral ocelli nearly as long as distance from posterior margin of lateral ocellus to posterior margin of vertexal area (Fig. 3.17c) 4
- (3) 1 At least T1 to T4 with apical hair bands (Fig. 3.9a; 3.9e; 3.9f); genal area, punctation less dense than, or as dense as, that of mesepisternum (Fig. 3.9c versus 3.9d) *A. buconis*
- 1 Only T1 with an apical hair band (Fig. 3.15a; 3.15c; 3.15f); genal area, punctation denser than that of mesepisternum (Fig. 3.15e versus 3.15d) *A. cubiceps*
- (4) 1 Face entirely covered with dense pubescence between inner margins of compound eyes (Fig. 3.17b); scape, elongate, at least 3x longer than greatest width (Fig. 3.17b) *A. gillettei*

- 1 Face not especially pubescent, pubescence not especially dense, absent at least in middle third of clypeus (Fig. 3.11c); scape not so elongate, not more than 3x as long as wide (Fig. 3.11c) *A. cactorum*

***Ashmeadiella buconis* (Say, 1837)**

Osmia buconis Say, 1837, Boston Jour. Nat. Hist., 1: 400.

Megachile osmioides Cresson, 1872, Amer. Ent. Soc. Trans., 4: 269.

Heriades denticulatum Cresson, 1878, Amer. Ent. Soc. Trans., 7: 108.

Heriades rotundiceps Cresson, 1879, Amer. Ent. Soc. Trans., 7: 205.

Ashmeadiella wislizeni Cockerell, 1922, Ann. and Mag. Nat. Hist., 9(10): 545.

Biology: *A. buconis* is polylectic and has been recorded foraging from many plant families including Asteraceae, Fabaceae and Polygonaceae (Robertson 1929; Ascher & Pickering 2016). In Canada, it has been collected from early June (12, Vernon, BC) to Late August (30, Walhachin, BC).

Diagnosis: The female of *A. buconis* can be recognized by the combination of mandible tridentate, clypeus mostly unmodified, flat or feebly convex along an unreflexed apical margin, vertexal area long, longer than frontal area and at least one and a half times as long as the distance between lateral ocelli. The male of *A. buconis* can be recognized by the combination of vertexal area long, longer than frontal area, metasoma with apical fasciae on at least T1 to T4, and T6 median teeth shorter than, or only as long as their basal width.

***Ashmeadiella buconis* redescription**

Figures: 3.2; 3.8; 3.9.

Female (N= 10): length (6.5 to 10mm); head width (2 to 3mm); ITW (1.5 to 2mm); forewing length (4 to 6mm).

Colouration: integument black, except as follows: cap of rutellum of mandible rufescent to piceous; flagellomeres brown, at least ventrally; tegula brown; wings hyaline, faintly dusky; tarsal claw of all legs rufescent to brown; sterna with narrow apical impressed margin golden.

Pubescence: hairs mostly white; head, mesosoma and metasoma with sparse, erect pubescence ($\sim 1.5\text{MOD}$), except as follows: hypostomal area with erect hairs (1.5MOD); paraocular area with subappressed pubescence (1MOD); frontal area with somewhat denser, suberect pubescence near the supraantennal depression ($<2\text{MOD}$); mesepisternum with suberect pubescence at anterior and posterior margins of lateral surface ($<1.5\text{MOD}$); posterior margin of mesoscutellum fringed with long, erect hairs ($>2\text{MOD}$); dorsolateral angle of pronotum with suberect pubescence ($<2\text{MOD}$); metasoma with apical fascia arising from premarginal line, long, at least as long as narrow apical impressed margins of T1-T6 (1MOD), usually less dense on T5; sternal scopa suberect, straw-coloured, oriented posteroventrally, arising from the disc (4MOD).

Surface sculpture: head, including mandible and antenna, with punctures large and dense ($i < d$), except as follows: mandible finely punctate ($i > d$), except along carinae where it is impunctate; clypeus more densely punctate ($i < 0.5d$) except for narrow, impunctate apical margin; supraclypeal area somewhat sparsely punctate medially ($i = d$); vertexal area narrowly impunctate posterior to the median ocellus; mesosoma and metasoma punctures large and dense ($i < 0.5d$), except as follows: tegula punctate only anteriorly ($i > 2d$), the punctures fine; axilla and lateral thirds of mesoscutellum more densely punctate ($i < 0.5d$); metapostnotum impunctate, roughened by carinulae, except weakly scrobiculate laterally; T1 with concave anterior surface impunctate, disc somewhat densely punctate ($i < d$), T2 also densely punctate; T3 less densely punctate ($i \sim d$); T4-T6 with larger, denser punctation ($i < 0.5d$), punctures of T6 especially deep.

Structure: head wider than long ($L:W = 53:49$); scape nearly four times as long as wide ($L:W = 23:6$); pedicel longer than wide ($L:W = 11:7$); mandible tridentate, teeth sharp, well defined, distance from the tooth of rutellum to second tooth of pollex less than one third the greatest width of compound eye ($11:38$); clypeus with apical margin truncate, apical margin of clypeal truncation feebly undulate or variably notched by small emarginations between distinct lateral angles; compound eyes convergent below ($UOD:LOD = 30:25$); $IAD:AOD = 9:6$; supraantennal depression shallow; $IOC < OOC$ ($14:17$); IOC roughly half OV ($14:27$); median ocellus anterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 24:31$); compound eye wider than genal area in lateral view ($18:12$); mesosoma slightly wider than long ($L:W = 60:64$); wings with first recurrent vein meeting posterior margin of second submarginal cell such that the proximal portion of the posterior

margin of the second submarginal cell is less than a third its total length (9:31); metasoma longer than wide, not especially elongate (L:W= 48:33).

Male (N= 8): length 7mm (6 to 8mm); head width 1.5mm (1.5 to 2.5mm); ITW: 1mm (1 to 1.5mm); forewing length 4mm (4 to 5mm).

Agrees with female, except for usual secondary sexual characters and as follows:

Colouration: S6 with apical teeth brown apically; wings nearly clear, dusky only narrowly along costal margin.

Pubescence: somewhat denser than in female, especially as follows: clypeus densely pubescent, hairs subappressed to suberect (>2MOD); paraocular and supraantennal areas with dense, subappressed pubescence (<1MOD); apical fascia absent on T6.

Surface sculpture: clypeus and lateral margins of supraclypeal area finely punctate ($i < 0.5d$) except along narrow impunctate apical margin; punctation of S1 to S4 especially large ($i < 1.2d$).

Structure: head length and width roughly equal (L:W= 63:60); scape more than 3x as long as wide (L:W= 17:5); mandible bidentate, distance from the tooth of the rutellum to the tooth of the pollex less than a third the greatest width of the compound eye (11:36); anterior margin of clypeus somewhat produced into broad, rounded lobe on each side; IAD:AOD= 11:7; IOC > OOC (11:9); IOC < OV (11:15); median ocellus anterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 15:18); compound eye 2x wider than genal area in side view (24:12); T6 with four teeth on posterior margin, median teeth subtruncate, nearly parallel-sided with apical margin angled toward lateral margin such that margin of median tooth nearest longitudinal midline of T6 extends further posteriorly than does the margin of the median tooth nearest the lateral margin of T6, median teeth longer than basal width (L:W= 8:6), apical width subequal to basal width (5.5:6), emargination between

median teeth weakly broadly concave, lateral teeth wider than long (L:W= 3:5), pointed, margin between lateral and median teeth concave; S5 to S8 retracted.

Genitalia: as in Fig. 3.9k.

Distribution: *Ashmeadiella buconis* is widely distributed throughout North America. In the west it ranges from southern British Columbia south through Mexico, and east to southern Saskatchewan, Wisconsin and Illinois south through Georgia and into Mexico. Though it has an extensive range it is chiefly a Western species, rare outside of the more arid parts of its range (Fig. 3.2a). [CAN: BC,AB,SK; USA: AR, AZ, CA, CO, GA, IA, ID, IL, IN, KS, LA, MI, MO, MT, NC, ND, NE, NM, NV, OR, SD, TX, UT, WA, WI, WY; MEX: CH, DU, SO.]

Specimens examined: CAN: Alberta: ♀ Cypress Co., Cypress Hills P.P., 04-05.viii.2013 (G Rowe & L Graham) [Barcoded]; CAN: British Columbia: Okanagan-Similkameen Reg. Dist.: 2 ♀ Vaseux Lk., 24.vi.2009 (L Packer) [Barcoded]; ♂ Keremeos, Grist Mill, 30.vi.2013 (G Rowe & L Graham) [Barcoded]; ♂ Keremeos, Grist Mill, 20.vii.2009 (TG Leischner); ♀ nr Osoyoos, 08.viii.2014 (C Sheffield); USA: California: ♀ San Diego Co., 30.v.2002, (ME Irwin & FD Parker) [Barcoded]; ♂ Riverside Co., 04.vi.2002 (FD Parker & ME Irwin) [Barcoded]; USA: Nevada: ♂ Clark Co., 30.vi.2004 (E. Ahlstrom) [Barcoded]; USA: New Mexico: ♀ Eddy Co., 02.viii.2010 (JD Herndon) [Barcoded]; ♂ Rattlesnake Springs, 28.vi.2011 (JD Herndon) [Barcoded]; USA: Texas: ♂ Monahans Sandhill S.P., 22.iv.2006 (JL Neff & A Hook) [Barcoded]; ♂ LaSalle Co., Chaparral Wildlife Management Area, 05.vi.2003 (L Packer) [Barcoded]; ♂ Travis Co., Austin: Hornsby Bend Research Area, 08.v.2013 (JL Neff); ♀ Travis Co., Austin: Vireo Preserve, 24.xi.2012 (JL Neff); ♀ Presidio Co., 19.v.2005 (JL Neff) [Barcoded]; USA: Wyoming: ♀ Worland, 05.vii.1917 (L Bruner); MEX: Sonora: ♀ 30km E Agua Prieta, 13.v.2006 (RL Minckley).

Type depository: Male, from Colorado, USA, in the Philadelphia Academy of Natural Sciences [Examined].

3.5 Genus *Atoposmia* Cockerell

Atoposmia is a small, wholly Nearctic, genus of osmiines currently with 28 described species in three subgenera (Michener 2007). This genus includes most of the Nearctic species that were formerly placed in *Anthocopa*, a Palaearctic subgenus of *Hoplitis* Klug (Michener 2007). The American species of *Anthocopa* were removed from *Hoplitis* due to their lack of the characteristic basal flaps on S6 found in nearly all male *Hoplitis* species and their seemingly closer relationship to *Osmia* (Michener 1943). Their Palaearctic counterparts are less easily separable from *Hoplitis* with characters somewhat intermediate to those of *Atoposmia* and the remaining *Hoplitis* (Michener 1941). But this complexity does not affect the Canadian species.

Atoposmia are distributed west of the eastern foothills of the Rocky Mountain Range, mostly at high altitudes. All species within any given subgenus appear to have very specific floral relationships, at least to the level of plant family (e.g. Michener 1936b; Hurd & Michener 1955). In Canada there are two species of *Atoposmia* representing two of the three named subgenera. The nesting behaviours of some American species were recorded by Parker (1975; 1977) and Yanega (1994).

Diagnosis: Canadian *Atoposmia* can be distinguished from other Canadian Osmiini by the combination of mesepisternum without a distinct carina separating the anterior and lateral surfaces, and the anterior surface with at least some punctation, especially adjacent to the angle separating the surfaces (Fig. 3.20c), short parapsidal lines, usually less than half as long as tegula but more than 3x as long as wide (Fig. 3.18c; 3.21b), marginal cell of forewing distinctly curving away from costal wing margin apically, usually for at least the last third of the marginal cell (Fig. 3.45f), and T1 with a sharp line delineating the flat or broadly concave anterior surface from the posterior surface (Fig. 3.18d; 3.19a; 3.21d) rather than a distinct carina, a rounded angle or a continuous convexity between the two surfaces that are characteristic of the other Osmiini (Fig. 3.46a; 3.50a; 3.53e; 3.60a; 3.61a). Females have the clypeus unmodified, without a median projection (Fig. 3.14b; 3.49b; 3.55b; 3.59c), and males have the apical margin of T6 apical margin rounded or inconspicuously sinuate laterally (Fig. 3.19b; 3.21e).

3.5.1 Key to the Canadian species of *Atoposmia*

(Adapted from Michener 2007)

Males and females

- (1) 1 Integument black, non-metallic (Fig. 3.18c); male, T7 exposed (Fig. 3.19b)
..... *A. (Atoposmia) abjecta*
- 1 Integument feebly metallic with a green-blue hue (Fig. 3.20a; 3.21a), not black; male, T7
not exposed, hidden by T6 (Fig. 3.21e) *A. (Hexosmia) copelandica*
-

Atoposmia abjecta (Cresson, 1878)

Osmia abjecta Cresson, 1878, Trans. Am. Ent. Soc., 7: 103.

Hoplitis mesae Cockerell, 1930, Amer. Mus. Novitates, 397: 2.

Osmia alta Michener, 1936, Canad. Ent., 68(2): 41.

Anthocopa (Atoposmia) nigrior Michener, 1943, Ann. Ent. Soc. Amer., 36: 54.

Anthocopa (Atoposmia) abjecta abjecta Cresson, 1878, Trans. Amer. Ent. Soc., 7: 103.

Anthocopa (Atoposmia) abjecta alta Michener, 1936, Can. Entomol., 68(2): 41.

Biology: *Atoposmia abjecta* has been recorded visiting *Petalonyx* sp. (Loasaceae) and *Penstemon* spp. (Scrophulariaceae) (Ascher & Pickering 2016). In Canada, one specimen has been collected in southern British Columbia on August 18th at high elevation (1630m).

Diagnosis: Both sexes of *A. abjecta* can be recognized by the characters that distinguish the genus, and the female can be distinguished from other Canadian *Atoposmia* by the black sternal scopa, and the male by the exposed seventh tergum.

Atoposmia abjecta redescription

Figures: 3.3; 3.18; 3.19

Female (N=2): length 7mm (8 to 8.5mm); head width 2.5mm (2.25 to 3mm); ITW 2mm (2 to 2.25mm); forewing length 6mm (5.5 to 6mm).

Colouration: integument black, except as follows: F3-F10 yellowed, at least ventrally; cap of rutellum piceous to black; abductor swelling of mandible rufescent; tegula piceous; wings hyaline, dusky, marginal cell darkest; tarsal claw of all legs rufescent; terga with narrow apical impressed margin piceous.

Pubescence: hairs mostly light brown; head and mesosoma covered in somewhat dense, suberect, plumose pubescence ($<2\text{MOD}$), except as follows: hairs of hypostomal area darker brown, somewhat bowed ventromedially ($>2\text{MOD}$); apical margin of labrum fringed with rufescent, erect setae (0.5MOD); apical margin of clypeus with short tufts of ochraceous setae on either side of the midline, arising from beneath the clypeal truncation, oriented anteromedially ($<0.5\text{MOD}$); clypeus with dark brown erect pubescence ($>2\text{MOD}$); pubescence in paraocular area denser, subappressed (2MOD); frontal area and vertexal area with pubescence longer, erect ($<3\text{MOD}$); posterior margin of pronotal lobe fringed with white tomentum ($\sim 0.5\text{MOD}$); mesepisternum, metanotum and dorsolateral angle of propodeum with long, suberect pubescence ($\sim 3\text{MOD}$), metapostnotum glabrate; axilla and posterior margin of mesoscutellum with dense, erect pubescence ($\sim 1\text{MOD}$); metasomal terga apically fasciate, hairs arising from the premarginal line and long enough to cover the narrow apical impressed margins, usually only laterally (1MOD); sternal scopa black ($>4\text{MOD}$), oriented posteroventrally and arising from the disc ($>2\text{MOD}$), S6 without scopa.

Surface sculpture: head, including mandible and antenna, moderately punctate ($i=1/3d$), except as follows: punctation of hypostomal area shallow and sparse, somewhat obscure ($i<d$); mandible impunctate along carinae; clypeus narrowly impunctate along apical margin between lateral angles of clypeal truncation; supraclypeal area somewhat sparsely punctate medially ($i<d$); scape with punctures shallow, less well defined ($i\sim 1/2d$); pronotum puncticulate, the punctures shallow and obscure ($i\sim d$), with the interspaces highly foveolate; mesepisternum punctured as genal area ($i=1/3d$); mesoscutum medially with larger, sparser ($i>d$) punctation than genal area, punctures becoming finer and denser ($i=1/3d$) toward margins; tegula finely and sparsely punctate ($i<d$), punctation somewhat denser anteriorly; mesoscutellum punctures large

($i=1/3d$), narrowly impunctate along longitudinal midline; metanotum imbricate-punctate; metepisternum coriarius-punctate, punctures sparse ($i>d$), with many areas impunctate, shiny; metapostnotum impunctate, shiny along midline, very finely punctate ($i\sim 1/2d$) basad toward a scrobiculate lateral extreme; propodeum with lateral surface more finely punctured than mesepisternum, similarly spaced ($i=1/3d$), but punctures shallow, not well defined, dorsal surface punctures larger, similarly spaced and only slightly more distinct, still shallow; metasoma more finely punctate than head and mesosoma, punctures generally shallow, less well defined, and less dense ($i>d$), except as follows: T1 anterior surface sulcus impunctate; puncture density increasing on more posterior terga and towards the sides of each tergum; apical margins of terga narrowly impunctate; S1-S5 punctures of disc large ($i=1/2d$), narrowly impunctate along apical margin; punctation of S6 finer than that of S5, similarly spaced ($i=1/2d$), finest in marginal zone ($i\sim 1/3d$).

Structure: head length to width roughly equal ($L:W=65:62$); scape longer than wide ($L:W=15:4$); pedicel and F1 longer than wide ($L:W=4:3$; $L:W=4:2$, respectively); flagellomeres flattened ventrally; hypostomal carina moderate; mandible tridentate, the teeth sharp, the margins between them sharply angled, distance from tooth of rutellum to first tooth of pollex nearly equal to the distance between teeth of the pollex (11:10), somewhat widened at apex, the apical width not as wide as the greatest width of compound eye (21:28); clypeus convex, truncate, the margin between lateral angles of truncation weakly concave, lateral angles of truncation well defined, rounded, lateral margins of truncation nearly straight; clypeus with a conspicuous longitudinal carina along midline, less conspicuous near apical margin; frontal line produced to a small, somewhat vertically elongate tubercle at midpoint between antennal bases; supraantennal depression shallow; $IAD>AOD=12:8$; $IOC=OOC$; $IOC=OV$; median ocellus posterior to midpoint between apical margin of clypeus and posterior margin of vertexal area ($FAL:VAL=29:22$); inner margins of compound eyes subparallel ($UOD:MID:LOD=40:42:40$); genal area wider than compound eye in lateral view (21:13); mesosoma wider than long ($L:W=59:69$); admedian line deep anteriorly; propodeum entirely declivous; metacoxa with inner ventral carina weak; metasoma longer than wide ($L:W=52:46$); marginal zone of T6 dorsally reflexed such that profile is concave; S6 somewhat triangulate in posterior view, the midline being further from T6 than the lateral extremes.

Male (N=4): length (8.5 to 9mm); head width (2 to 2.5mm); ITW (2 to 2.25mm); forewing length (5 to 6mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: F3 to F10 less conspicuously yellowed than in female; tegula darker than in female, nearly black; wings hyaline; sterna with narrow apical impressed margin light brown to rufescent.

Pubescence: clypeus with apical setae longer than in female, of equal length between lateral angles of clypeal truncation, oriented anteriorly ($>2\text{MOD}$); pubescence of clypeus denser, less erect, longer and not darkened ($>2\text{MOD}$); pubescence of paraocular area denser, shorter and more appressed ($\sim 1\text{MOD}$); only T1 to T3 apically fasciate laterally ($>2\text{MOD}$); apical margin of S3 fringed, hairs denser in median emargination, hairs long ($\sim 2\text{MOD}$), S4 with somewhat dense, dark ochraceous to brown hairs in marginal zone, oriented posteromedially, sometimes resembling a median tuft at the median emargination ($\sim 1\text{MOD}$).

Surface sculpture: hypostomal area punctured as in genal area ($i=1/3d$); mandible with punctuation of outer interspace imbricate-punctate; punctures of mesoscutum not larger than those of genal area, still sparser medially ($i>d$), becoming denser ($i=1/3d$) toward margins; mesoscutellum punctured as in posterior margin of mesoscutum ($i=1/3d$), narrowly impunctate along longitudinal midline; S2 –S4 with shallow, large punctuation in disc ($i\sim d$), narrowly impunctate along apical margin.

Structure: head wider than long ($L:W= 59:63$); scape longer than wide ($L:W= 26:5$); pedicel as long as wide; penultimate flagellomere longer than wide ($L:W= 16:11$), ultimate flagellomere with length and width subequal ($L:W=11:10$); distance from tooth of rutellum to first tooth of pollex much greater than the distance between teeth of the pollex (15:9), mandible not especially widened at apex; clypeal truncation short, with lateral angles of truncation rounded, extending anteriorly beyond the margin between them, the margin gently undulate; inner margin of compound eyes subparallel ($UOD:MID:LOD= 65:68:66$); $IAD>AOD= 18:15$; IOC subequal OV (13:12); median ocellus posterior to midpoint between apical margin of clypeus and posterior margin of vertexal area ($FAL:VAL= 24:20$); genal area wider than

compound eye in lateral view (32:25); mesosoma length to width subequal (L:W=46:48); metasoma longer than wide (L:W= 72:48); lateral margin of T6 produced to a small, broadly rounded tooth, tooth half as long as its basal width (L:W= 3:6); T7 tri-lobed, median lobe much reduced, inconspicuous, often appearing as nothing more than a sinuate margin, lateral lobes somewhat broadly rounded, length subequal to basal width (L:W= 4:5); S1 short, angled at premarginal line such that the sternum is thickened subapically and the marginal zone is posterior facing; disc of S2 much produced, the rounded apical margin extending posteriorly and covering most of S3; apical margin of S3 conspicuously emarginate; margin of S4 rounded; S5-S8 retracted.

Genitalia: as in Fig. 3.19c.

Distribution: *A. abjecta* is a montane species distributed along the Rocky Mountain Range, at higher elevations. It has been collected as far north as southern British Columbia and south to California. It ranges as far east as Colorado and Wyoming (Fig. 3.3a). [CAN: BC; USA: CA, CO, ID, NV, OR, UT, WY.]

Specimens examined: CAN: **British Columbia:** ♀ *East Kootenay Reg. Dist.*, Ram Creek, 18.viii.2009, 1630m (LR Best); USA: **California:** ♂ *Mariposa Co.*, Gallison Lk., 26.vii.2006, 3189m (H Ikerd) [Barcoded]; ♂ *Madera Co.*, SW Red Peak, 12.viii.2006, 2042m (E Stephens) [Barcoded]; ♂ *Mono Co.*, White Mountains Observatory, 07.vii.2004, 3885m (AS Menke & FD Parker) [Barcoded]; USA: **Utah:** ♂ *Cache Co.*, Mt Naomi, 24.vii.2008 (TL Griswold) [Barcoded].

Type depository: Female, from Colorado, in the Academy of Natural Sciences of Philadelphia. [Examined]

3.6 Genus *Chelostoma* Latreille

Bees of the genus *Chelostoma* are represented by 54 described species (Michener 2007). The genus is most diverse in the Palaearctic where it is represented by 42 described species in five subgenera (Sedivy et al. 2008). There are 11 species (nine native and two introduced) in

three subgenera (Michener 2007) in the Nearctic. One species—*C. (Eochelostoma) aureocinctum* (Bingham 1897)—has been collected in the Oriental region (Griswold & Michener 1998).

Chelostoma nest in small, preexisting cavities using mud sometimes mixed with nectar, sand and/or pebbles to construct brood cells (Michener 2007). A large-scale study on the host-plant choice of Palaearctic, Nearctic and Indomalayan *Chelostoma* confirmed that all but two species are oligolectic at the level of plant family or genus (Sedivy et al. 2008), an observation that has been long-standing (Michener 1938b). The two generalist species were shown to have evolved from oligolectic ancestors, suggesting the more recent origin of wider hostplant use, and reaffirming oligolecty as the ancestral state among *Chelostoma* (Sedivy et al. 2008).

Diagnosis: Both sexes of Canadian *Chelostoma* can be recognized by the combination of mesosoma elongate anteriorly such that an imaginary line drawn tangential to the anterior margins of the tegulae would cross near the middle of the mesoscutum (Fig. 3.24f), and forewing with marginal cell hardly curving away from costal margin apically, if at all (Fig. 3.30d).

3.6.1 Key to the Canadian species of *Chelostoma*

(Adapted from Michener 1938b, and Hurd & Michener, 1955)

Females

- (1) 1 Genal area 1.5x wider than compound eye in lateral view (Fig. 3.28b); base of labrum modified, bearing yellowish membranes at lateral extremes (Fig. 3.28c; 3.28d) *C. (Prochelostoma) philadelphi*
- 1 Genal area not especially wide, compound eye at least as wide as genal area in lateral view (Fig. 3.26c; 3.30a); base of labrum unmodified, without yellowish membranes at lateral extremes (Fig. 3.22d; 3.24e); **2**
- (2) 1 Clypeus with apical margin distinctly crenulate, crenulations well defined, at least as long as their basal widths (Fig. 3.30b); preoccipital carina present (Fig. 3.30c) *C. (Gyrodromella) rapunculi*

- 1 Clypeal margin not distinctly crenulate, either feebly crenulate or undulate, or straight between lateral margins (Fig. 3.22d; 3.24c; 3.26b); preoccipital carina absent (Fig. 3.22c) **3**
- (3) 1 Metasomal terga apically fasciate, at least on T1 to T3, fasciae usually medially effaced (Fig. 3.26a); scape elongate, at least 2.5 times longer than wide (Fig. 3.26b) ***C. (Foveosmia) phaceliae***
- 1 Metasomal terga without apical fascia on T1 to T5 (Fig. 3.22a; 3.24d); scape somewhat thickened, not especially elongate, not more than 2 times longer than wide (Fig. 3.22d; 3.24c) **4**
- (4) 1 Clypeus with apical margin straight (Fig. 3.24c); supraantennal depression strong in paraocular area posteriorly nearly to an imaginary line drawn tangential to the anterior margin of the median ocellus (Fig. 3.24b) (west of the Great Plains) ***C. (Foveosmia) minutum***
- 1 Clypeus with apical margin feebly crenulate or undulate, not distinctly straight (Fig. 3.22d); supraantennal depression less strong, feeble at an imaginary line drawn tangential to the anterior margin of the median ocellus (Fig. 3.22b) (east of the Great Plains) ***C. (Foveosmia) campanularum***

Males

- (1) 1 S2 with a distinct protuberance in longitudinal third of disc, protuberance high, apex either broadly rounded or conical and angulate (Fig. 3.27c; 3.31a) in profile; T7 with apical margin bearing three processes, the processes either short truncate lobes (Fig. 3.31c), or long and slender, spine-like (Fig. 3.27d) **2**
- 1 S2 without a distinct protuberance, disc either unmodified (Fig. 3.25a), feebly swollen (Fig. 3.23a) or with a low, transverse swelling (Fig. 3.29a; 3.29b); T7 with two or four processes (Fig. 3.23b; 3.25b; 3.29d) **3**

- (2) 1 S3 with a distinct patch of short, bristle-like setae submarginally on either side of the longitudinal midline, the setae black, thick, oriented posteroventrally (Fig. 3.31b); S5 with a distinct tranverse apical fringe, the hairs modified, bowed ventrally from their base for a third their length then zigzagged to apices (Fig. 3.31b); preoccipital carina present *C. (Gyrodromella) rapunculi*
- 1 S3 without modified pubescence, without patches of bristle like setae submarginally (Fig. 3.27b); S5 not fringed laterally, median emargination fringed with long hairs, the hairs oriented toward midline forming a distinct tuft, the tuft sinuate in profile, bowed ventrally in basal third, then straight, then bent dorsad at apical third (Fig. 3.27b); preoccipital carina absent *C. (Foveosmia) phaceliae*
- (3) 1 T7 with apical margin produced to four short projections, the projections hardly longer than their basal widths (Fig. 3.29d); S5 without an apical fringe *C. (Prochelostoma) philadelphi*
- 1 T7 either bidentate (Fig. 3.23b) or quadridentate (Fig. 3.25b), if with four projections then these are long and slender, at least 2.5 times their basal widths; S5 with a distinct apical fringe (Fig. 3.23c; 3.25c) 4
- (4) 1 T7 bidentate (Fig. 3.23b); S5 with apical fringe tranverse, the hairs evenly bowed dorsally (Fig. 3.23c); T6 with apical margin reflexed dorsally (Fig. 3.23a) (east of the Great Plains) *C. (Foveosmia) campanularum*
- 1 T7 quadridentate (Fig. 3.25b); S5 not fringed laterally, the hairs modified, zigzagged or undulate, not evenly bowed, bent ventrally from base at a third the length then bowed dorsally to apices (Fig. 3.25c); T6 apical margin unmodified, not reflexed dorsally (Fig. 3.25a) (west of the Great Plains) *C. (Foveosmia) minutum*

***Chelostoma campanularum* (Kirby, 1802)**

Apis florissomnis minima Christ, 1791, Naturgeschichte, Klassifikation und Nomenclatur der Insekten, p. 197. [in German] [Homonym]

Apis campanularum Kirby, 1802, Monographia Apum Angliae, 2: 256. [in German]

Biology: *C. campanularum* is oligolectic for pollen on *Campanula* (Campanulaceae) and polylectic for nectar resources (Westrich 1989; Eickwort 1980; Amiet et al. 2004; Sedivy et al. 2008). It was introduced to New York State in the mid 1900s (Eickwort 1980). In Canada, *C. campanularum* has been collected in Ontario throughout the month of July (6-18, Toronto, ON) and is common at least in urban areas where its host is grown as a garden plant.

Diagnosis: The female of *C. campanularum* can be recognized by the combination of base of labrum without membrane, supraantennal depression only moderate in paraocular area, feeble posteriorly beyond posterior margin of antennal socket, preoccipital carina absent, and metasomal terga without apical fasciae. The male can be recognized by the combination of T6 with apical margin feebly reflexed dorsally, T7 with apical margin bidentate, and disc of S2 a low, transverse swelling.

***Chelostoma campanularum* redescription**

Figures: 3.4; 3.22; 3.23

Female (N=13): length (5 to 7mm); head width (1 to 1.25mm); ITW (0.5 to 1mm); forewing length (3 to 4.5mm).

Colouration: integument black, except as follows: cap of rutellum of mandible piceous; tegula dark brown; wings hyaline, dusky, veins and stigma dark; hind tibial spur straw-coloured; tarsi and tarsal claw of all legs light brown to rufescent.

Pubescence: hairs mostly white, except somewhat ochraceous dorsad; integument sparsely pubescent, hairs erect (<1MOD), except as follows: posterior margin of mesoscutellum fringed with sparse, long, erect pubescence (>1.5MOD); T6 with apical fascia, the hairs straw-coloured, arising from premarginal line, at least as long as narrow apical impressed margin

(<1MOD); sternal scopa suberect, straw-coloured, oriented posteroventrally and arising from the disc (>2MOD).

Surface sculpture: head, including mandible and antenna, moderately and evenly punctate ($i < 1/3d$), except as follows: apical margin of lateral tubercle of clypeus narrowly impunctate; clypeus and supraclypeal area with finer and sparser punctation ($i > 1/2d$); mesosoma and metasoma punctured as for head, except less evenly spaced ($i < d$), except as follows: tegula sparsely punctate, punctures fine ($i > 2d$); axilla more finely punctate ($i = 1/2d$); punctures of mesoscutellum less dense, especially medially ($i < 1.5d$); metanotum punctures large and dense punctate ($i = 1/3d$); metapostnotum with horizontal basal zone scrobiculate, otherwise finely punctate ($i \sim 1/2d$); propodeum with lateral surface and dorsal surface with larger punctures ($i \sim 1/2d$); T1 anterior surface mostly impunctate; T5 much more finely punctate than T4 ($i < d$), T6 even more finely punctate ($i = 1/2d$); sterna with marginal zone finely punctate ($i \sim d$).

Structure: head slightly longer than wide (L:W= 65:62); scape nearly 3x as long as wide (L:W= 14:5); pedicel longer than wide (L:W= 9:5); flagellomeres somewhat ventrally flattened, F10 longer than wide (L:W= 11:9); labrum thickened along apical margin; mandible tridentate, teeth sharp, well defined, distance from tooth of rutellum to first tooth of pollex subequal to distance between two teeth of pollex (5:4) and approximately 1/2 total length of clypeus (9:19); hypostomal carina high; clypeus convex, except at extreme lateral margins where the apical margin is subtruncate, the truncation broadly rounded, covering less than 1/4 the width of the apical margin, the margin between rounded truncations crenulate; clypeus roughly 2.5x longer than clypeoantennal distance (13:5); IAD:AID= 17:10; IOC subequal OOC (11:12); IOC < OV (11:15); median ocellus behind midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 23:20); supraantennal depression moderately deep; paraocular carina high; compound eyes convergent below (UID:LID= 43:37); compound eyes wider than genal area in lateral view (23:20); parapsidal line elongate, nearly 3/4 as long as tegula (21:34); hind coxa carinate along inner ventral margin; T1 anterior surface convex with a distinct longitudinal furrow.

Male (N= 12): length (4 to 5mm); head width (0.5 to 1mm); ITW (0.5 to 1mm); forewing length (3.5 to 4.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: tarsal claw of all legs ferruginous; tarsi of all legs dark brown to black; wings darker than in female.

Pubescence: sparser than in female; mesoscutellum with thin fringe of long hairs at posterior margin; S4 with apical fringe of white setae oriented posteriorly ($<1.5\text{MOD}$); S5 with apical fringe of ochraceous setae bowed dorsad for their length, setae conspicuously thicker than those of the apical fringe of S4.

Surface sculpture: punctation of clypeus finer only in anterior half ($i \sim 1/2d$); metanotum less densely punctate ($i < d$) than in female; T1 disc with finer, denser punctation ($i < d$) than on T2 to T4 ($i < 1.5d$); T5 with finer, denser ($i \sim d$) punctation than T4; T6 punctures somewhat finer than those of T5, though similarly spaced; apical processes of T7 almost imbricate punctate ($i \sim 1/2d$); sterna impunctate on marginal zones; S1 and S2 with large, uneven punctation on discs ($i < 2d$); S3 and S4 moderately densely punctate ($i < 1.5d$); S5 and S6 with finer punctation ($i \sim d$).

Structure: head length to width nearly equal ($L:W = 58:60$); scape nearly 2x as long as wide ($L:W = 23:12$), pedicel length to width equal ($L=B$); F11 flattened ventrally; labrum short, not thickened at apex, thickened basad; mandible bidentate, distance from tooth of rutellum to first tooth of pollex nearly $1/3$ the total length of clypeus ($5:14$); clypeus weakly truncate, the lateral angles of truncation not well defined, broadly rounded, the margin between them concave; clypeoantennal distance half total length of clypeus ($10:20$); $IAD:AID = 9:18$; paraocular carina low; supraclypeal area with conspicuous tubercle on frontal line at midpoint between antennal bases; $IOC > OOC$ ($18:15$); $IOC > OV$ ($18:9$); median ocellus posterior to midpoint between antennal socket and posterior margin of vertexal area such that frontal area is 2x longer than vertexal area ($FAL:VAL = 24:12$); compound eyes convergent below ($UOD:LOD = 70:56$); compound eye wider than genal area in lateral view ($29:22$); parapsidal line elongate, over $3/4$ as long as tegula ($19:23$); apical margin of T6 reflexed dorsally, sinuate in profile, convex basally, concave towards apex; apical margin of T7 bidentate, the projections long and slender, the

distance between them not greater than the width of one projection, the margin between them concave, marginal area with a median, subapical, circular, deep and distinct pit; discs of S2 and S3 swollen transversely, S2 more distinctly so than S3; apical margin of S3 convex; S6 to S8 retracted.

Genitalia: as in Fig. 3.23d.

Distribution: *C. campanularum* is common throughout Europe (except the far North) and was introduced to New York State in the mid 1900s where it was first collected in 1973 (Eickwort 1980). Since its introduction it has expanded its range north to southern Ontario (Buck, Paiero & Marshall 2005). It is the only North American species of *Foveosmia* east of the Great Plains (Fig. 3.4a). [CAN: ON; USA: NY].

Specimens examined: CAN: Ontario: 2 ♂ Toronto, 06.vii.2006 (J Gibbs) [2 ♂ Barcoded]; 2 ♂ Toronto, ON, 18.vii.2006 (J Gibbs); ♀ ♂ Toronto, ON, 14-17.vii.2006 (J Gibbs) [♀ Barcoded]; 11 ♀ 6 ♂ Southern Ontario, 12.vii.2007 (M Horn) [11 ♀ 6 ♂ Barcoded]; USA: New York: ♂ Ontario Co., Canandaigua, 09.vii.1978 (G & K Eickwort); RUS: Moscow: ♀ Troitse-Lobanovo, 12.vii.2007 (TV Levchenko); SVK: CSSR: ♀ Štúrovo, 08.vi.1964 (Z Pádr).

Type material: No original type material known. Lectotype, female, from the United Kingdom, by designation of Tkalcu. Depository unknown. [Not examined]

3.7 Genus *Heriades* Spinola

*Heriades*³ is one of the most widely distributed genera among the Osmiini. It is diverse in terms of number of species described across its range (Palearctic, Nearctic, and Afrotropical

³A note on the gender of *Heriades* is required in order to avoid perpetuating the use of misnomers, many of which occur among *Heriades*. Although the origin of *Heriades* has been debated (eg. masculine: *Eriades*, Dalla Torre and Friese, 1895; feminine: Royal Entomological Society of London, 1934), Spinola (1808) uses terminology in his paper that describes the word “*Heriades*” as a third declension plural noun, making the singular form *Heriad*. *Heriad* translates to either a son of Eris (masculine) or a mountain nymph (feminine). Spinola (1808) included two species in his description of the genus—*Heriades pusilla* and *Heriades sinuata*—both feminine, thus outlining his intention for a feminine genus. Although the subsequent designation of *Apis*

regions), and has been collected in both the Oriental and Neotropical regions (Michener 2007). The discovery in Colombia of *Heriades tayrona* marked the first record of Osmiini in South America (Gonzalez & Griswold 2011). Currently there are 110 described species in nine subgenera (Michener 2007). Only one subgenus, *Neotrypetes*, occurs in the New World, with 13 described species, four of which occur in Canada. The subgenus *Neotrypetes* contains species previously included in *Physostetha*, which was synonymized with *Neotrypetes* Robertson by Griswold (1985). The genus is in need of a revision of its New World species, many of which are undescribed (Gonzalez & Griswold 2011).

Bees of the genus *Heriades* are black, with large punctures and strongly carinate. The majority of species are small (4 to 7mm), though a few are over 10mm (Michener 2007). Nearctic representatives tend to be polylectic (Krombein et al. 1979), and as such, often have long flight seasons and have been collected throughout North America from early spring to late summer. This is also true for Canadian species. These slender, nearly parallel-sided bees nest in pre-existing cavities using resin to construct their brood cells (Rau 1922; Matthews 1965; Krombein 1967; Jansen et al. 2007).

Diagnosis: Both sexes of Canadian *Heriades* can be recognized by the combination of propodeum with narrow basal zone separated into a single transverse row of pits by longitudinal carinae and delimited from the posterior surface by a distinct ridge (Fig. 3.32e), and T1 anterior surface delimited from the dorsal surface by a distinct transverse carina (Fig. 3.32d; 3.32e).

3.7.1 Key to the Canadian species of *Heriades*

(Adapted from Hurd & Michener 1955; Griswold & Michener 1998)

Females

truncorum as type species by Latreille (1809) suggests a masculine gender, it has no bearing because, according to Article 30 of the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature, fourth ed.) gender is determined by originally included species rather than by type species (D. Yanega, 2016, personal communication).

- (1) 1 Mandible with condylar ridge and outer ridge meeting in outer interspace (Fig. 3.32c; 3.34c); mandible with acetabular carina distinct, high into acetabular interspace, higher than outer ridge (Fig. 3.32a) **2**
- 1 Mandible with condylar ridge not intersecting outer ridge (Fig. 3.36c; 3.38c); mandible with acetabular carina not especially high into acetabular interspace, not distinctly higher than outer ridge (Fig. 3.36b; 3.38b) **3**
- (2) 1 Labrum medially with one basal, round tubercle (Fig. 3.32a); clypeal margin straight between lateral tubercles (Fig. 3.32a) ***H. carinata***
- 1 Labrum with one U-shaped basal tubercle, often appearing as two tubercles, on either side of the midline (Fig. 3.34b); clypeal margin concave between lateral tubercles, not straight (Fig. 3.34b) ***H. cressoni***
- (3) 1 T6 with apical fascia beige-coloured, more closely matching apical fascia of S6 rather than that of T5 (Fig. 3.36a; 3.36e); T5 with punctation distinctly less dense than that of T6 (Fig. 3.36e) ***H. leavitti***
- 1 T6 with apical fascia mostly white, more closely matching apical fascia of T5 rather than that of S6 (Fig. 3.38a; 3.38d); T5 with punctation as dense, or nearly so, as that of T6, not distinctly less so (Fig. 3.38d) ***H. variolosa***

Males

- (1) 1 Foreleg with at least the femur distinctly pale, amber coloured (Fig. 3.37d; 3.39d); S1 large, covering much of S2, its apical margin pointed or rounded, often touching, or hidden beneath T6 when metasoma recurved (Fig. 3.37c; 3.39c; 3.39d) **2**
- 1 Foreleg wholly black (Fig. 3.33b; 3.35e); S1 short, not extending out and over S2, truncate at apex, not pointed or rounded, not reaching T6 when metasoma recurved (Fig. 3.33c; 3.33f; 3.35d) **3**

- (2) 1 S1, apical margin distinctly pointed at midline, apex not obscured by pubescence (Fig. 3.39e); F1 at least as long as wide (Fig. 3.39d) *H. variolosa*
- 1 S1, apical margin not acutely pointed, though margin often tapered to centre, the tip remains rounded, often obscured by pubescence (Fig. 3.37c); F1 wider than long (Fig. 3.37b) *H. leavitti*
- (3) 1 Metasoma, T3, punctation less dense than that of T4 (Fig. 3.33d); S1 process broad, evenly rounded to apex (Fig. 3.33c; 3.33e; 3.33f; 3.33g) *H. carinata*
- 1 Metasoma, T3, punctation not distinctly less dense than that of T4, similarly punctured (Fig. 3.35c); S1 process slender in profile, its apex emarginate when viewed from posterior (Fig. 3.35b; 3.35d)..... *H. cressoni*
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***Heriades carinata* Cresson, 1864**

Heriades carinatum Cresson, 1864, Proc. Ent. Soc. Phila., 2: 383.

Heriades glomerans Schletterer, 1889, Zool. Jahrb. Abt. f. System., 4: 681.

Trypetes barbatus Robertson, 1903, Trans. Am. Ent. Soc., 29: 171 (not *sensu auct.*).

Heriades (Physostetha) carinatus Cresson, 1864, Proc. Ent. Soc. Phila., 2: 383.

Biology: *H. carinata* is polylectic and has been recorded visiting many plant families for floral resources (Ascher & Pickering 2016). In Canada, *H. carinata* has been collected coast to coast from June (2, Seton Lake, AB) through August (26, Penticton, BC).

Diagnosis: The female of *H. carinata* can be recognized by the clypeus which has distinct, well produced lateral tubercles on apical margin, apical margin straight between lateral tubercles. The male of *H. carinata* can be recognized by S1 with a broad projection, the projection evenly rounded to apex rather than with a narrow, emarginate apex.

***Heriades carinata* redescription**

Figures: 3.5; 3.32; 3.33; 3.40

Female (N= 47): length 7mm (6 to 8.5mm); head width 1.5mm (1.5 to 2.25mm); ITW 1mm (1 to 1.5mm); forewing length 4.5mm (4 to 5.5mm).

Colouration: integument black, except as follows: cap of rutellum of mandible piceous; antenna brown; tegula dark brown to piceous; all tarsi and tarsal claws testaceous; hind tibial spur honey-coloured; wings hyaline, dusky, darkest along costal margin in marginal cell; terga with narrow apical impressed margin paler, brown to rufescent; sterna with narrow apical impressed margin golden.

Pubescence: hairs mostly white; head, mesosoma and metasoma sparsely pubescent with erect, plumose hairs (1MOD), except as follows: clypeus with ochraceous, erect setae arising from apical margin and oriented anteriorly (~1MOD); clypeus, basad and laterally, and frontal area with subappressed pubescence (<1MOD); paraocular area with dense, subappressed pubescence (<1MOD); posterior margin of mesoscutellum fringed with long, erect pubescence (2MOD); mesepisternum with denser pubescence toward ventral surface of mesosoma (<2MOD); metasoma with apical fascia arising from premarginal line, at least as long as narrow apical impressed margins, fascia of T1 medially effaced and short (<0.5MOD); sternal scopa white or straw-coloured, oriented posteroventrally and arising from the disc (>3MOD).

Surface sculpture: head, including mandible and antenna, and mesosoma with punctures large and dense ($i < 1/3d$), the punctures deep and well defined, interspaces shining, except as follows: punctures of scape fine ($i \sim 1/2d$); punctation of mandible fine in outer groove ($i \sim 1/2d$), the interspaces dull, punctation of acetabular interspace moderately dense basad ($i < d$), larger than those of outer groove, becoming finer and denser toward apex of pollex ($i \sim 1/2d$), impunctate along carinae; punctures of hypostomal area fine, shallow, not well defined ($i < d$); clypeus imbricate-punctate ($i < 0.5d$), puncture size variable, the interspaces convex; punctures of supraclypeal area larger than those of clypeus, less dense along midline ($i < 1/3d$), the interspaces not especially convex; punctures of lower paraocular area finer than those of frontal area, somewhat less dense ($i < 1/2d$); pronotum with interspace diameter variable, nearly impunctate at lateral extremes of dorsal surface of pronotal collar and in pronotal lobe; punctures of mesoscutum and mesepisternum larger than those of vertexal area and genal area, respectively, similarly dense ($i < 1/3d$); tegula impunctate, strigate; punctation of axilla somewhat obscure, the

punctures variably sized, the interspaces convex, somewhat dull; mesoscutellum punctured as mesoscutum, except posterior margin laterally where it is narrowly declivous, the posterior surface scrobiculate; metanotum with punctures obscure, strigate-rugose, the interspaces somewhat dull; punctation of metepisternum finer than that of mesepisternum, less dense ($i < 2d$); metapostnotum with horizontal basal zone scrobiculate, the pits deep and well defined by carinae, otherwise shiny; propodeum with lateral surface puncticulate, the punctures large, shallow, not well defined, the interspaces roughened, declivous posterior surface with punctures somewhat fine, well defined, well spaced ($i > d$); T1 anterior surface less densely punctate ($i < 2d$) than disc, disc with punctures larger than those of T2 and T3, somewhat denser ($i < 3/4d$); disc of T2 with punctation somewhat finer than that of T3, similarly dense ($i < 1.5d$); punctures of T4 and T5 larger and denser ($i \sim 1/3d$) than those of T3; punctures of T6 largest, densest ($i \sim 1/4d$); sterna somewhat densely punctate in disc ($i < d$), impunctate in narrow apical impressed margins.

Structure: head slightly shorter than wide ($L:W = 70:75$); scape 3x as long as wide; pedicel longer than wide ($L:W = 7:5$); flagellomeres mostly unmodified, F1-F5 wider than long, F6-F9 length and width equal, F10 longer than wide ($L:W = 12:7$); labrum with a conspicuous erect basal tubercle at midline, broadest at base, with a broadly rounded apex; mandible tridentate, teeth rounded at apex, not especially sharp, distance between tooth of rutellum and first tooth of pollex slightly more than half the distance between first and second tooth of pollex (7:13), condylar ridge and outer ridge meeting close to mandible base in the outer interspace, the outer ridge curving ventrally, enclosing the outer groove and developed into a tubercle at the meeting point of the outer and condylar ridges, acetabular carina thickened, strongest in acetabular interspace, stronger than outer ridge; hypostomal carina highest posteriorly; clypeus convex medially, apex truncate at lateral extremes and produced to erect tubercles, tubercles distinct, feebly reflexed meso-dorsad, roughly parallel sided, nearly in line with the antennal socket and the tentorial pit, or slightly lateral to this imaginary line, the apical margin between tubercles straight; $IAD:AOD = 23:17$; paraocular carina high; supraantennal depression deep; IOC subequal to OOC (10:11); IOC less than OV (11:14); median ocellus nearly at midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 21:20$); eyes convergent below ($UOD:LOD = 45:40$); genal area wider than compound eye in lateral view (23:20); mesosoma longer than wide ($L:W = 50:43$); metanotum with transverse

ridge strong along anterior margin, the posterior surface declivous; metapostnotum with a narrow horizontal, pitted basal zone; T1 transverse carina evenly convex, the carina thickened; marginal zone of T6 feebly reflexed dorsad, feebly concave in profile.

Male (N= 59): length (6.5 to 7.5mm); head width (1.25 to 2mm); ITW (1.25 to 1.5mm); forewing length (4 to 5.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: tegula and all legs piceous; tarsal claws rufescent; wings darkest at apex of marginal cell.

Pubescence: hypostomal area densely pubescent, the hairs long, conspicuously curved, the apices oriented toward the midline anteriorly ($>2\text{MOD}$); clypeus with dense, suberect pubescence (1MOD); paraocular area with dense, subappressed pubescence (0.5MOD); frontal area with dense, suberect pubescence, the hairs long ($\sim 2\text{MOD}$); T1 to T5 apically fasciate, the hairs short, arising from the premarginal line and at least as long as the narrow apical impressed margins, usually only laterally on T1 ($<0.5\text{MOD}$); S1 and S2 moderately pubescent on disc, the hairs white or pale ochraceous, suberect, on S1 densest at apex of central swelling ($\sim 1\text{MOD}$), S2 denser laterally; S3 with dense, suberect pubescence in middle of disc, the hairs oriented toward the midline ($\sim 1\text{MOD}$), the apical margin with an erect fringe on the middle 1/3, the hairs thick, oriented ventrally ($\sim 1\text{MOD}$); apical margin of S5 with ochraceous, thin setae, the hairs erect, fanning out at apicolateral margins, and with highly papillate, minute dark hairs along apical margin.

Surface sculpture: hypostomal area with punctures moderately large, dense ($i \sim 1/2d$); clypeus finely and evenly punctate ($i \sim d$); T1 disc punctured as in vertexal area ($i \sim 1/2d$); T2 and T3 with somewhat finer, sparser punctation ($i \sim d$); T4 and T5 punctures of disc large and dense ($i \sim 1/3d$); T6 somewhat less densely punctate ($i \sim 1/2d$) than T5; S1 punctures of disc large ($i > 1/2d$), largest laterally, with finer, more obscure punctation in pregradular area and marginal zone ($i > d$); S2 irregularly punctate on disc, laterally large ($i > 1/2d$), finely and obscurely punctate in longitudinal 1/3 of disc, the latter continuing in premarginal zone; narrow disc of S3 very

finely punctate ($i \sim 1/2d$), narrowly impunctate at apical margin; S4 to S8 retracted, without notable surface sculpture.

Structure: head wider than long (L:W= 43:46); scape at least 2x as long as wide (L:W= 18:8); pedicel as long as wide, F1 wider than long (L:W= 4:6), F2-F10 longer than wide, F11 longest (L:W= 11:5); hypostomal carina moderately high; labrum thickened basad, without median tubercle; mandible bidentate, the teeth not sharp, the tooth of the pollex somewhat wide at apex; paraocular carina lower than in female; IOC<OOC (11:14); IAD:AOD= 9:5; eyes convergent below (UOD:LOD= 30:25); compound eye wider than genal area in lateral view (17:10); mesosoma longer than wide (L:W= 62:50); T6 with disc feebly swollen and marginal zone somewhat reflexed dorsad, sinuate in profile, the disc a U-shaped bulge in dorsal view; T5 to T7 strongly recurved; S1 wider than long, with apical margin broadly truncate, the margin between lateral angles of truncation shallowly and narrowly emarginate, the disc bearing a truncate projection submedially, the posterior surface of the projection steeper in profile than that of anterior surface, apex of projection broadly rounded; disc of S2 feebly swollen, more conspicuously so laterally, marginal zone conspicuously impressed, broadly truncate, apical margin between lateral angles of truncation broadly and shallowly concave; sterna as in Figure 3.40.

Genitalia: as in Fig. 3.40 (1)i.

Distribution: *H. carinata* is widespread throughout North America, from the most southern states and into Canada. It has been collected as far north as Fraser River Canyon, British Columbia, and from coast to coast (Fig. 3.5a). [CAN: BC, AB, SK, MB, ON, QC, NB, NS; USA: AL, AR, AZ, CO, CT, DE, FL, GA, IA, ID, IL, KS, KY, MA, ME, MD, MI, MN, MO, MS, MT, NC, NE, ND, NH, NJ, NM, NY, OH, OR, PA, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY.]

Specimens examined: CAN: Alberta: ♀ Patricia, 23.vii.2013 (C Sheffield & E Nichols); CAN: British Columbia: Okanagan-Similkameen Reg. Dist.: ♀ Vaseux Lake, 24.vi.2009 (L Packer) [Barcoded]; ♂ Osoyoos, 16.vii.2008 (LR Best) [Barcoded]; ♀ Flathead R., 18.viii.2009 (LR Best); ♀ Mahoney Lk., 17.viii.2008 (LR Best) [Barcoded]; 5 ♂ 1 ♀ Keremeos, Grist Mill,

28.vi.2013 (G Rowe & L Graham); 3 ♂ 1 ♀ Keremeos, Grist Mill, 29.vi.2013 (G Rowe & L Graham); 6 ♂ Keremeos, Grist Mill, 30.vi.2013 (G Rowe & L Graham); ♂ Kelowna, 8.vi.2007 (J Gibbs & C Sheffield); 2 ♂ Okanagan Falls, Scudder House, 25.vi.2010 (L Neame); ♂ Strawberry Crk. Rd., 30.vi.2010 (LR Best); ♂ ♀ Ram Crk., 18.viii.2009 (LR Best); 2 ♀ Osoyoos, Mt. Kruger, 16.vii.2008 (LR Best); ♀ Oliver, Ripley Lk., 15.vii.2008 (LR Best) [Barcoded]; ♀ Oliver, Ripley Lk., 12.vii.2008 (LR Best) [Barcoded]; ♀ Oliver, 19.vii.2010 (L Neame); ♀ Oliver, 13.vii.2008 (LR Best); *East Kootenay Reg. Dist.*: 8 ♂ 2 ♀ Invermere, 5.vii.2013 (G Rowe & L Graham); 12 ♂ 5 ♀ Wasa, 9.vii.2013 (G Rowe & L Graham); 2 ♂ 1 ♀ Kimberley, 6.vii.2013 (G Rowe & L Graham); ♂ Lk. Koocanusa, 12.vii.2010 (LR Best); 7 ♀ Grassmere, 18.viii.2009 (LR Best) [Barcoded]; ♂ ♀ nr Cranbrook, Pine Butte Ranch, 4.vii.2013 (G Rowe & L Graham); 6 ♂ 2 ♀ nr Cranbrook, Pine Butte Ranch, 9-10.vii.2013 (G Rowe & L Graham); 3 ♂ nr Cranbrook, Pine Butte Ranch, 5.vii.2013 (G Rowe & L Graham); *Kootenay Boundary Reg. Dist.*, ♂ ♀ Jewel Lk., 4.viii.2009 (LR Best); *Thompson-Nicola Reg. Dist.*: 3 ♀ Savona, 16.viii.2008 (LR Best) [2 Barcoded]; **CAN: Manitoba**: ♂ Aweme Criddle Homestead, 24.vii.2007 (H Goulet); **CAN: New Brunswick**: ♀ Kouchibouguac NP, 23.viii.1977 (col. unk.); ♀ St. John, 21.vii.1991 (col. unk.); **CAN: Nova Scotia**: 2 ♀ *Kings Co.*, Lockhartville (trapnest 2001) (C Sheffield); ♂ Picton, 1.viii.1914 (col. unk.); **CAN: Ontario**: ♀ Georgian Bay Isl. N.P., 30.vii.2009 (C Sheffield); ♀ nr Ottawa Airport, 16-23.vii.1985 (H Goulet, S Perkins & L Leblanc); ♂ 3km N Almonte, 17-24.vi.1986 (Denis & Dumouchel); **CAN: Quebec**: ♂ Outaouais, Lac Jean-Venne, La Pêche, 10-13.vii.1995; ♂ Outaouais, Gatineau Park, 22.vii.1981; ♀ Outaouais, Hull, 5.viii.1965; ♀ Eardley, 26.vi-11.vii.1991 (BRC HYM team); **CAN: Saskatchewan**: ♀ Wascana Habitat Conservation Area, 9.vii.2013 (D. Frier); ♀ Regina, 21.vii.2012 (C Sheffield & K Sheffield); **USA: Oregon**: ♀ *Lane Co.*, nr McCreddie Hot Springs, 27.vii.2001 (L Packer); **USA: South Dakota**: 2 ♀ Black Hills, 12.vii.2013 (R Poulin).

Type depository: Lectotype, female, from Pennsylvania, in the Academy of Natural Sciences of Philadelphia. [Examined]

3.8 Genus *Hoplitis* Klug

The genus *Hoplitis* is the largest and most diverse genus in the Osmiini. It contains 377 described species (Müller 2016) in 16 subgenera (Sedivy et al. 2013; Ascher & Pickering 2016;

Müller 2016) and while it is far more diverse in the Palaearctic where it originated (Michener 2007; Sedivy et al. 2013; Müller 2016), the Nearctic region is home to 57 described species in four subgenera (*Alcidamea*, *Formicapis*, *Proteriades* and *Robertsonella*) (Michener 2007; Sedivy et al. 2013). Several species in the genus are polytypic and many still await description (Michener 1947; Mitchell 1962). In Canada, 12 described *Hoplitis* have been recorded, representing three subgenera.

Nesting behaviours and floral relationships among *Hoplitis* are exceptionally diverse (e.g.s Michener 1947; 1968; 2007; Hurd & Michener 1955; Mitchell 1962; Eickwort 1975; Sedivy et al. 2013). Some species occupy preexisting cavities while others nest in excavated burrows in the ground or in pithy stems, or build exposed nests either on the surface of rocks or hidden under dense vegetation (e.g.s Warncke 1991; Michener 2007; Sedivy et al. 2013). One subgenus, *Bytinskia* Mavromoustakis, includes the only cleptoparasitic bees in the Osmiini (Mavromoustakis 1954; Michener 2007). Both polylecty and oligolecty are common among *Hoplitis* (Hurd & Michener 1955; Mitchell 1962; Ascher & Pickering 2016).

Hoplitis is a morphologically diverse genus. Species range from slender to robust, short to long (3mm to 18mm). All species are black with the exception of a few species which are brilliantly metallic blue to green, or have the metasoma red (Hurd & Michener 1955; Michener 2007). Many *Hoplitis* species, especially those of the subgenus *Alcidamea*, differ by only subtle morphological characters, and few morphological characters unite the species in many of the morphologically diverse subgenera.

Diagnosis: Both sexes of Canadian *Hoplitis* can be distinguished from other Canadian Osmiini by the combination of parapsidal lines linear (Fig. 3.18c; 3.21b; 3.45d; 3.55e), long, at least half the length of the tegula (Fig. 3.45d; 3.55e), forewing, marginal cell distinctly curving away from costal wing margin apically, usually for at least the last third of the marginal cell (Fig. 3.45f), mesepisternum with anterior and lateral surfaces delimited by a rounded angle, the angle not carinate (Fig. 3.20c), and T1 with anterior surface not distinctly flat or concave, not delimited from the dorsal surface by a distinct line, convex in profile (Fig. 3.46a; 3.50a; 3.53e; 3.60a; 3.61a). Females have the clypeus without a median projection (Fig. 3.14b; 3.49b; 3.55b; 3.59c) or with a short, snout-like median projection (Fig. 3.57b; 3.57c) or with a low carina along the

midline (Fig. 3.63b; 3.63c). Males can be further recognized by the combination of T6 with lateral tooth or feeble angle, S6 with a pair of thin, translucent, hairless basal flaps arising near the gradulus and lying against the ventral sternal surface for the full width of the sternum.

3.8.1 Key to the Canadian species of *Hoplitis*

(Adapted from Michener 1947; 2007; Hurd & Michener 1955; Mitchell 1962; Eickwort 1970)

Females

- (1) 1 Clypeus, apical margin modified, bearing a triangular, snout-like projection medially (Fig. 3.57a; 3.57b; 3.57c); scape less than three times longer than wide (Fig. 3.57b) *H. (Formicapis) robusta*
- 1 Clypeus mostly unmodified, without a snout-like projection medially (Fig. 3.41c; 3.45b); scape elongate, at least three times longer than wide (Fig. 3.41c; 3.43c) **2**
- (2) 1 Clypeus, apical margin crenulate between lateral angles of truncation (Fig. 3.43c); labrum, base, with a conspicuous membrane at lateral extremes, membrane visible when mandibles closed (Fig. 3.43b) *H. (Hoplitis s. str.) anthocopoides*
- 1 Clypeus, apical margin without distinct crenulations between lateral angles of truncation, either straight (Fig. 3.63b; 3.63c; 3.63d), concave (Fig. 3.45b; 3.47d; 3.49b; 3.55b) or feebly undulate (Fig. 3.61b); labrum, base unmodified, not bearing membranes at lateral extremes (Fig. 3.61b) **3**
- (3) 1 S6 modified, bearing EITHER a strong, median, longitudinal ridge in disc, ending somewhat abruptly at premarginal line, the ridge produced to a small, blunt process at apical margin (Fig. 3.49c) OR bearing a short, median apical process, the process pointed, somewhat curved ventrally (Fig. 3.41d); genal area at least 1.5 times wider than compound eye in lateral view (Fig. 3.41b; 3.49a) **4**

- 1 S6 unmodified, not bearing a median, longitudinal ridge, without apical process (Fig. 3.61e); genal area not 1.5x wider than compound eye in lateral view (Fig. 3.53b; 3.63a) **5**
- (4) 1 Mandible quadridentate (Fig. 3.41c); S6 bearing a short, median apical process, the process pointed, somewhat curved ventrally (Fig. 3.41d) *H. (Alcidamea) albifrons*
- 1 Mandible tridentate (Fig. 3.49b); S6 bearing a strong, median, longitudinal ridge in disc, ending somewhat abruptly at premarginal line, the ridge produced to a small, blunt process at apical margin (Fig. 3.49c) *H. (Alcidamea) hypocrita*
- (5) 1 Integument brilliantly metallic blue, green, or purple (Fig. 3.45a; 3.51a); metasomal scopa dark, brown to black (Fig. 3.45e; 3.51a) **6**
- 1 Integument black, not brilliantly metallic blue, green, or purple (Fig. 3.55a); metasomal scopa light, white to ochraceous, not dark (Fig. 3.61a) **7**
- (6) 1 Compound eye nearly parallel sided in lateral view, ventral and dorsal ends nearly of equal width (Fig. 3.51c) *H. (Alcidamea) louisae*
- 1 Compound eye not parallel sided, dorsal end tapered, narrower than ventral end (Fig. 3.45a; 3.45b; 3.45c) *H. (Alcidamea) fulgida*
- (7) 1 Mandible quadridentate (Fig. 3.61b; 3.61d); metapostnotum with sculpture the same as that of the posterior surface of the propodeum (Fig. 3.61c) *H. (Alcidamea) spoliata*
- 1 Mandible tridentate (Fig. 3.63b); metapostnotum with sculpture different from that of the posterior surface of the propodeum (Fig. 3.55c; 3.59d; 3.63e) **8**
- (8) 1 T2 to T4 with gradular furrow distinctly deepened, especially that of T4 (3.59e; Fig. 3.63g); interantennal distance less than, or equal to, antennocular distance (Fig. 3.59c; 3.63d) **9**

- 1 T2 to T4 with gradular furrows not especially deep, that of T4 distinctly shallower than that of T3 (Fig. 3.53e; 3.55a); interantennal distance distinctly wider than antennocular distance (Fig. 3.53d; 3.55b)..... **10**
- (9) 1 Clypeus modified, bearing a longitudinal carina in at least part of midline, apical margin thickened (Fig. 3.63b; 3.63c); hind tibial spurs light, honey coloured to light brown (Fig. 3.63f) ***H. (Alcidamea) truncata***
- 1 Clypeus unmodified, not bearing a carina and not thickened at apical margin (Fig. 3.59b; 3.59c); hind tibial spurs dark, piceous to black, not light (Fig. 3.59e) ***H. (Alcidamea) sambuci***
- (10) 1 T1 and T2 punctation very fine, finer than that of vertexal area, sparse for middle fifth of marginal width, this area especially shiny; T1 distinctly impunctate along longitudinal midline (Fig. 3.55d); scape not so elongate, hardly more than 3x longer than wide, or only 3x as long as wide (Fig. 3.55b) ***H. (Alcidamea) producta***
- 1 T1 and T2 punctures at least as large as those of vertexal area, not especially fine, punctation not especially sparse in middle fifth of marginal width, not especially shiny and T1 not distinctly impunctate along longitudinal midline (Fig. 3.53e); scape elongate, distinctly more than 3x longer than wide (Fig. 3.47d; 3.53d) **11**
- (11) 1 T6 with punctures deeper and denser than those of T5 (Fig. 3.53f); genal area distinctly wider than compound eye in lateral view (Fig. 3.53b); head, distance between lateral ocelli greater than 1.5x the width of the median ocellus (Fig. 3.53c) ***H. (Alcidamea) pilosifrons***
- 1 T6 with punctures not deeper and denser than those of T5, punctures similar to those of T5 (Fig. 3.47e); genal area not especially wide, compound eye as wide or wider than genal area in lateral view (Fig. 3.47c); head, distance between lateral ocelli short, hardly greater than width of median ocellus (Fig. 3.47b)..... ***H. (Alcidamea) grinnelli***

Males

- (1) 1 Mandible tridentate (Fig. 3.50d); T6 and T7 apical margin tridentate (Fig. 3.50b; 3.50c)
..... *H. (Alcidamea) hypocrita*
- 1 Mandible bidentate (Fig. 3.48a); T7 apical margin not tridentate, EITHER a broad truncation (Fig. 3.60b; 3.64d) OR a median pointed spine (Fig. 3.54c) OR 4-lobed (Fig. 3.58c) 2
- (2) 1 Base of labrum modified, bearing yellowish membranes at lateral extremes (Fig. 3.44b); T6 with apical margin between lateral teeth not smooth, irregularly notched, especially along middle third of marginal width (Fig. 3.44c) *H. (Hoplitis s. str.) anthocopoides*
- 1 Base of labrum unmodified, not bearing yellowish membranes at lateral extremes (Fig. 3.56c); T6 with apical margin smooth between lateral teeth, not notched (Fig. 3.46d; 3.58c) 3
- (3) 1 Clypeus with short, appressed, silvery tomentum (Fig. 3.42b); S5 apical fringe conspicuously wavy, the hairs definitely not straight (Fig. 3.42d)
..... *H. (Alcidamea) albifrons*
- 1 Clypeus without silvery tomentum, EITHER pubescence subappressed or suberect (Fig. 3.56c; 3.58b; 3.62b) OR clypeus not especially pubescent (Fig. 3.60c); S5 apical fringe EITHER straight (Fig. 3.46c) OR the hairs feebly bowed (Fig. 3.62c) OR without a conspicuous apical fringe (Fig. 3.56d), hairs never conspicuously wavy 4
- (4) 1 Antenna with flagellomeres modified, F2 to F5 conspicuously widened and bearing a few short, ochraceous setae along ventral surface (Fig. 3.62b); S5 with two fringes, one near midlength of disc with hairs erect, infuscated and oriented ventrally, and one apical fringe extending for at least the middle half the width of the marginal zone with hairs suberect, mostly white and oriented posteriorly (Fig. 3.62c) *H. (Alcidamea) spoliata*
- 1 Antenna mostly unmodified, F2 to F5 not especially widened and not bearing setae along ventral margin (Fig. 3.48e; 3.52b; 3.56b); S5 EITHER not bearing a fringe (Fig. 3.56d)

- OR with only one fringe which is towards the apex of the marginal zone (Fig. 3.46c; 3.48c), and not on the disc, if a fringe is present, the hairs are suberect, mostly white and oriented posteriorly **5**
- (5) 1 T7 apical margin 4-lobed (Fig. 3.58c); clypeus, apical margin distinctly crenulate between lateral angles of truncation (Fig. 3.58b) ***H. (Formicapis) robusta***
- 1 T7 apical margin not 4-lobed, EITHER a broad truncation (Fig. 3.64d) OR with a median pointed spine (Fig. 3.54c); clypeus, apical margin without distinct crenulations, either straight (Fig. 3.64b), concave (Fig. 3.60c) or feebly undulate (Fig. 3.56c) between lateral angles of truncation **6**
- (6) 1 Integument brilliantly metallic blue, green or purple (Fig. 3.46a; 3.52a); S2 produced to a small median, apical, spine-like process or an acute point (Fig. 3.46c; 3.52d) **7**
- 1 Integument black (Fig. 3.60a), non-metallic, not blue, green or purple; S2 unmodified, apical margin EITHER rounded (Fig. 3.54d) OR straight (Fig. 3.60d) OR emarginate at midline (Fig. 3.56d; 3.64c), never pointed or produced to a spine-like process **8**
- (7) 1 T7 truncate at apex (Fig. 3.46d); F11 apex rounded (Fig. 3.46b) ... ***H. (Alcidamea) fulgida***
- 1 T7 apex produced to a median, pointed spine (Fig. 3.52c), not truncate; F11 distinctly pointed at apex (Fig. 3.52b), not rounded ***H. (Alcidamea) louisae***
- (8) 1 T7 truncate at apex (Fig. 3.60b; 3.64d); clypeus, apical margin distinctly thickened, the margin rounded from dorsal to ventral surface (Fig. 3.60c; 3.64b) **9**
- 1 T7 produced to a median, pointed spine-like process (Fig. 3.54c), not truncate; clypeus, apical margin unmodified, flat, not thickened, the margin not distinctly rounded (Fig. 3.56c) **10**
- (9) 1 S2, apical margin rounded, nearly straight along midline (Fig. 3.60d); T7, truncation narrow, not more than 1/3 the distance between inner margins of lateral teeth of T6 (Fig. 3.60b) ***H. (Alcidamea) sambuci***

- 1 S2 apical margin distinctly emarginate medially (Fig. 3.64c); T7, truncation broad, at least half the distance between inner margins of lateral teeth of T6 (Fig. 3.64d) *H. (Alcidamea) truncata*
- (10) 1 S2 disc with a low swelling, swelling broadly rounded at apex, across at least half the width of the sternum, the swelling highest at midline (Fig. 3.54a; 3.54b; 3.54d); T6 punctures distinctly larger than those of T5 (Fig. 3.54c) *H. (Alcidamea) pilosifrons*
- 1 S2 with a high, median protuberance in the middle third of disc, apex of protuberance conical, not especially broad (Fig. 3.48a; 3.56a); T6 with punctures only as large as those of T5 (Fig. 3.48f) **11**
- (11) 1 S2, protuberance sub-basal, posterior surface nearly at centre of sternum (Fig. 3.48a; 3.48c; 3.48d); antenna, scape over 2.5 times longer than wide, F1 longer than wide, tapered, basal width distinctly narrower than apical width (Fig. 3.48e) *H. (Alcidamea) grinnelli*
- 1 S2, protuberance in middle of disc, posterior surface anterior to centre of sternum (Fig. 3.56a; 3.56d); antenna, scape less than 2.5 times longer than wide, usually little more than twice as long, F1 at least as wide as long, not distinctly tapered from base to apex (Fig. 3.56b) *H. (Alcidamea) producta*

***H. albifrons* (Kirby, 1837)**

Chelostoma albifrons Kirby, 1837, In Richardson, Fauna Bor.-Amer., 4: 270.

Monumetha borealis Cresson, 1864, Ent. Soc. Phila. Proc. 2: 388.

Monumetha obsoleta Cresson, 1864, Ent. Soc. Phila. Proc., 2: 388.

Megachile oblonga Provancher, 1882, Nat. Canad. 13: 230.

Monumetha argentifrons Cresson, 1864, Proc. Ent. Soc. Philadelphia, 2: 387.

Osmia maura Cresson, 1878, Trans. Amer. Ent. Soc., 7: 104.

Andronicus hesperius Cockerell, 1903, Bull. Southern California Acad. Sci., 2: 35.

Hoplitis (Monumetha) albifrons albifrons Michener, 1947, Evolution, 1: 184.

Hoplitis (Monumetha) albifrons argentifrons Michener, 1947, *Evolution*, 1: 185.

Hoplitis (Monumetha) albifrons maura Michener, 1947, *Evolution*, 1: 185.

Hoplitis (Alcidamea) albifrons argentifrons Sedivy et al., 2013, *Zool. J. Linn. Soc.*, 167: 41.

Hoplitis (Alcidamea) albifrons maura Sedivy et al., 2013, *Zool. J. Linn. Soc.*, 167(1): 28-42.

Biology: *Hoplitis albifrons* is polylectic and has been recorded foraging on many plant families including Asteraceae, Boraginaceae, Fabaceae and Hydrophyllaceae (Ascher & Pickering 2016). It is common in Canada and has been collected from late May (25, Ripley Lake, BC) to early August (1, Oliver, BC).

Diagnosis: The female of *H. albifrons* can be recognized by the combination of mandible quadridentate and S6 with a short, median apical process. The male can be recognized by its modified pubescence, silvery tomentum on the clypeus and lower paraocular area and wavy hairs forming an apical fringe on S5.

H. albifrons **redescription**

Figures: 3.6; 3.41; 3.42

Female (N=52): length (10 to 15mm); head width (3 to 4.25mm); ITW (2.25 to 3.25mm); forewing length (8 to 11mm).

Colouration: integument black, except as follows: flagellomeres dark brown; tarsi and basitarsi dark brown; wings hyaline, dusky, marginal cell darkest; tarsal claw piceous; hind tibial spurs black; sterna with narrow apical impressed margin brown.

Pubescence: hairs mostly black, mixed with white and cinereous; head, mesosoma and metasoma moderately pubescent with erect hairs (>2MOD), pubescence denser on the following: hypostomal area where hairs are conspicuously bowed with apices oriented toward the midline anteriorly (2MOD); clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation (~1MOD); paraocular area with long, dense, suberect pubescence (~3MOD), hairs mostly white; frontal area with long, dense, erect pubescence (~3MOD), the hairs somewhat

ochraceous or cinereous; mesoscutum anteriorly, axilla, mesoscutellum, metanotum and dorsolateral angle of propodeum with dense, suberect pubescence ($>3\text{MOD}$), hairs mostly white; mesepisternum with dense, suberect pubescence ($>3\text{MOD}$), hairs usually dark ochraceous; metasoma with apical fascia arising from premarginal line, long, at least as long as narrow apical impressed margins of T1 to T6, usually interrupted in middle third of segment, often entirely effaced on T4 and T5, hairs mostly white ($\sim 2\text{MOD}$); sternal scopa black, oriented posteroventrally, arising from the disc ($>4\text{MOD}$).

Surface sculpture: head, including mandible and antenna, and mesosoma with punctation moderately dense, interspaces shining ($i=1/2d$), except as follows: scape with punctation finer, less dense ($i\sim d$); mandible with finer punctation, ($i=1/2d$), except along carinae which are impunctate; hypostomal area with punctation less well defined, shallower, though spaced as in genal area ($i=1/2d$); clypeus with narrow impunctate apical margin between lateral angles of clypeal truncation; supraclypeal area and frontal area finely and densely punctate ($i<1/2d$); mesepisternum and mesoscutum punctured as in genal and vertexal areas, respectively ($i=1/2d$), except for medially on mesoscutum where punctation sparser ($i>d$); metepisternum with punctation inconspicuously finer than that of mesepisternum, similarly spaced ($i=1/2d$); tegula finely punctate and sparsely punctate ($i>d$), punctures somewhat denser anteriorly; axilla and posterior margin of mesoscutellum with denser punctation, but punctures somewhat obscured by dulled interspaces ($i\sim 1/3d$); metanotum imbricate-punctate; metapostnotum areolate ($i<1/4d$), impunctate below; propodeum with lateral surface puncticulate ($i>1/2d$), punctures of declivous dorsal surface more obvious than those of lateral surface; T1 anterior surface impunctate; T1 to T4 discs punctures fine, sparse medially ($i>1.5d$), denser toward lateral margins ($i<d$); narrow apical impressed margin of T1 to T5 impunctate; T5 with punctures of disc denser than those of T4, density even to lateral margins ($i\sim d$) and with impunctate apical margin narrower than that of T4; T6 with denser, finer punctation ($i<d$), punctures of marginal zone larger than those of disc, similarly spaced ($i<d$); S1 to S6 with moderate punctation in disc ($i<d$), S1 to S5 with marginal zone impunctate, that of S6 punctured as on disc.

Structure: head length to breadth subequal ($L:W=64:66$); scape elongate, over 3x longer than wide ($25:7$); pedicel exposed, as long as wide; flagellomeres mostly unmodified: F1 longer than wide ($8:5$), F2-F9 length to width nearly equal, F10 longer than wide ($9:5$), apex rounded;

mandible quadridentate, widened at apex, the apex wider than the greatest width of the compound eye (38:26), distance between tooth of rutellum and first tooth of pollex more than twice the distance between the first and second teeth of the pollex (19:8), this owing in part to the elongated and incurved rutellum, and nearly twice the distance between the second and third teeth of the pollex (19:11); compound eyes convergent below (UOD:LOD= 65:59); hypostomal carina low, higher posteriorly and nearly absent toward anterior; clypeus convex in middle 1/3, flat at lateral and apical margins; clypeus truncate, the lateral margins of truncation nearly straight, feebly convex to well defined, lateral angles of truncation rounded, margin between angles of truncation concave; tentorial pits deep, well defined; convexity of clypeus continuing in supraclypeal and frontal areas such that supraantennal depression appears strong; IAD:AOD= 30:28; IOC<OOC (11:14); IOC less than ½ OV (11:24); median ocellus anterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 24:28); genal area conspicuously wider than compound eye in lateral view (36:20); mesosoma length to width nearly equal (L:W= 52:48); mesoscutellum and metanotum gently sloping posteriorly to an entirely declivous propodeum; metasoma elongate (L:W= 68:38); T1 anterior surface with a short, narrow, longitudinal furrow, anterior surface gradually rounded onto dorsal surface, the two surfaces not distinctly delineated by ridge, carina or line; T6 marginal zone reflexed dorsally, concave in profile; S6 with a short, median apical process, the process pointed and curved ventrally.

Male (N=27): length 10.5mm (8.5 to 13mm); head width 2.5mm (2.25 to 3.25mm); ITW 2mm (2 to 2.5mm); forewing length 7mm (7 to 8mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres brownish-yellow, lighter to apex; cap of rutellum of mandible piceous; tegula piceous; wings not conspicuously dusky distally beyond apex of marginal cell; terga with narrow apical impressed margin brown.

Pubescence: hairs mostly white; head and mesosoma covered in dense, suberect pubescence (>2MOD), pubescence denser on the following: hypostomal area pubescence not

conspicuously bowed ($\sim 2\text{MOD}$); setae arising from the apical margin of the clypeus between lateral angles of truncation forming a uniform thin fringe, the hairs oriented anteriorly; clypeus and lower paraocular area covered with short, appressed silvery tomentum ($<1\text{MOD}$), rest of paraocular area with dense, subappressed pubescence ($<2\text{MOD}$), hairs white; frontal area with long, dense, suberect pubescence ($\sim 3\text{MOD}$); S2 to S5 with apical fringe of long, straw-coloured hairs arising from the gradulus, oriented posteroventrally ($<3\text{MOD}$); S5 with apical fringe wavy, hairs bent laterally at midline, and bent toward midline at apical $\frac{1}{4}$, the hairs infusate ($\sim 2\text{MOD}$), the fringe longest medially.

Surface sculpture: punctuation generally finer than that of female, though similarly spaced ($i=1/2d$), except as follows: hypostomal area with punctures shallow, as in female, larger, and less dense ($i<1/2d$) than those of genal area; clypeus with finer, somewhat sparser punctuation ($i<d$) than rest of head, and with impunctate apical margin more conspicuous and inconspicuously broadest medially in comparison to female; punctures of supraclypeal area and of lower paraocular area finer, similarly dense ($i=1/2d$), punctures becoming larger toward ocelli; metepisternum sparsely punctate ($i>1/2d$); T1 to T6 similarly punctured, dense on discs ($i=1/2d$), impunctate in marginal zone; punctures of T7 larger than those of T6, somewhat denser ($i\sim 1/3d$), marginal zone impunctate; S1 to S5 disc moderately punctate ($i=1/2d$), marginal zone impunctate, except as follows: S2 to S4 disc impunctate, midline sparsely and finely punctate; S5 disc with large punctures along midline ($i<1/2d$), otherwise impunctate.

Structure: head length to width subequal ($L:W=71:74$); scape elongate, over 3x longer than wide (30:12), pedicel nearly entirely enclosed by scape; flagellomeres mostly unmodified, F1 and F2 hardly longer than wide, F3 to F10 as wide as long, or wider than long, F11 longer than wide (12:7), flattened to a rounded apex; mandible bidentate, not widened at apex, the apex less than a third as wide as the greatest width of the compound eye (16:51), the outer interspace of the mandible along a vertical plane, the angle between the outer interspace and the upper carina sharp, nearly 90° such that the outer ridge, acetabular interspace and upper carina are flat and in focus along the same plane as the clypeus; compound eyes feebly convergent below ($\text{UOD}:\text{LOD}=64:61$); hypostomal carina low; clypeus with lateral margins of truncation rounded, not as well defined as in female, margin between lateral angles somewhat thickened, broadly concave; $\text{IAD}:\text{AOD}=24:14$; $\text{IOC}>\text{OOC}$ (24:18); IOC subequal to OV (24:26); median ocellus

anterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 41:52); genal area not as wide as compound eye in lateral view (44:51); mesosoma length to width nearly equal (L:W= 32:28); metasoma elongate, over twice as long as wide (L:W= 57:26); T6 with apical margin rounded, lateral teeth pointed, slender, somewhat longer than their basal width (L:W= 5:4); T7 truncate at apex, with truncation wider than long (L:W= 40:70), the margin between angles of truncation feebly convex; S1 and S2 with a median, apical spine arising submarginally, oriented posteriorly, that of S1 short (L=B) with apex rounded, that of S2 elongate, over 4x longer than its basal width (L:W= 18:4) and with apex pointed; S1 and S2 with apical margins rounded; S2 to S5 with discs swollen submarginally, except narrowly along midline and only feebly swollen in S5; apical margin of S3 nearly straight, very narrowly medially emarginate; apical margin of S4 feebly concave in middle 1/3 of width; apical margin of S5 concave in middle ½ of width; S6 to S8 retracted.

Genitalia: as in Fig. 3.42f.

Distribution: *Hoplitis albifrons* is common and widely distributed throughout Alaska and Canada and through the western half of the United States, otherwise occupying only the northern parts of the Great Plains and the northeastern states. It is apparently absent from Iowa, Kansas, Oklahoma and Louisiana east to Ohio and Delaware and south through to Florida (Fig. 3.6a). [CAN: AB; BC; MB; NB; NL; NS; NT; ON; QC; SK; YK; USA: AK; AZ; CA; CO; ID; ME; MI; MN; MT; NE; NH; NM; NV; NY; PE; OR; SD; TX; UT; VT; WA; WI; WY]

Specimens examined: CAN: Yukon: ♂ ♀ Whitehorse, Schwatka Lk., 06.vi.2009 (SG Cannings) [♂ ♀ Barcoded]; CAN: Northwest Territories: ♀ Rae, Hwy 3, 21.vi.2005 (C Sheffield & A Gunn) [Barcoded]; ♀ Yellowknife, Negus Pt., 18.vii.2003 (A Gunn) [Barcoded]; ♀ Yellowknife, Willow Flats, 9.vii.2003 (A Gunn) [Barcoded]; CAN: British Columbia: Okanagan-Similkameen Reg. Dist.: ♀ Oliver, Ripley Lk., 25.v.2013 (G Rowe & L Graham); ♀ ♂ Oliver, Ripley Lk., 17.vi.2013 (G Rowe & L Graham); ♀ Oliver, Ripley Lk., 01.vii.2013 (G Rowe & L Graham); ♀ ♂ Oliver, Ripley Lk., 31.v.2013 (G Rowe & L Graham); ♂ Oliver, Ripley Lk., 10.vii.2010 (G Gielans); ♂ Oliver, Ripley Lk., 12.vii.2008 (LR Best); ♀ Oliver, Ripley Lk., 13.vii.2008 (LR Best); ♂ 4 ♀ Oliver, McKinney Camp Rd., 26.vii.2008 (LR Best); ♀ Oliver, Camp McKinney Rd., Sandy Cut, 1.viii.2009 (LR Best) [Barcoded]; ♀ Keremeos, Grist Mill,

28.vi.2013 (G Rowe & L Graham); ♀ Keremeos, Grist Mill, 30.vi.2009 (TG Leischner) [Barcoded]; ♀ Keremeos, Grist Mill, 30.vi.2013 (G Rowe & L Graham); ♂ Sparrow Grasslands, 23.vi.2013 (G Rowe & L Graham); ♂ Osoyoos, Mt. Kruger, 7.vi.2008 (LR Best); ♀ Summerland, Garnet Lk., 8.vii.2010 (LR Best); ♀ Okanagan Falls, Mahoney Lk., 22.vi.2008 (LR Best) [Barcoded]; ♀ Willowbrook, Green Lk., 14.vi.2008 (LR Best) [Barcoded]; *Bulkley-Nechako Reg. Dist.*: ♂ ♀ Burns Lk., Francois Lk., 16.vi.2006 (LR Best) [Barcoded]; *East Kootenay Reg. Dist.*: ♀ Grasmere, 18.viii.2009 (LR Best) [Barcoded]; ♀ Nature Trust Hoodoos Fairmont, 24.vi.2010 (LR Best & TNT) [Barcoded]; 2 ♂ Bull River, 25.vi.2010 (LR Best); 5 ♀ Pine Butte Ranch, NCC, 9-10.vii.2013 (G Rowe & L Graham); ♀ Marion Benchlands, NCC, 7.vii.2013 (G Rowe & L Graham); 2 ♀ Marion Benchlands, NCC, 10.vii.2013 (G Rowe & L Graham); *North Okanagan Reg. Dist.*: 2 ♀ Cherryville, Monashee P.P., 19.vii.2008 (LR Best) [2 ♀ Barcoded]; ♂ Cherryville, Monashee P.P., 20.vii.2008 (LR Best); ♂ Lumby, Twin Crks., 13.vi.2008 (LR Best); *Cariboo Reg. Dist.*: ♀ Alexis Crk., Hwy 26, 15.viii.2008 (LR Best) [Barcoded]; *Thompson-Nicola Reg. Dist.*: 2 ♂ Nicola Valley, Clapperton, 20-27.vi.2010 (LR Best); *Central Okanagan Reg. Dist.*: ♂ Winfield, Okanagan Lk., 8.vi.2008 (LR Best); **CAN: Alberta:** *Cypress Co., Cypress Hills P.P.*: ♀ 30.vii.2013 (G Rowe & L Graham); ♂ 04-05.viii.2013 (G Rowe & L Graham); ♀ 27.vii.2010 (N de Silva); **CAN: Manitoba:** ♂ Churchill, 04.viii.2007 (P Kevan) [Barcoded]; **USA: Oregon:** 2 ♀ ♂ Crook Co., Hwy 26, 28.vi.2007 (J Gibbs & C Sheffield) [1 ♀ Barcoded]; ♀ 2 ♂ Jackson Co., Hwy 140, 02.vii.2007 (J Gibbs & C Sheffield); **USA: Idaho:** ♀ Blaine Co., Hwy 26, 24.vi.2007 (J Gibbs & C Sheffield) [Barcoded]; 2 ♀ Fremont Co., Hwy 20, 23.vi.2007 (J Gibbs & C Sheffield); **USA: Montana:** ♂ ♀ Gallatin Co., near Yellowstone, 23.vi.2007 (J Gibbs & C Sheffield); **USA: Colorado:** ♂ Ward Co., Boulder, 14.vii.1982 (L Packer); ♀ Park Co., near Eleven Mile State Park, 30.vii.2007 (J Gibbs & C Sheffield); ♀ Boulder Co., Nederland, 19.v.2007 (J Gibbs & C Sheffield); ♀ Teller Co., W of Florissant Hwy 24, 30.vii.2007 (J Gibbs & C Sheffield); **USA: California:** ♂ Mariposa Co., Wawona Dome, 8.vi.2006 (L Xialoling Zou); **USA: Arizona:** ♂ Coconino Co., Hwy 67, N of Grand Canyon N.P., 22.vi.1999 (L Packer); ♂ Graham Co., Mt. Graham, 1.vi.1999 (L Packer); **USA: Utah:** 3 ♂ San Juan Co., La Sal Mts., 28.vi.1999 (L Packer); 2 ♂ 2 ♀ Kane Co., Coral Pink Sand Dunes, 21.vi.1999 (L Packer).

Type: Male, from Pike’s Peak, Colorado, in the Academy of Natural Sciences of Philadelphia.
[Examined]

3.9 Genus *Protosmia* Ducke

Protosmia is a geographically disjunct genus of small (3.5mm to 9mm) bees that is far more diverse in the Palaearctic than in any other ecoregion. Twenty-four species have been described in four subgenera, 22 of which are Palaearctic while there is one in each of the Nearctic and Oriental regions (Michener 2007). Due to its presence in northern Washington, USA, near the Canadian border, one species—*P. (Chelostomopsis) rubifloris*—is thought to range into the southernmost parts of British Columbia, but no true Canadian record is known.

Palaearctic *Protosmia* often nest in the ground (Praz et al. 2008) while the North American species is known to nest in preexisting cavities in wood or in pinecones (Griswold 1986; Michener 1941). Most *Protosmia* species are polylectic insofar as has been analyzed (Krombein et al. 1979) and use resin to construct their brood cells (cell partitions and nest plugs), sometimes embedding pebbles or gravel (Hurd & Michener 1955; Griswold 1986; Michener 2007).

Diagnosis: Female Canadian *Protosmia* can be recognized by the modified clypeus, the apical margin bearing a long, narrow, dorsoventrally flattened, spatulate median projection (Fig. 3.65a; 3.65b; 3.65c). The male is unique among Canadian Osmiini in having the apical margin of T6 produced into three broad lobes, median lobe roughly 2x wider than lateral lobe (Fig. 3.66b).

***Protosmia rubifloris* (Cockerell, 1898)**

Chelynia rubifloris Cockerell, 1898, Can. Entomol., 30: 50.

Raphidostoma ceanothi Cockerell, 1936, Pan-Pac. Ent., 12: 134.

Biology: *Protosmia rubifloris* is polylectic and has been recorded foraging on flowers from many plant families including Asteraceae, Hydrophyllaceae and Scrophulariaceae (Ascher & Pickering 2016). No Canadian collection record for *Protosmia rubifloris* is known. It has been

collected in northern Washington in the month of June. It is expected to be present and to have a similar phenology in southern British Columbia.

Diagnosis: The female of *P. rubifloris* can be recognized by the combination of a uniquely modified clypeus, the apical margin bearing a long, narrow, dorsoventrally flattened spatulate median projection and an enlarged head, nearly as long as the mesosoma. The male of *P. rubifloris* can be recognized by T6, the apical margin produced into three broad lobes, the median lobe roughly twice as wide as the lateral lobe.

Protosmia rubifloris **redescription**

Figures: 3.7; 3.65; 3.66

Female (N=1): length 8mm (7.5mm); head width 2.25mm (2mm); ITW 1.5mm (1.25mm); forewing length 5mm (5mm).

Colouration: integument black, except as follows: flagellomeres and pedicel brown; cap of rutellum of mandible, labrum and apical projections of clypeus piceous; tegula rufescent; wings hyaline, dusky; all legs piceous; terga with narrow apical impressed margin rufescent; sterna with narrow apical impressed margin amber.

Pubescence: hairs mostly white; integument sparsely pubescent with plumose hairs (1MOD), except as follows: paraocular area with subappressed pubescence (1.5MOD), somewhat denser than rest of head; posterior margin of mesoscutellum fringed with long erect hairs (~3MOD); dorsolateral angle of propodeum with denser, suberect pubescence (2MOD); T1, T2 and T6 with ochraceous apical fascia arising from premarginal line, long, at least as long as narrow apical impressed margins, interrupted medially on T1 and T2, entire on T6 (0.5MOD); sternal scopa long, white to straw-coloured (<3MOD), oriented posteroventrally and arising from the disc (<1MOD).

Surface sculpture: integument finely and evenly punctate, that of head and mesosoma larger but similarly-spaced ($i=1/2d$), except as follows: mandible impunctate along carinae, finely punctate in outer interspace and acetabular interspace ($i=1/2d$); median apical projection of

clypeus finely punctate ($i=1/2d$) except impunctate narrowly at apical margin; dorsal surface of pronotal lobe with minute carinulae, the carinulae parallel to the posterior margin of the pronotal lobe; mesoscutum and mesepisternum with punctures somewhat larger and less dense ($i\sim 1/2d$) than those of vertexal and genal areas; mesepisternum less densely punctate ($i\sim d$) than genal area; tegula finely punctured ($i=1/2d$); axilla finely and densely punctate, dull ($i=1/4d$); punctures of metanotum obscure, somewhat imbricate-punctate, especially in middle $1/3$ the width of metanotum; narrow horizontal basal zone of metapostnotum scrobiculate, otherwise alveolate; propodeum moderately punctate ($i<1/2d$), the punctures of the dorsal surface larger and less dense; T1 anterior surface impunctate; rest of T1 and T2- T3 with punctures finer than elsewhere, well spaced ($i\sim d$); T4 and T5 with punctures somewhat larger than those of T3, those of T4 as dense as T3 ($i\sim d$), those of T5 denser ($i\sim 3/4d$); T6 with punctures largest and densest ($i\sim 1/4d$); sterna with large punctures beneath scopa ($i\sim 1/2d$), impunctate in impressed apical margins of S1-S5, apical margin of S6 with finer punctation ($i\sim 1/2d$).

Structure: head longer than wide (36:33); scape longer than wide (22:7); pedicel longer than wide (5:4); hypostomal carina high; labrum elongate, longer than greatest length of mandible (56:54), nearly parallel sided in dorsal view, sinuate in lateral view and with an inconspicuous, narrow thickening medially on its apical margin; base of labrum with narrow tubercles at lateral extremes, medial to the lateral tubercles of clypeal margin, about as long as their basal widths; mandible elongate, bidentate, the tooth of the rutellum sharp, that of the pollex blunt, somewhat rounded; clypeus with lateral margins rounded to angulate, lateral projections, the projections flat and somewhat reflexed dorsally; apical margin of clypeus between lateral projections with a median, long, spatulate projection strongly reflexed dorsally; clypeal margin between lateral and median projections broadly concave; $IAD>AOD=15:11$; anterior tentorial pits broadly depressed, well defined; paraocular carina moderately high; median ocellus behind midpoint between posterior margin of antennal base and posterior margin of vertexal area ($FAL:VAL=29:21$); $IOC<OOC$ (11:15); $IOC<OV$ (11:15); inner margins of compound eyes subparallel ($UOD:LOD=53:51$); genal area wider than compound eye in lateral view (29:25); mesosoma length to width nearly equal (36:34); inner ventral angle of hind coxa carinate; marginal zone of T6 weakly reflexed dorsally such that it is concave in profile.

Male (N=3): length (5 to 6.5mm); head width (1.5 to 1.75mm); ITW (1 to 1.5mm); forewing length (4 to 5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres dark brown; metasomal terga with narrow apical impressed margin dark brown.

Pubescence: hairs mostly ochraceous; hypostomal area with plumose, white pubescence, the hairs suberect ($<3\text{MOD}$); clypeus with suberect pubescence ($<3\text{MOD}$), hairs white; paraocular area with suberect pubescence (2MOD); lateral extremes of dorsal surface of pronotal collar with erect pubescence ($\sim 2\text{MOD}$), hairs ochraceous; mesepisternum with subappressed pubescence ($\sim 2\text{MOD}$); fringe of long erect hairs of mesoscutellum extending anteriorly along the lateral margins of the axilla and mesoscutum ($>3\text{MOD}$); terga without apical hair bands; disc of S1, S2 and at lateral extremes of S3 with long, highly plumose hairs ($>2\text{MOD}$); S3 apical margin fringed in concavity, the hairs oriented posteriorly ($\sim 1.5\text{MOD}$); apical margin of S4 with inconspicuous thin fringe, the hairs erect, oriented ventrally and somewhat toward midline ($<1\text{MOD}$).

Surface sculpture: clypeus entirely more finely punctate ($i \sim d$); punctation of axilla well defined ($i = 1/2d$); metapostnotum impunctate except in horizontal basal zone where it is scrobiculate; T1 anterior surface finely, inconspicuously punctate ($i \sim d$); T1 with finest punctation ($i \sim 1/2d$), T2 to T6 ($i \sim d$); S1 and S2 moderately punctate in disc, ($i < d$), impunctate along narrow, apical impressed margin; S3 very finely punctate ($i < 1/2d$), almost foveolate, in disc, except at lateral extremes where it is moderately punctate ($i < d$), impunctate along narrow, apical impressed margin; S4 disc puncticulate, the punctures large, shallow, not well defined ($i > d$), the interspaces conspicuously roughened.

Structure: head length and width equal; flagellomeres elongate, longer than wide, and F10 and F11 ventrally depressed, appearing pit-like from underneath; hypostomal carina moderate; labrum and mandible not especially elongate, both not more than twice as long as their greatest widths; apical margin of clypeus broadly concave and evenly crenulate in concavity; clypeoantennal distance $1/3$ length of clypeus (6:18); (IAD:AOD= 9:5); median ocellus posterior

to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 24:22); IOC<OOC (9:14); IOC<OV (9:14); compound eyes convergent below (UOD:LOD= 44:39); compound eye wider than genal area in lateral view (25:18); mesosoma longer than wide (70:76); apical margin of T6 produced to three lobes, the median lobe broad, at least as broad as half the greatest width of the terga, lateral lobes inconspicuous, about ¼ the greatest width of the terga; T7 hidden entirely by T6; S1 short, apical margin straight; S2 unmodified, apical margin feebly rounded; S3 and S4 with disc thin, not strongly sclerotized, hyaline, translucent, S4 more so than S3; apical margin of S3 feebly concave, the concavity broad, nearly the width of the segment; S4 apical margin reflexed ventrally, rounded; S4 to S8 retracted.

Genitalia: as in Fig. 3.66c.

Distribution: This species is confined to the Nearctic region. Its North American range extends for much of the Pacific coast, west of the Rocky Mountain Range, from southern British Columbia (presumably) to southern Arizona (Fig. 3.7). [USA: AZ, CA, ID, NV, OR, UT, WA].

Specimens examined: USA: **California:** ♀ *Calaveras Co.*, 2mi NE of Arnold, 17.vi.1999 (JS Ascher); USA: **Washington:** 3 ♂ *Thurston Co.*, 19.iv.2009 (C Fimbel).

Type depository: Female, in the US National Museum, Washington D.C., USA. [Examined]

3.10 FIGURES

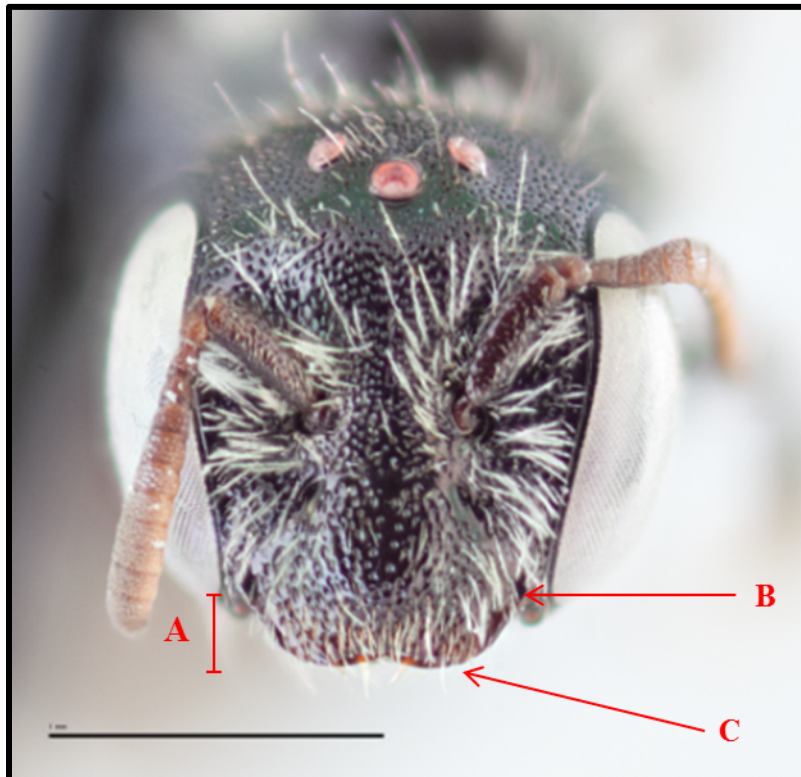
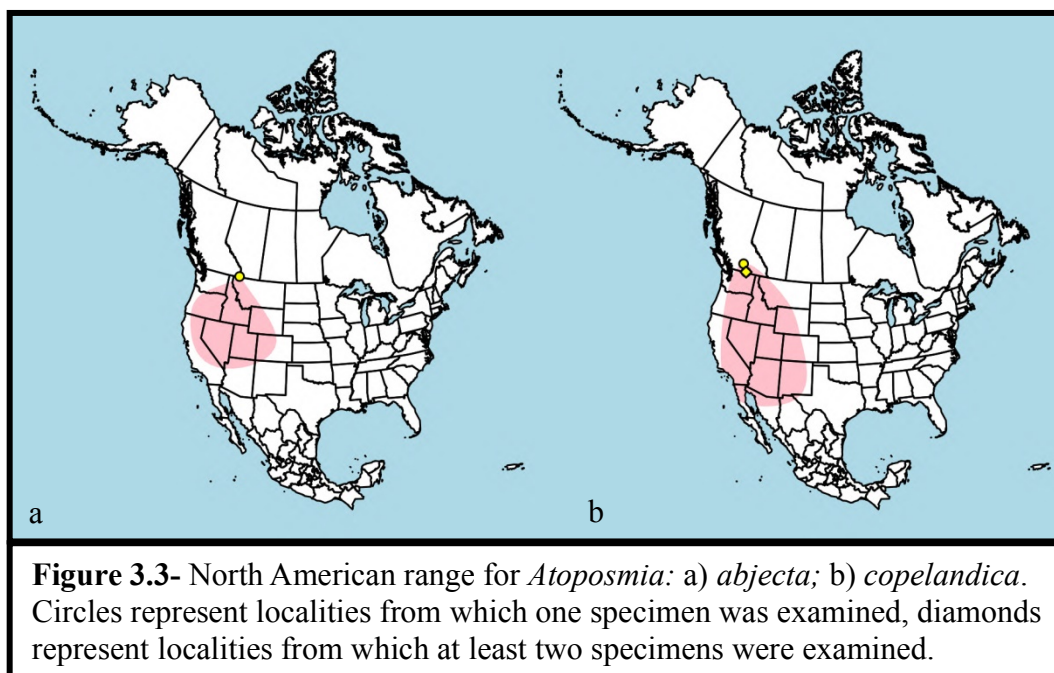
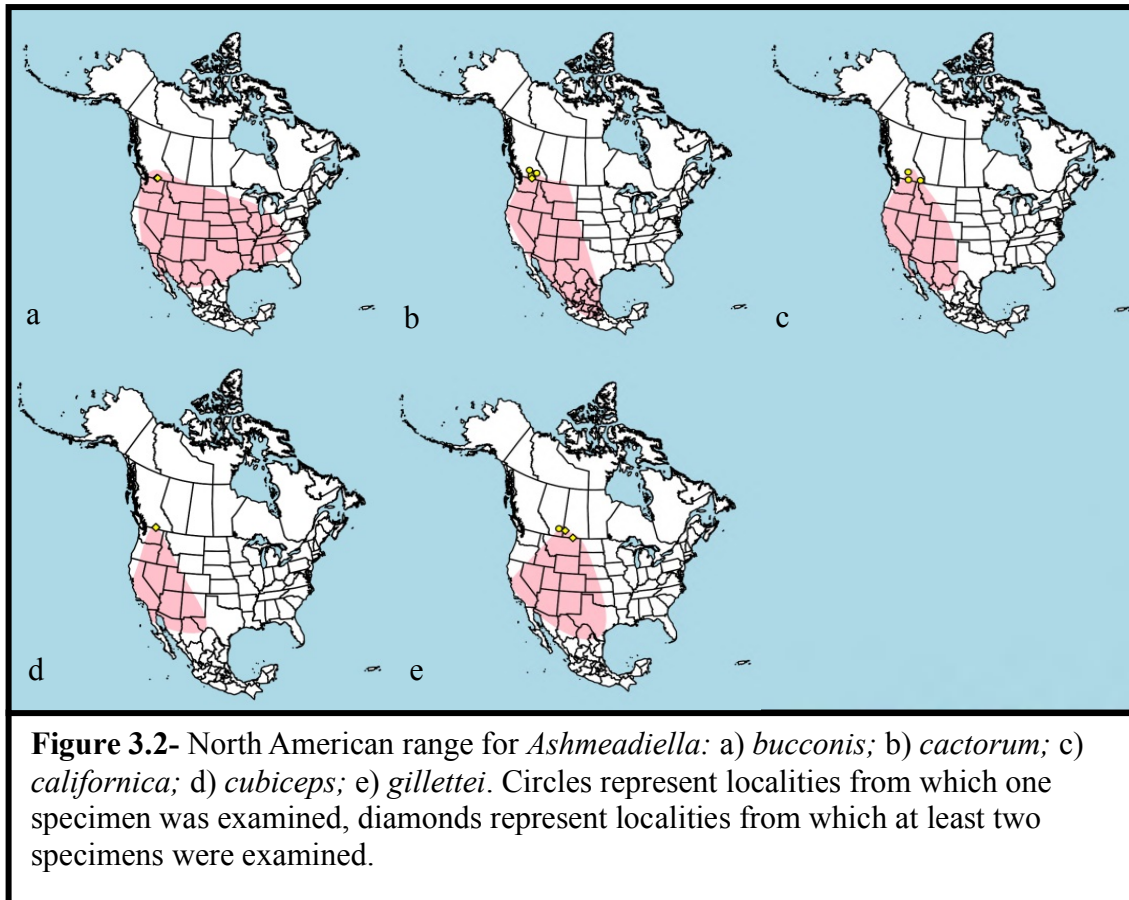


Figure 3.1- *Hoplitis producta*, female, clypeus. A) Clypeal truncation: extent to which the clypeus is produced anteriorly beyond the base of the labrum (B); C) Lateral angle of truncation: the point at which the lateral margin of the clypeal truncation ceases to be produced anteriorly.



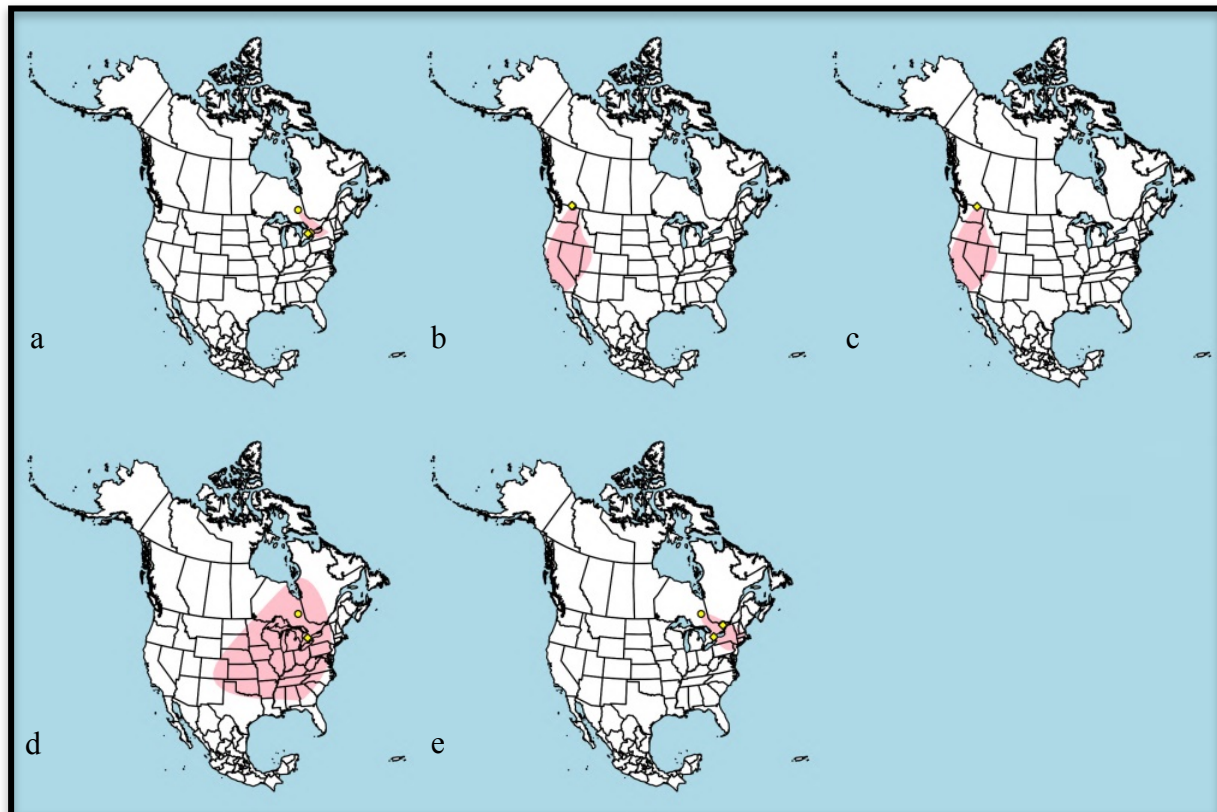
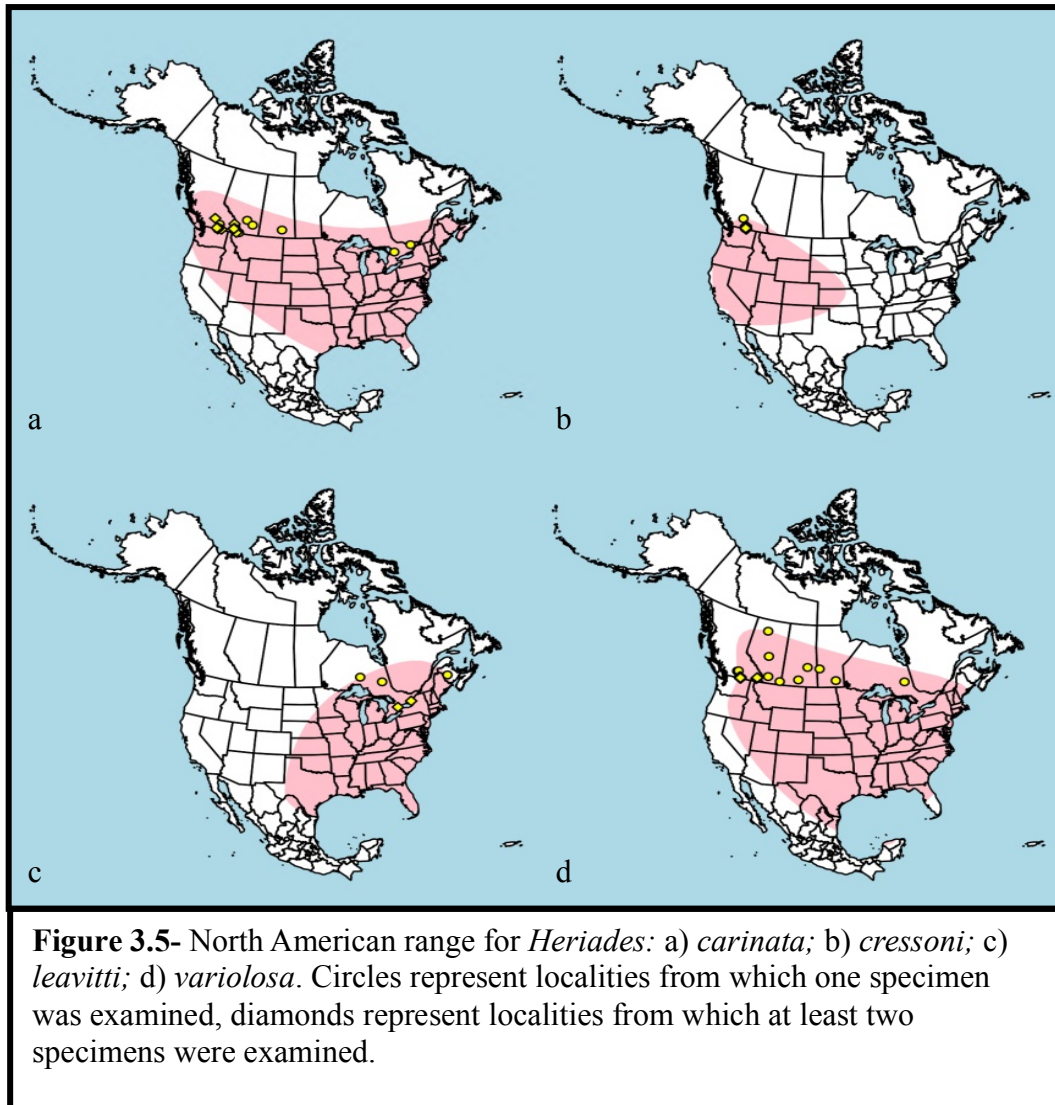


Figure 3.4- North American range for *Chelostoma*: a) *campanularum*; b) *minutum*; c) *phaceliae*; d) *philadelphi*; e) *rapunculi*. Circles represent localities from which one specimen was examined, diamonds represent localities from which at least two specimens were examined.



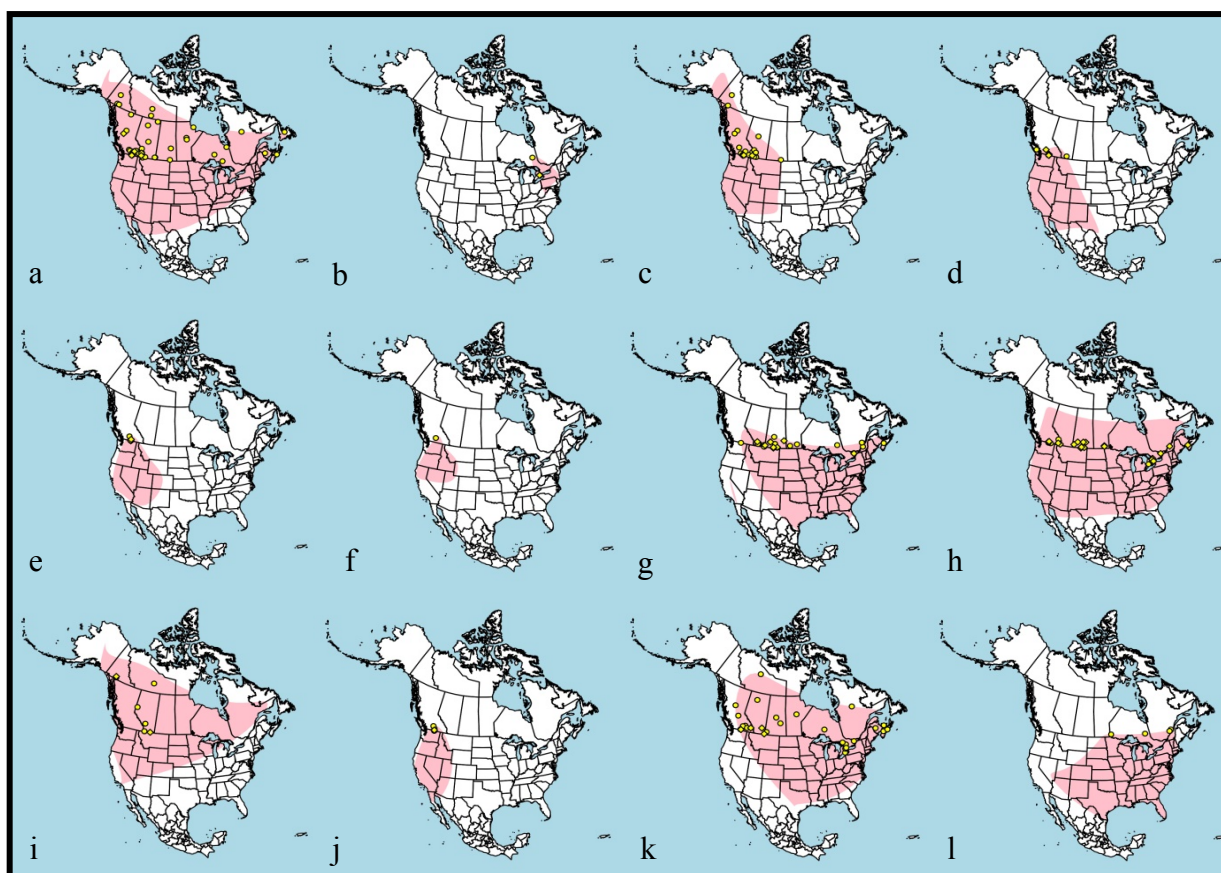


Figure 3.6- North American range for *Hoplitis*: a) *albifrons*; b) *anthocopoides*; c) *fulgida*; d) *grinnelli*; e) *hypocrita*; f) *louisae*; g) *pilosifrons*; h) *producta*; i) *robusta*; j) *sambuci*; k) *spoliata*; l) *truncata*. Circles represent localities from which one specimen was examined, diamonds represent localities from which at least two specimens were examined.

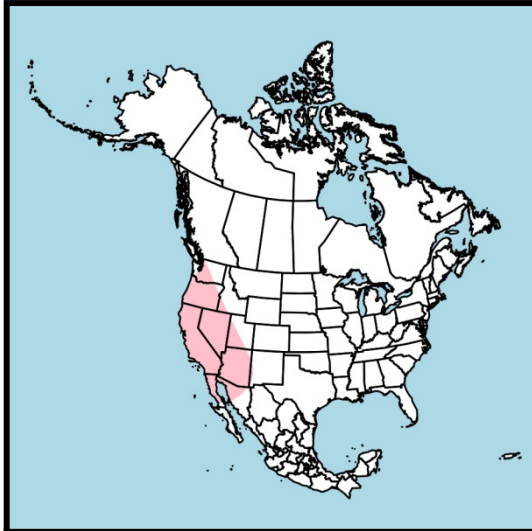
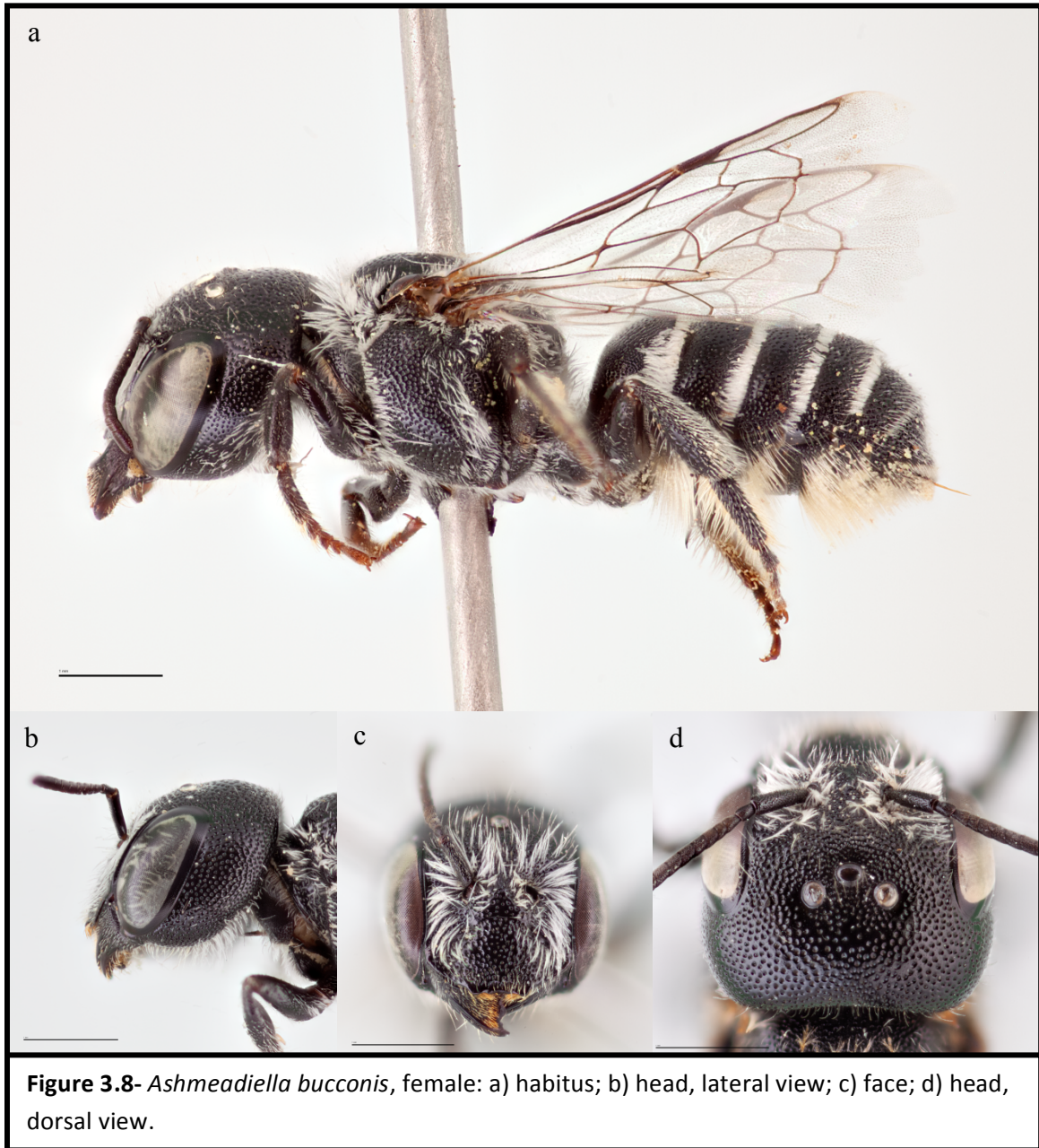


Figure 3.7- North American range for *Protosmia rubifloris*.



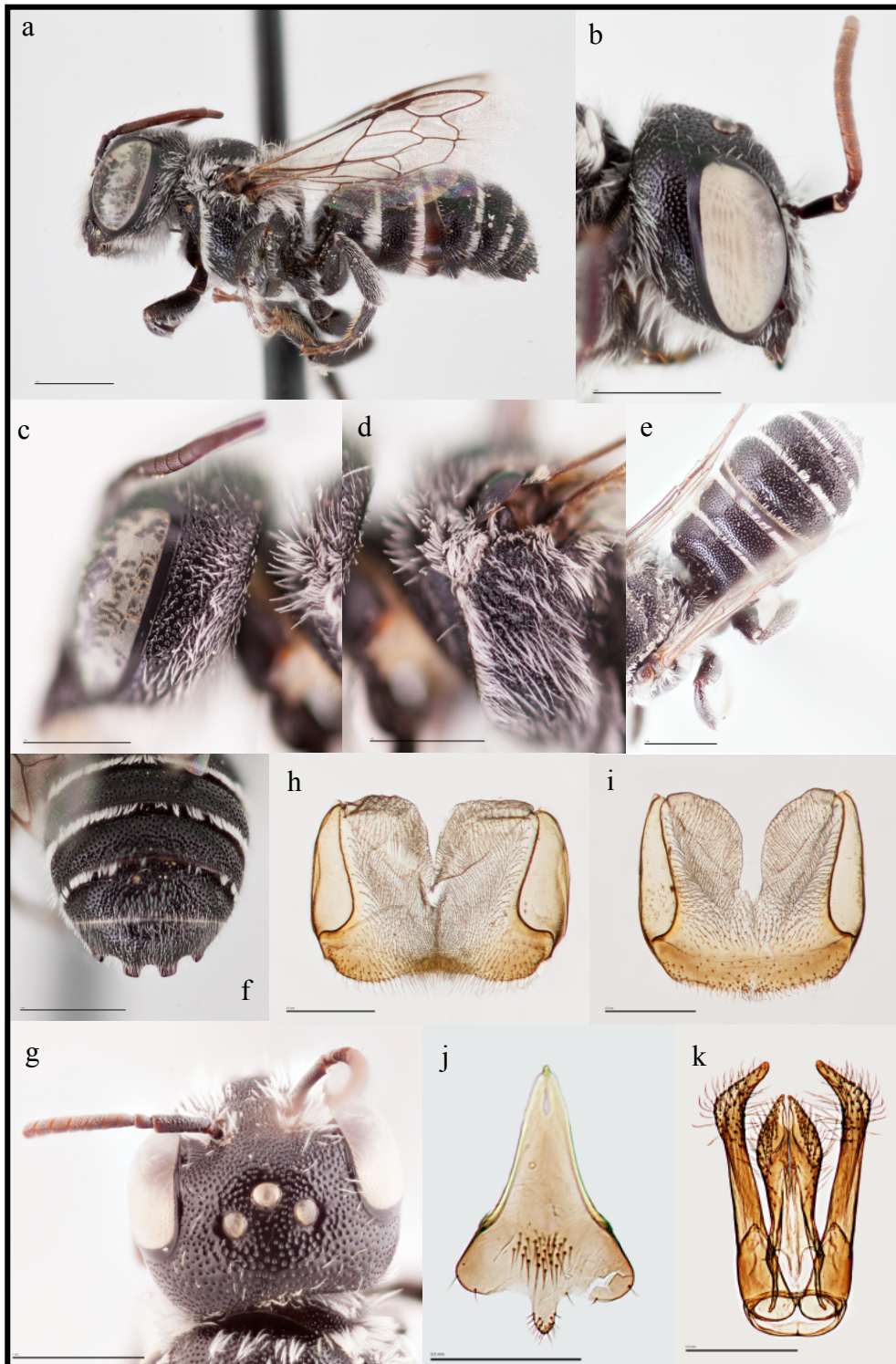
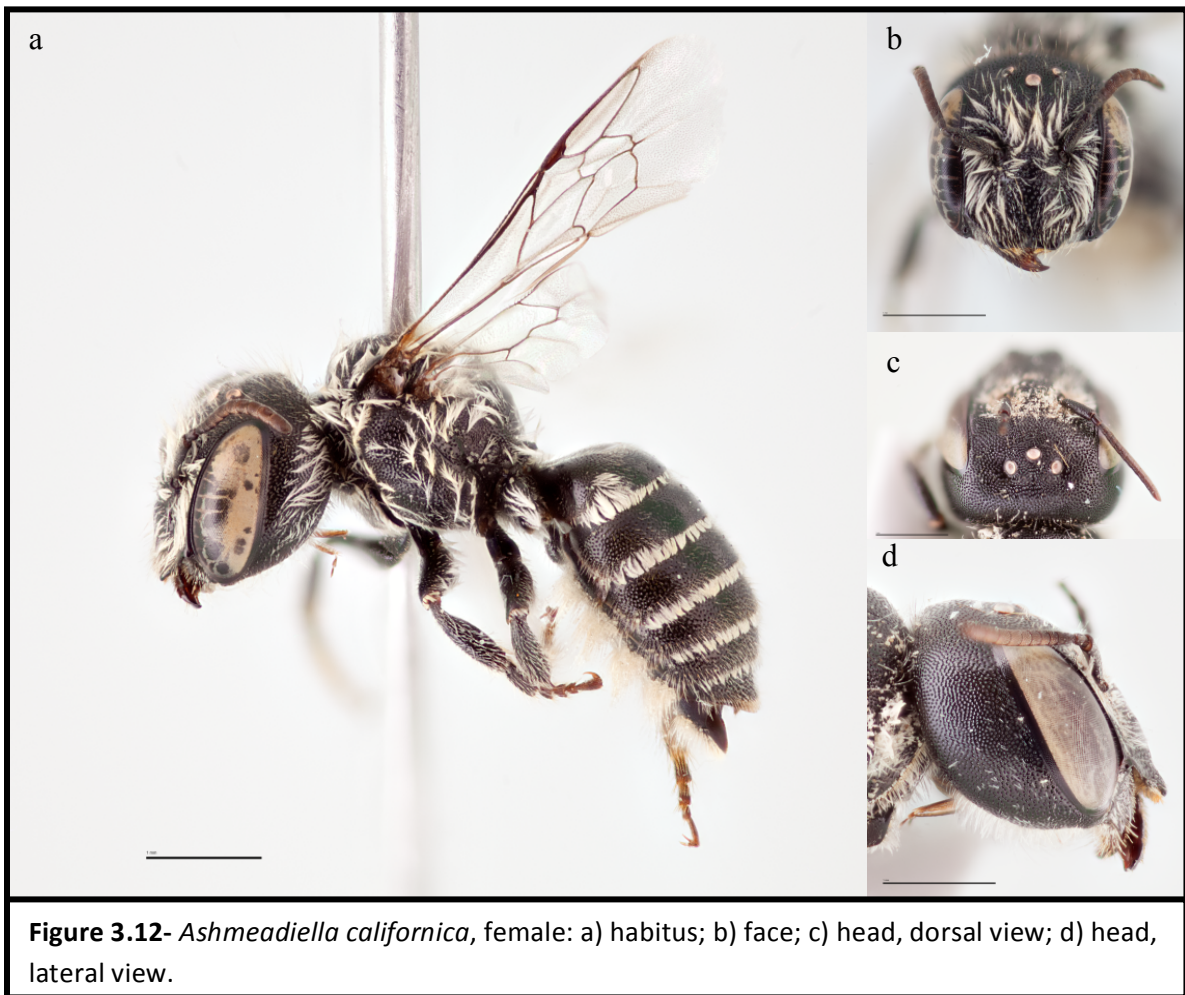
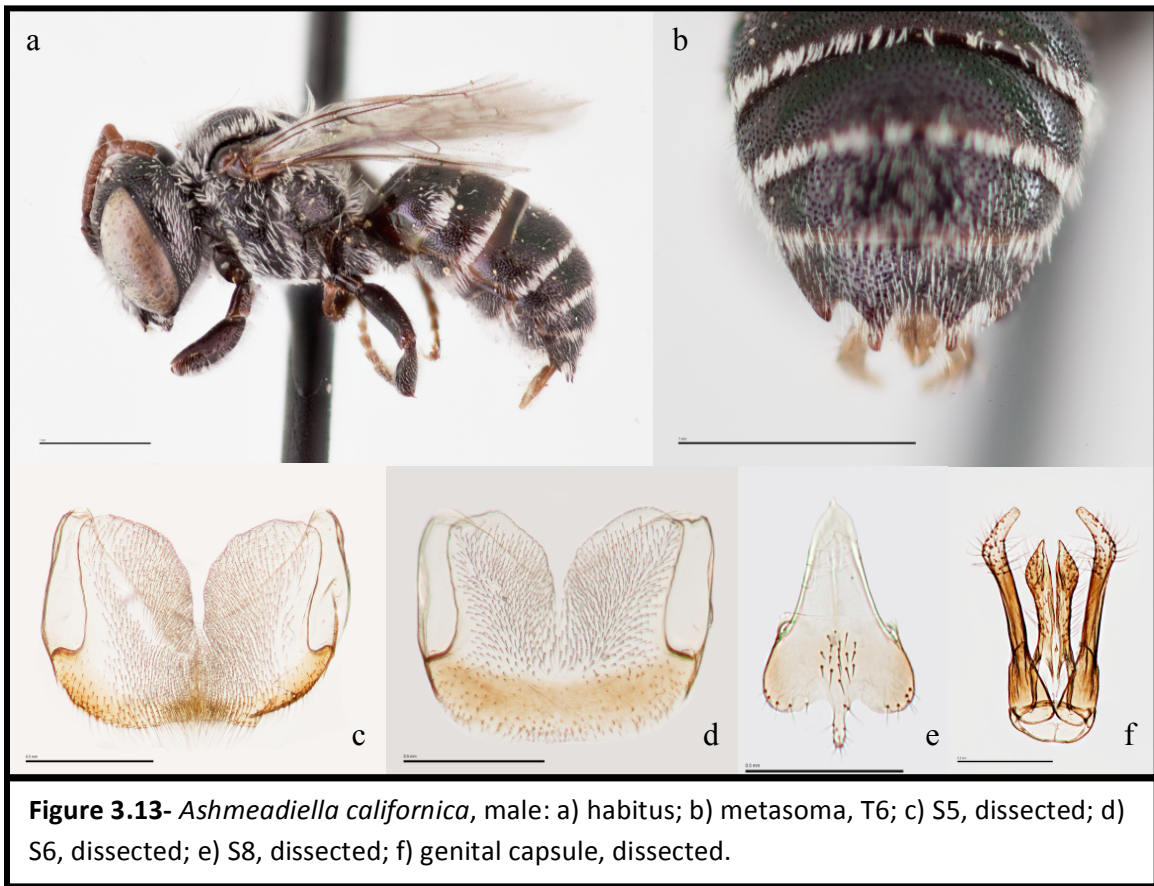


Figure 3.9- *Ashmeadiella buconis*, male: a) habitus; b) head, lateral view; c) genal area, punctation; d) mesepisternum, punctation; e) metasoma, dorsal view; f) metasoma, T6; g) head, dorsal view; h) S5, dissected ; i) S6, dissected; j) S8, dissected; k) genital capsule, dissected.









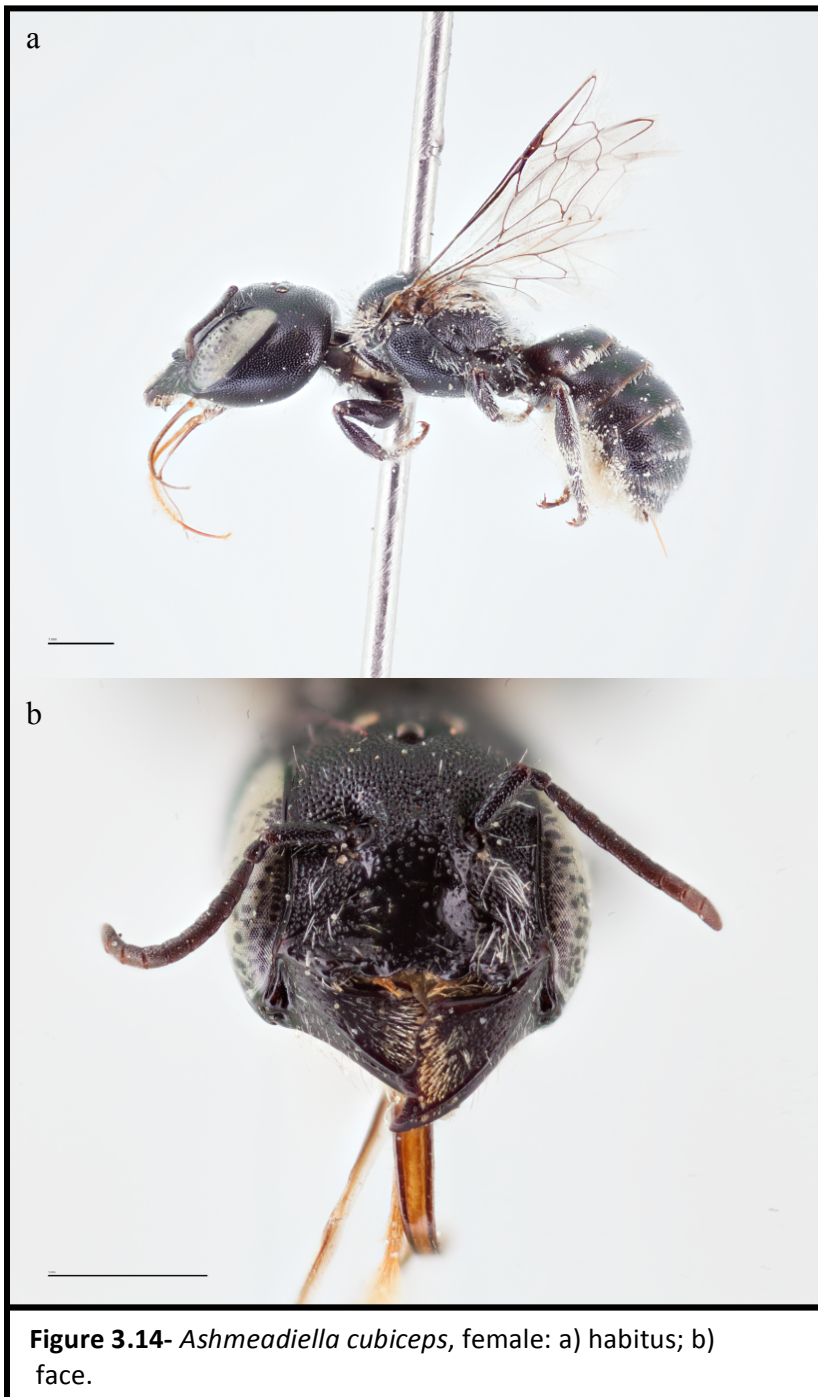
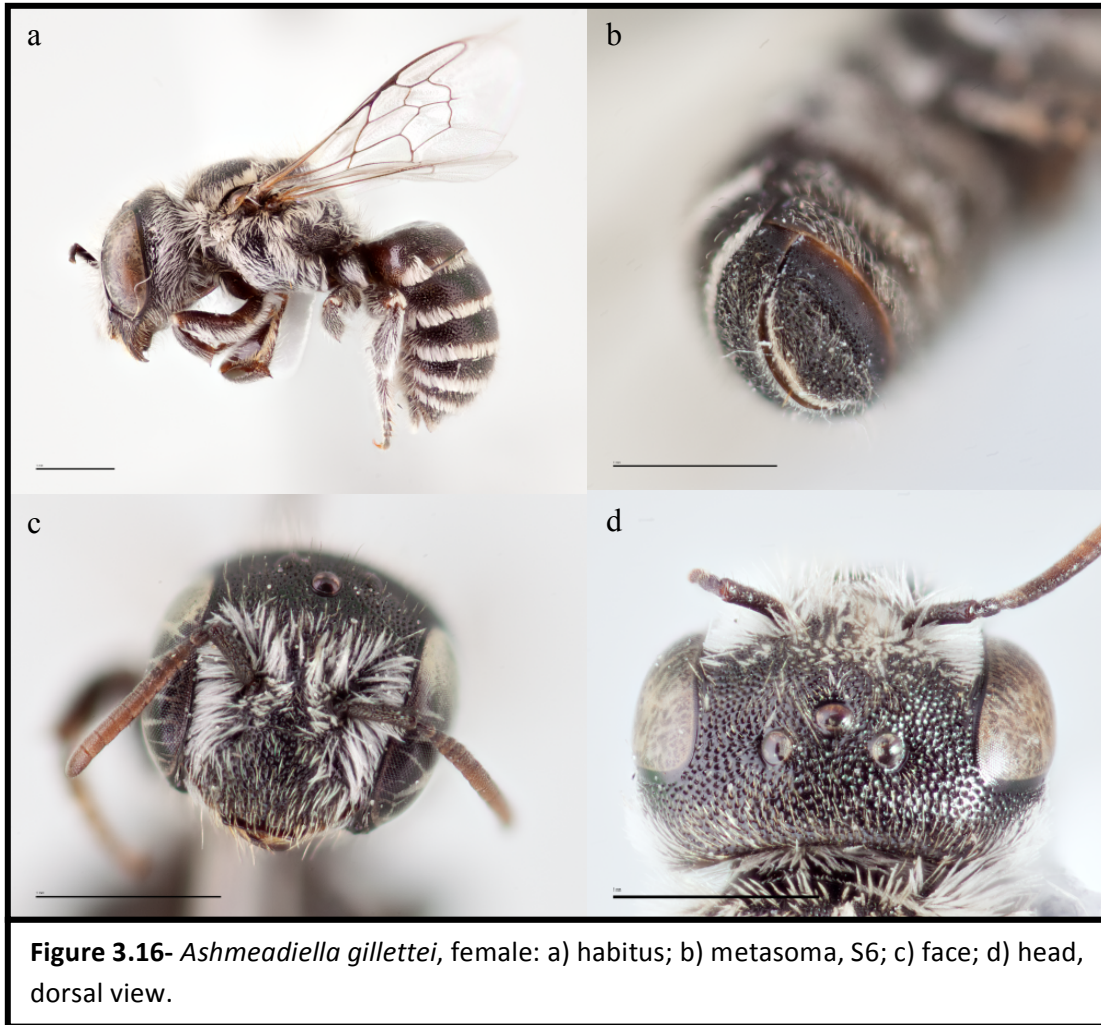


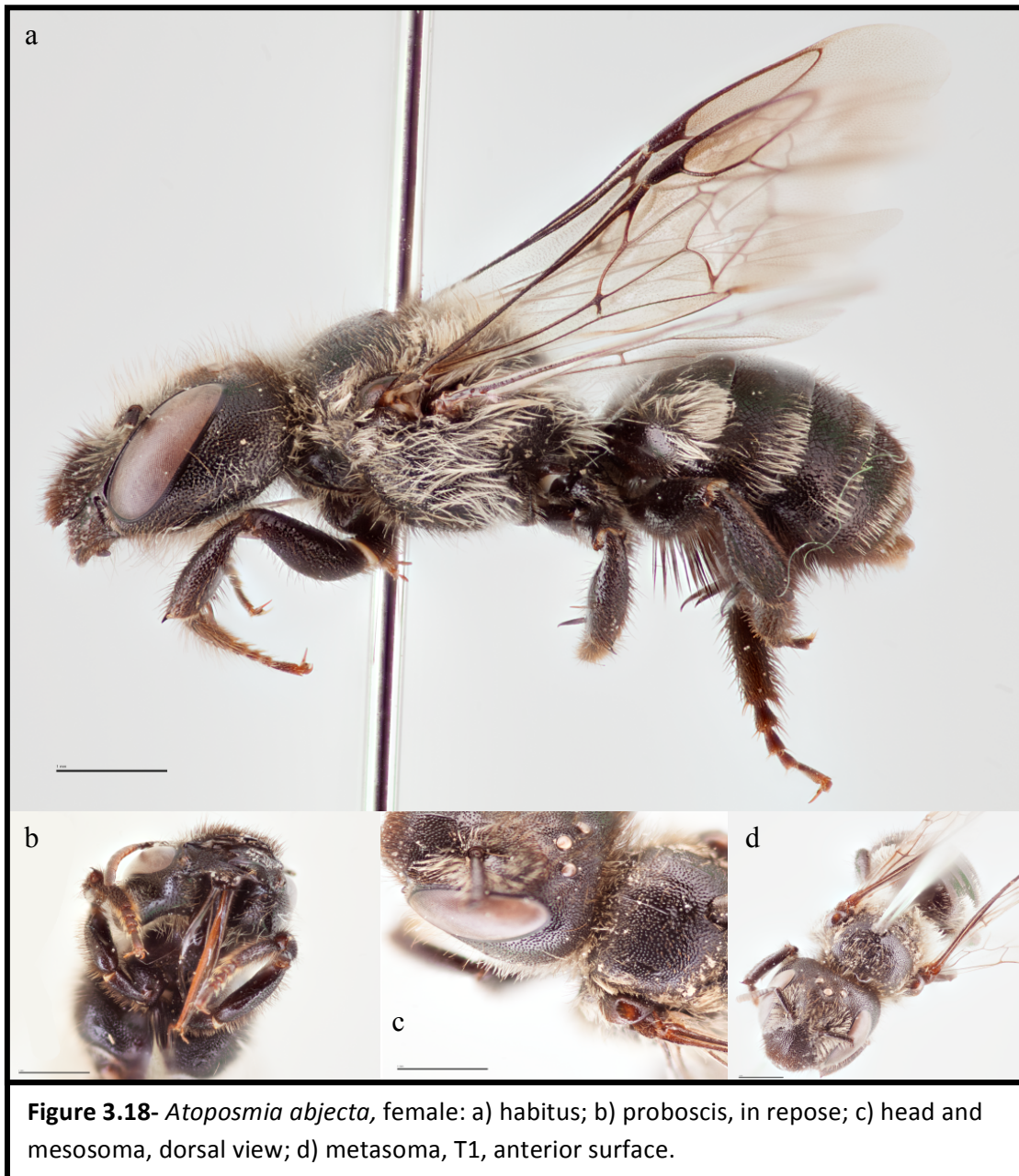
Figure 3.14- *Ashmeadiella cubiceps*, female: a) habitus; b) face.

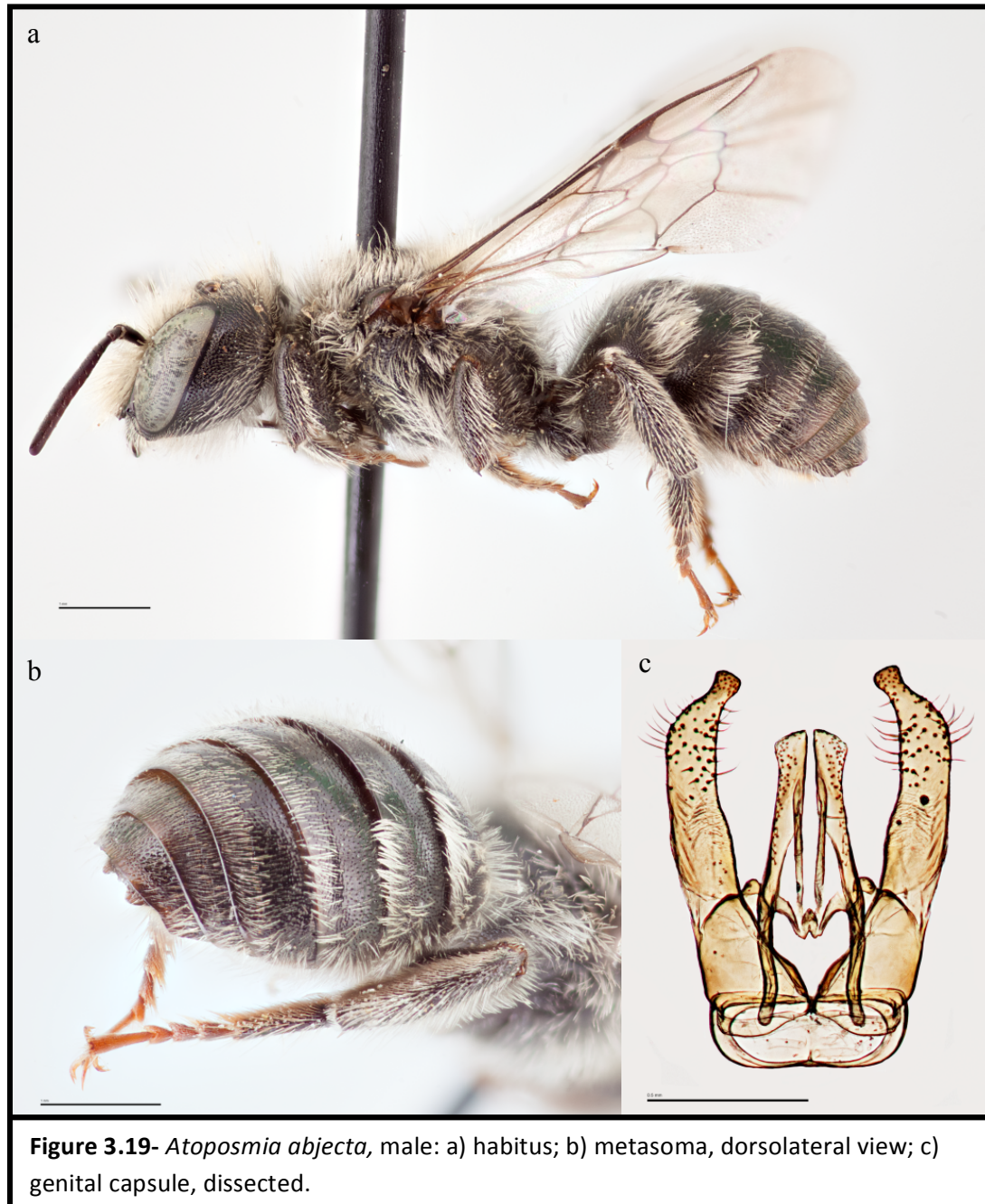


Figure 3.15- *Ashmeadiella cubiceps*, male: a) habitus; b) head, dorsal view; c) metasoma, dorsal view; d) mesepisternum, punctation; e) genal area, punctation; f) metasoma, T6; g) head, lateral view; h) S5, dissected; i) S6, dissected; j) S8, dissected; k) genital capsule, dissected.









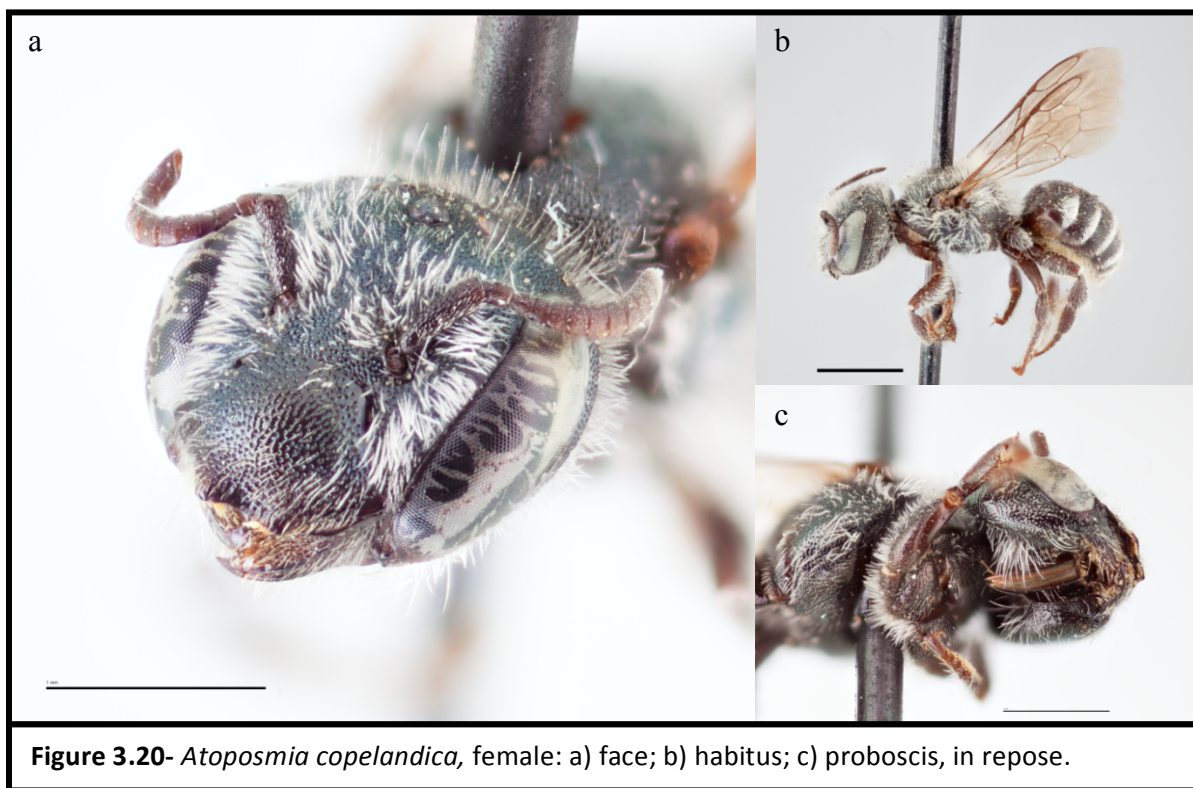




Figure 3.21- *Atoposmia copelandica*, male: a) habitus; b) head and mesosoma, dorsal view; c) proboscis, in repose; d) metasoma, T1, anterior surface; e) metasoma, dorsolateral view; f) genital capsule, dissected.



Figure 3.22- *Chelostoma campanularum*, female: a) habitus; b) paraocular area; c) head, dorsolateral view; d) face; e) mesosoma, dorsal view.



Figure 3.23- *Chelostoma campanularum*, male: a) habitus; b) metasoma, T7; c) metasoma, S5, fringe; d) genital capsule, dissection.

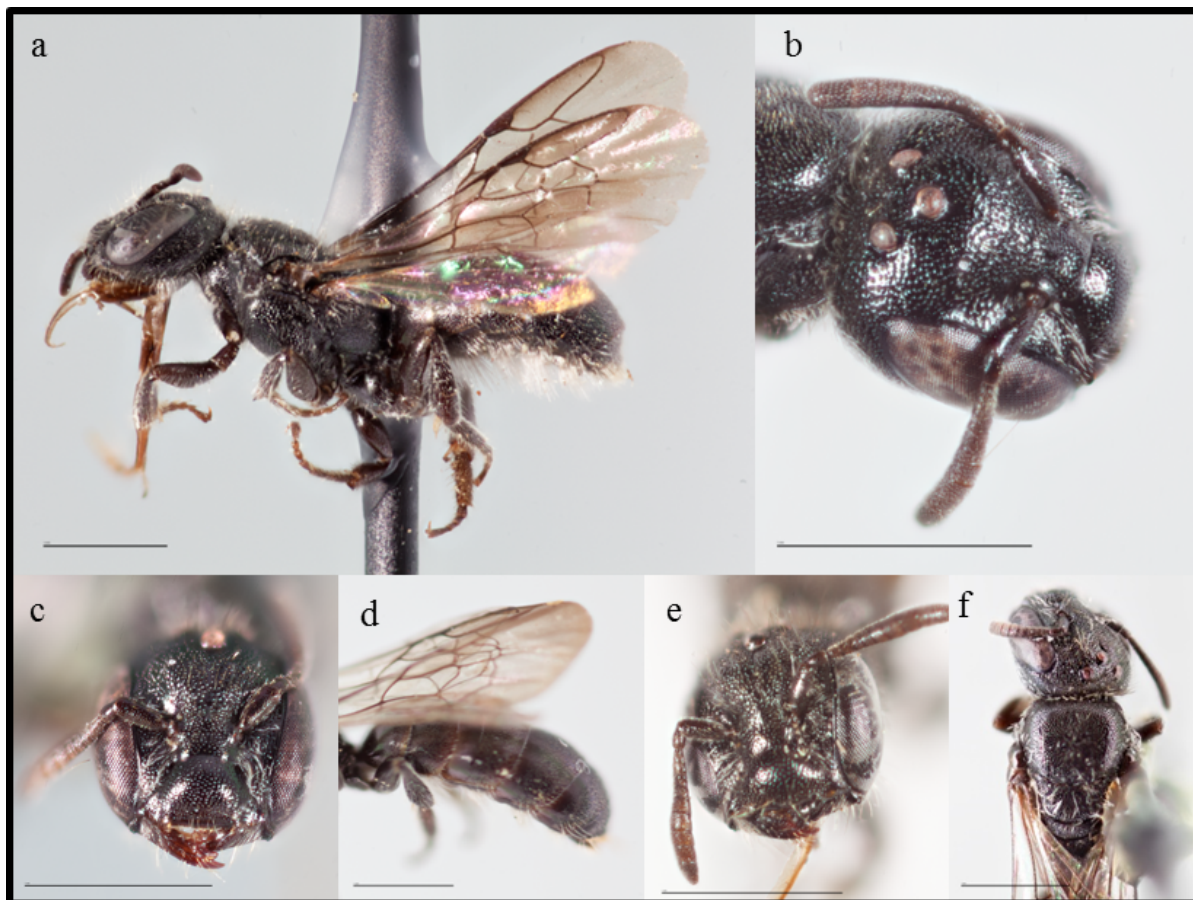
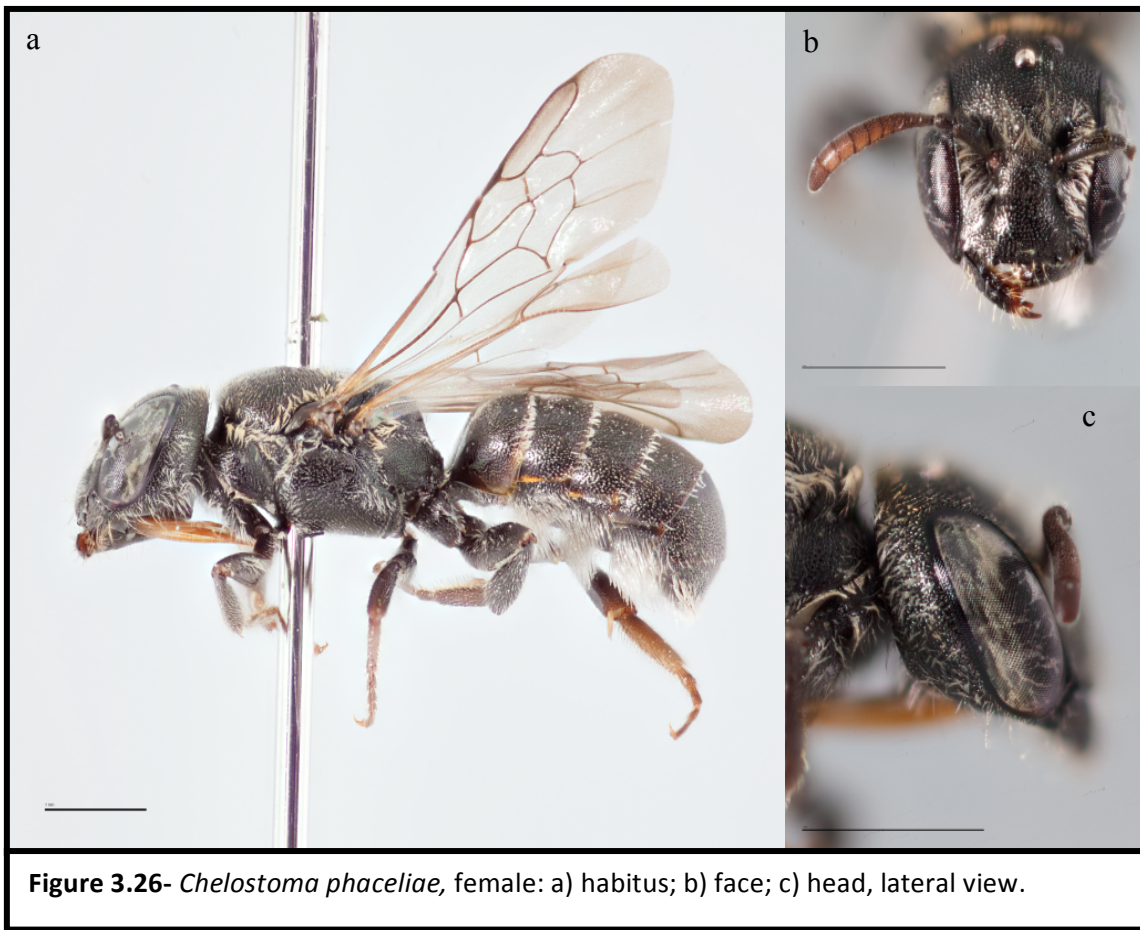


Figure 3.24- *Chelostoma minutum*, female: a) habitus; b) head, dorsal view; c) face; d) metasoma, lateral view; e) head, antenna; f) mesosoma, dorsal view.





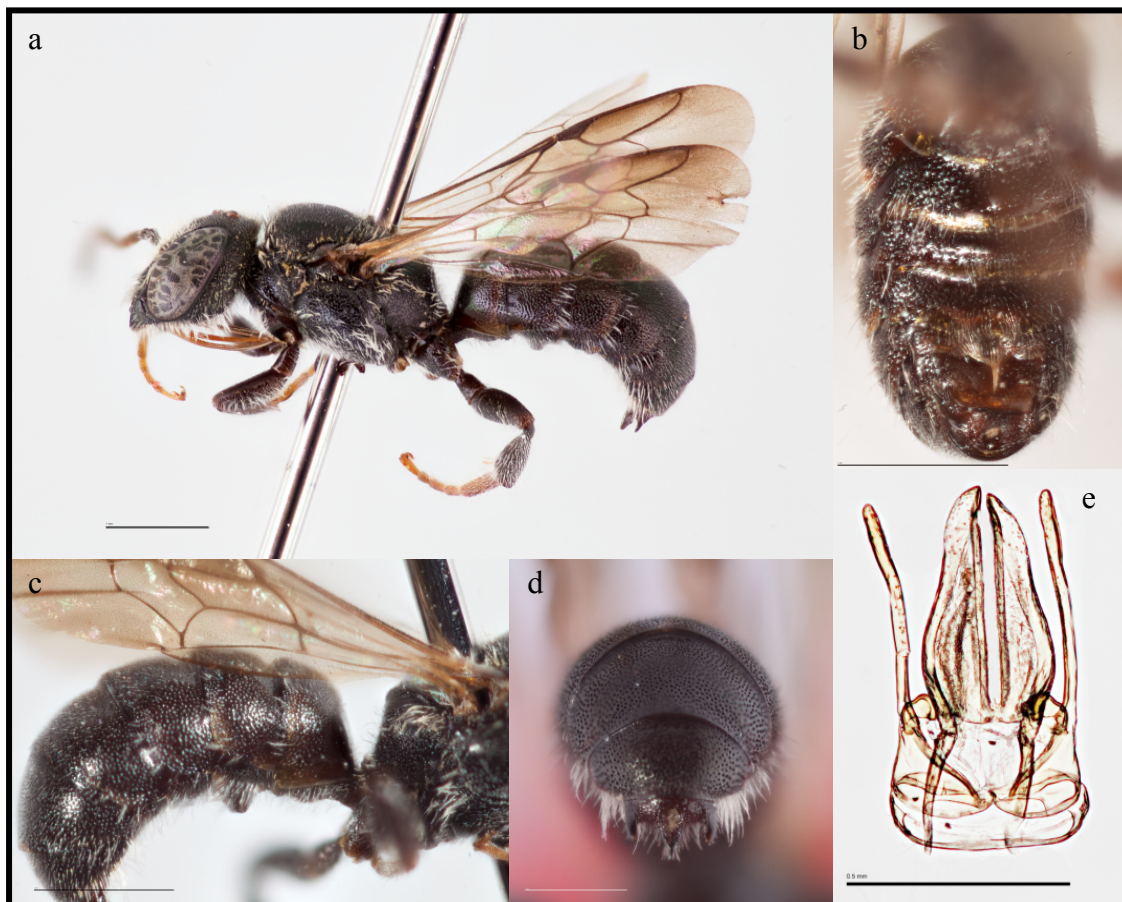


Figure 3.27- *Chelostoma phaceliae*, male: a) habitus; b) metasoma, S5; c) metasoma, lateral view; d) metasoma, T7; e) genital capsule, dissected.

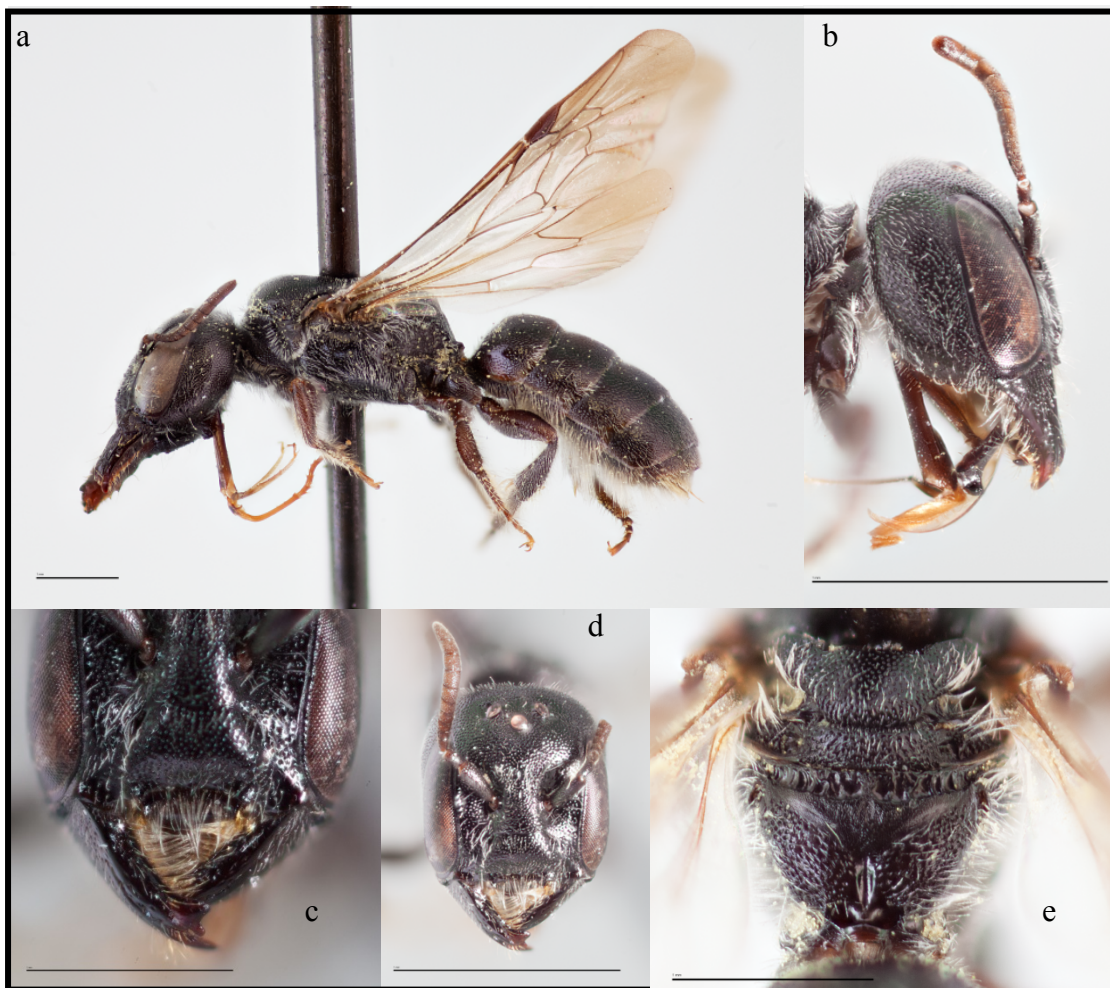
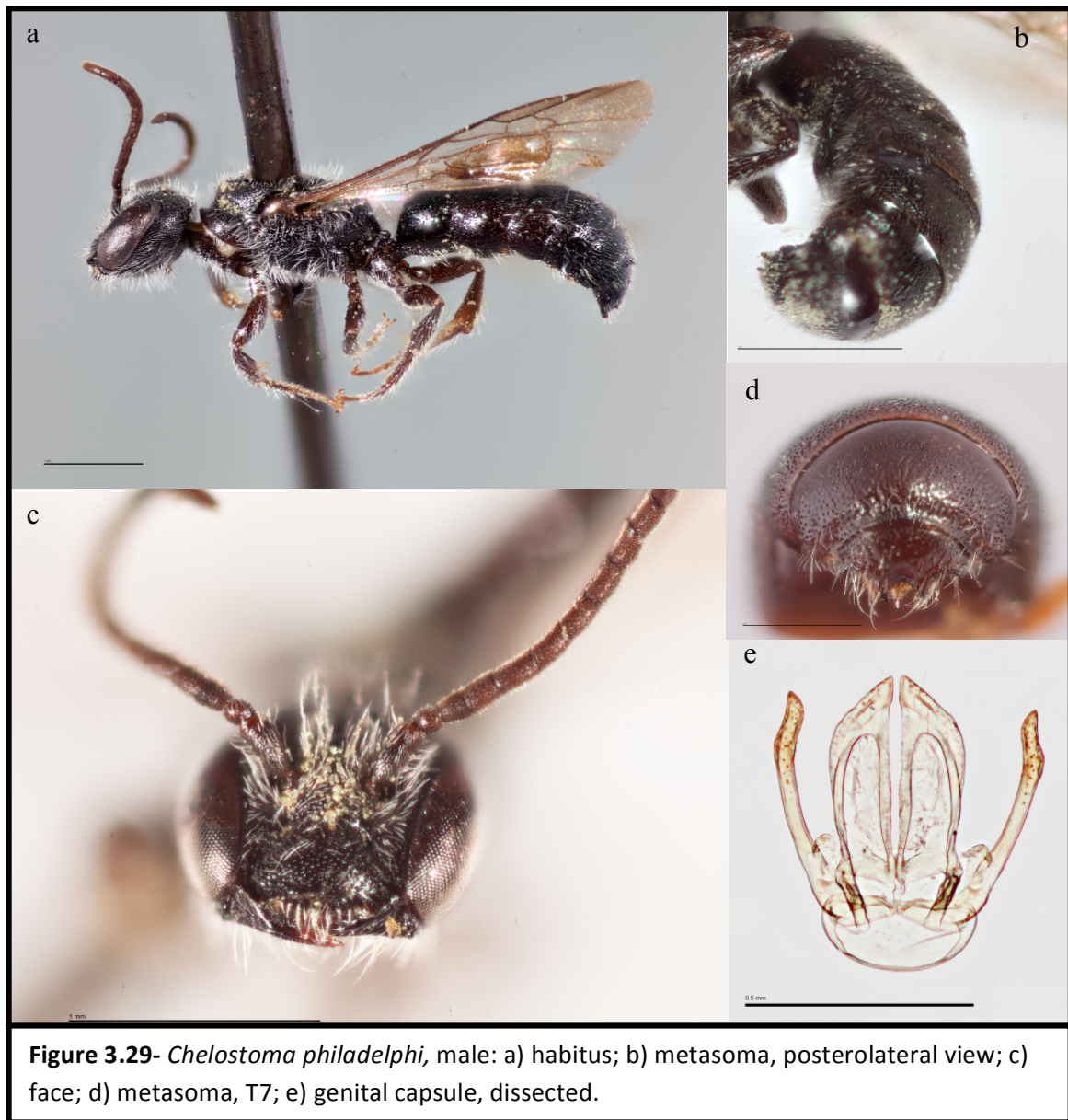
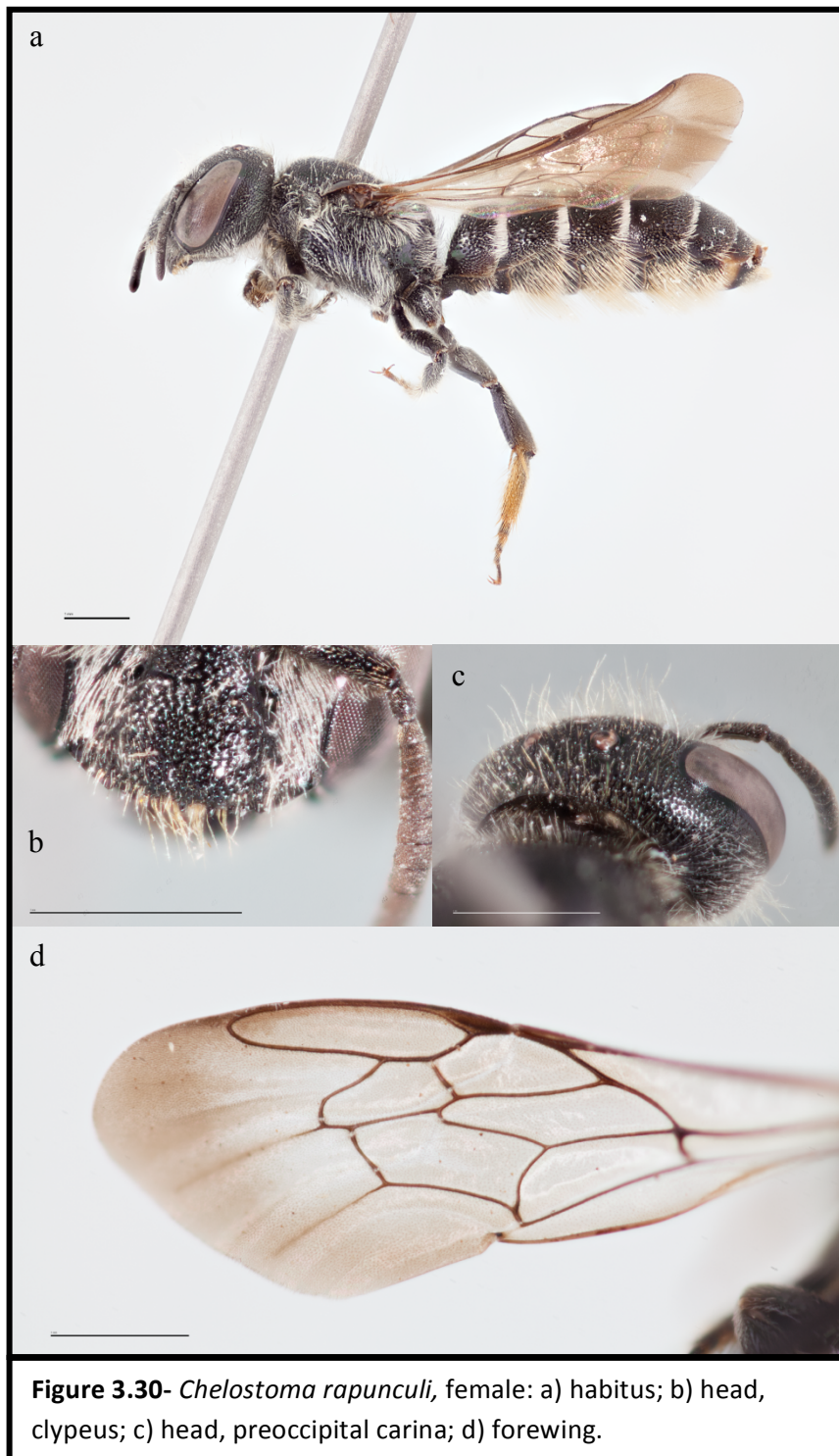


Figure 3.28- *Chelostoma philadelphi*, female: a) habitus; b) head, lateral view; c) head, clypeus; d) face; e) propodeum, dorsal view.





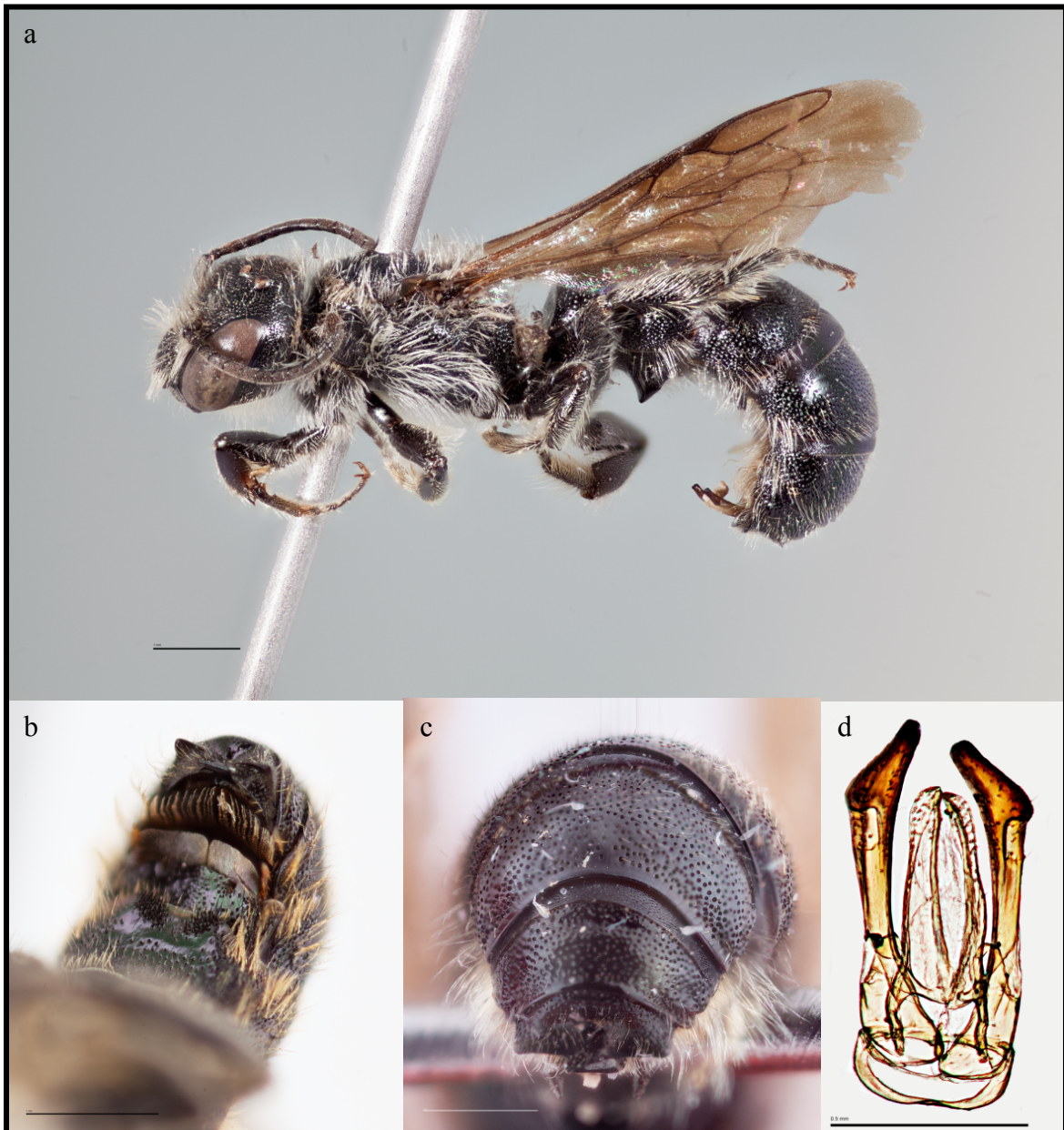


Figure 3.31- *Chelostoma rapunculi*, male: a) habitus; b) metasoma, S3 to S5; c) metasoma, T7; d) genital capsule, dissected.



Figure 3.32- *Heriades carinata*, female: a) face; b) habitus; c) mandible, lateral view; d) T1, dorsolateral view; e) propodeum and T1, dorsal view.

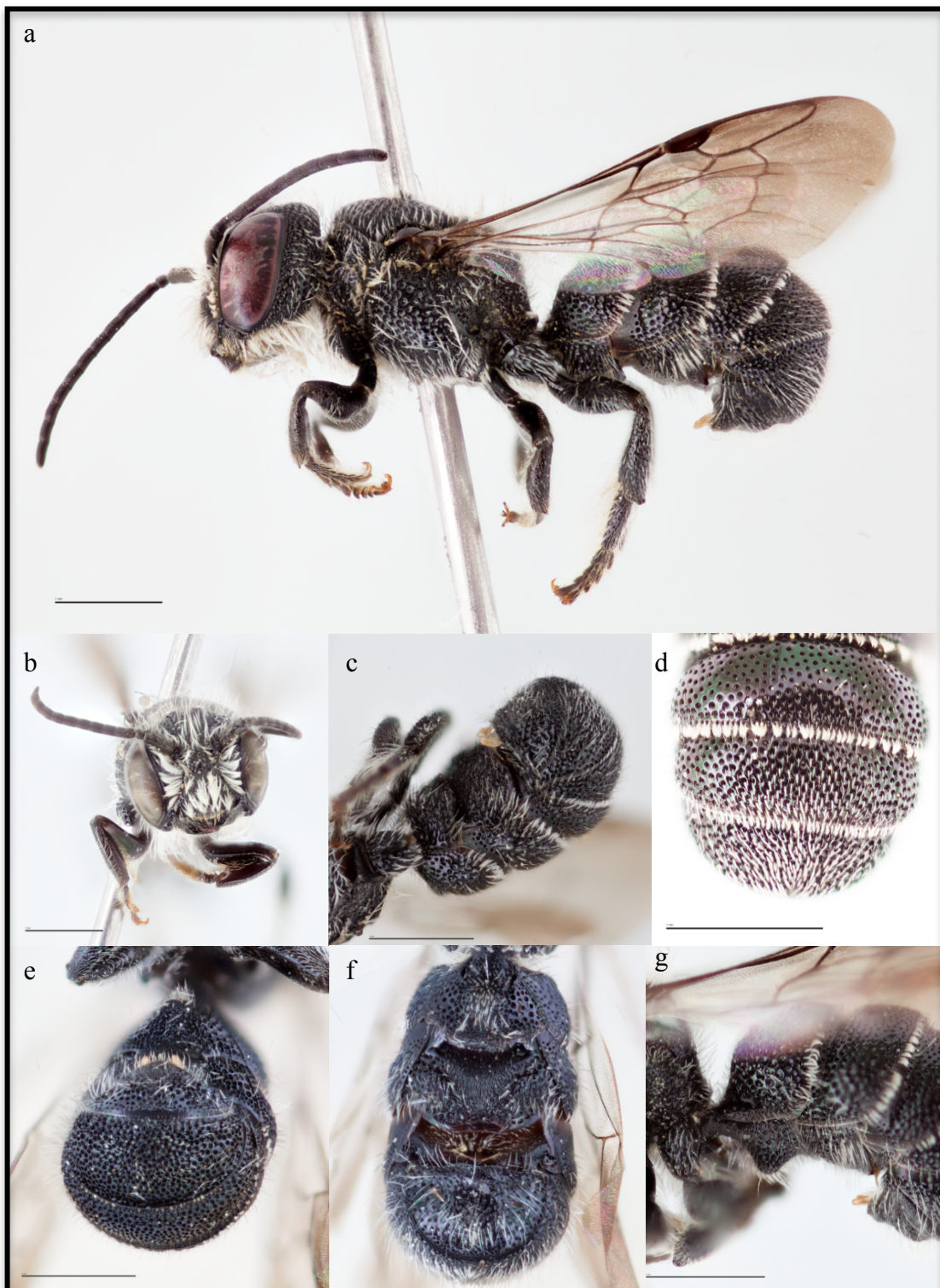


Figure 3.33- *Heriades carinata*, male: a) habitus; b) face; c), metasoma, vetrolateral view; d) metasoma, dorsal view; e) metasoma, S2, posterior view; f) metasoma, S1 and S2, ventral view; g) metasoma, S1 and S2, lateral view.

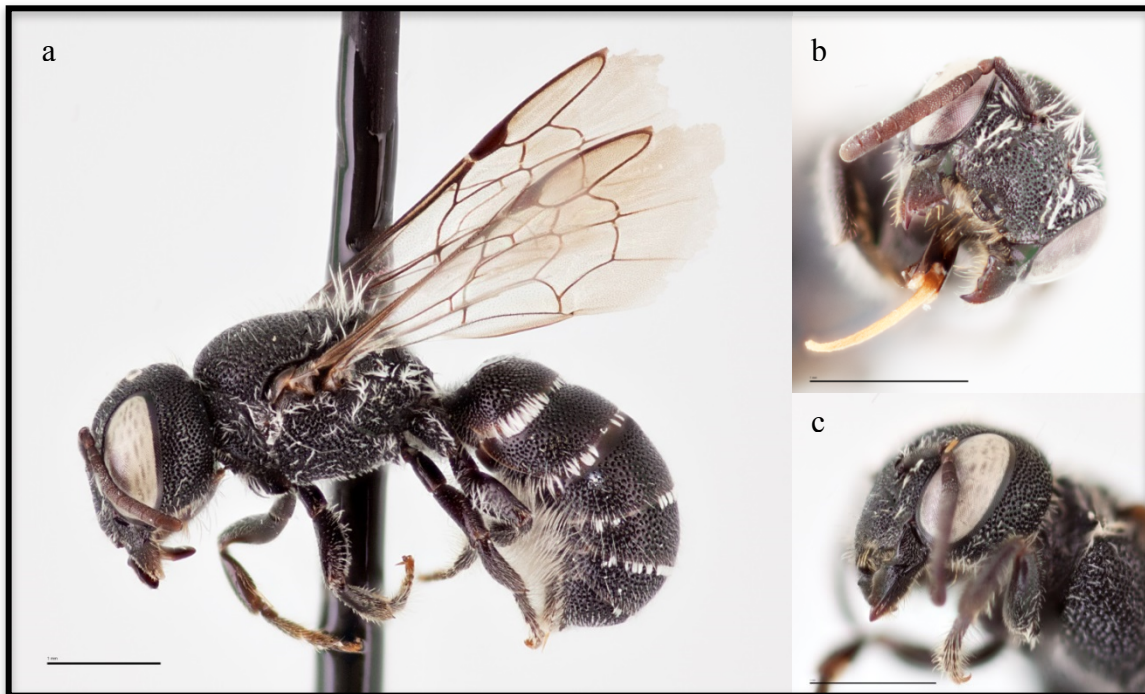


Figure 3.34- *Heriades cressoni*, female: a) habitus; b) face; c) mandible, lateral view.

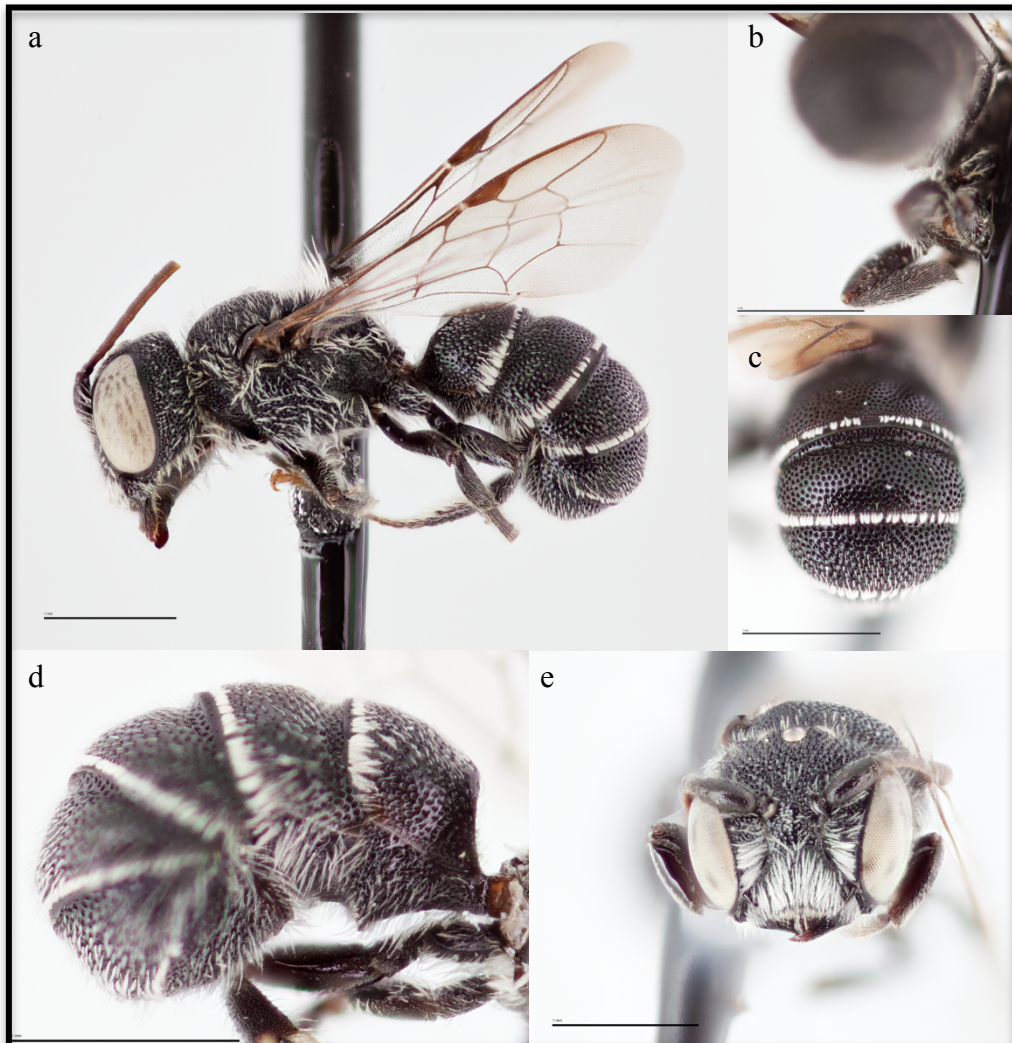


Figure 3.35- *Heriades cressoni*, male: a) habitus; b) metasoma, S1, posterior view; c) metasoma, dorsal view; d) metasoma, lateral view; e) face.

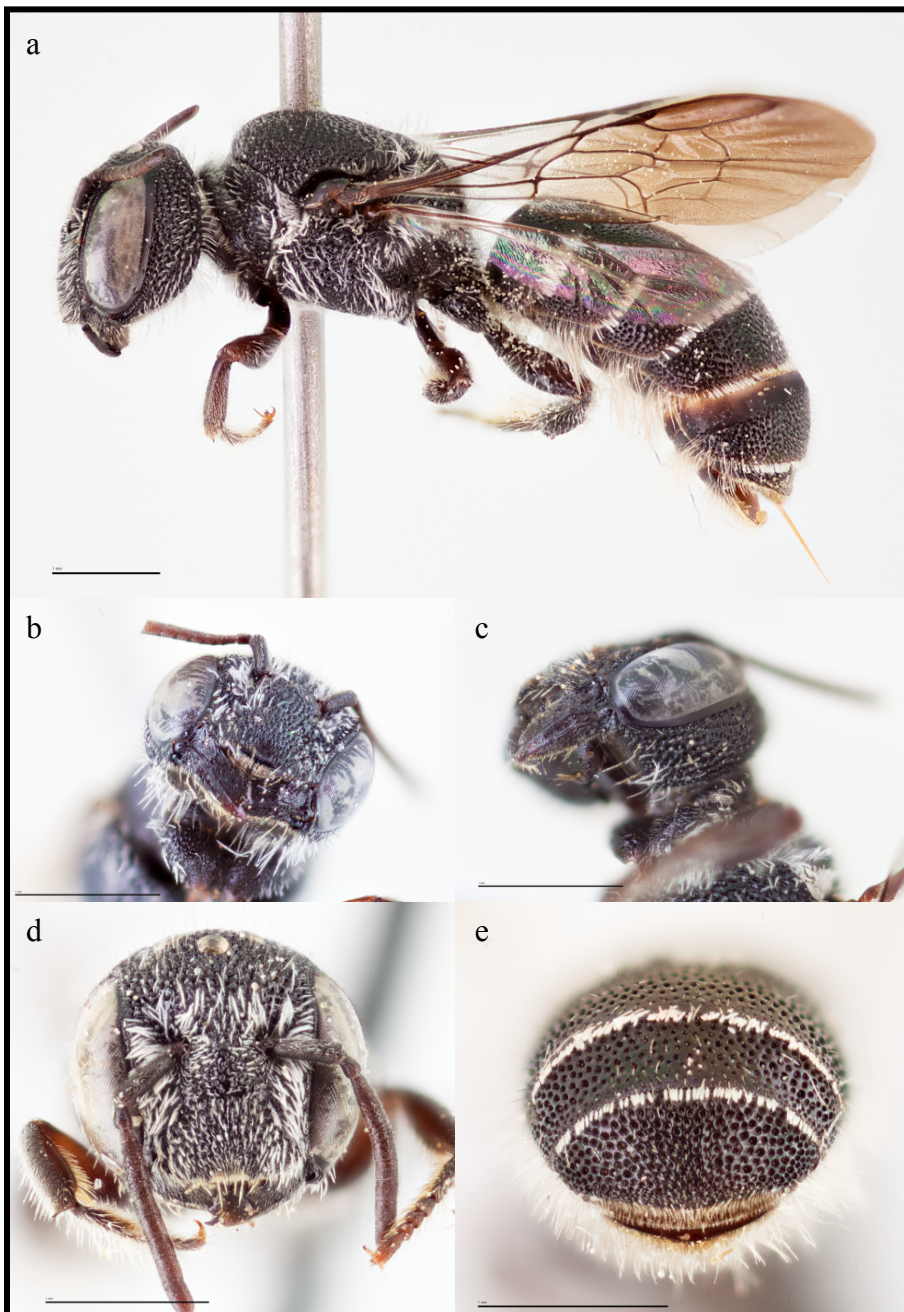
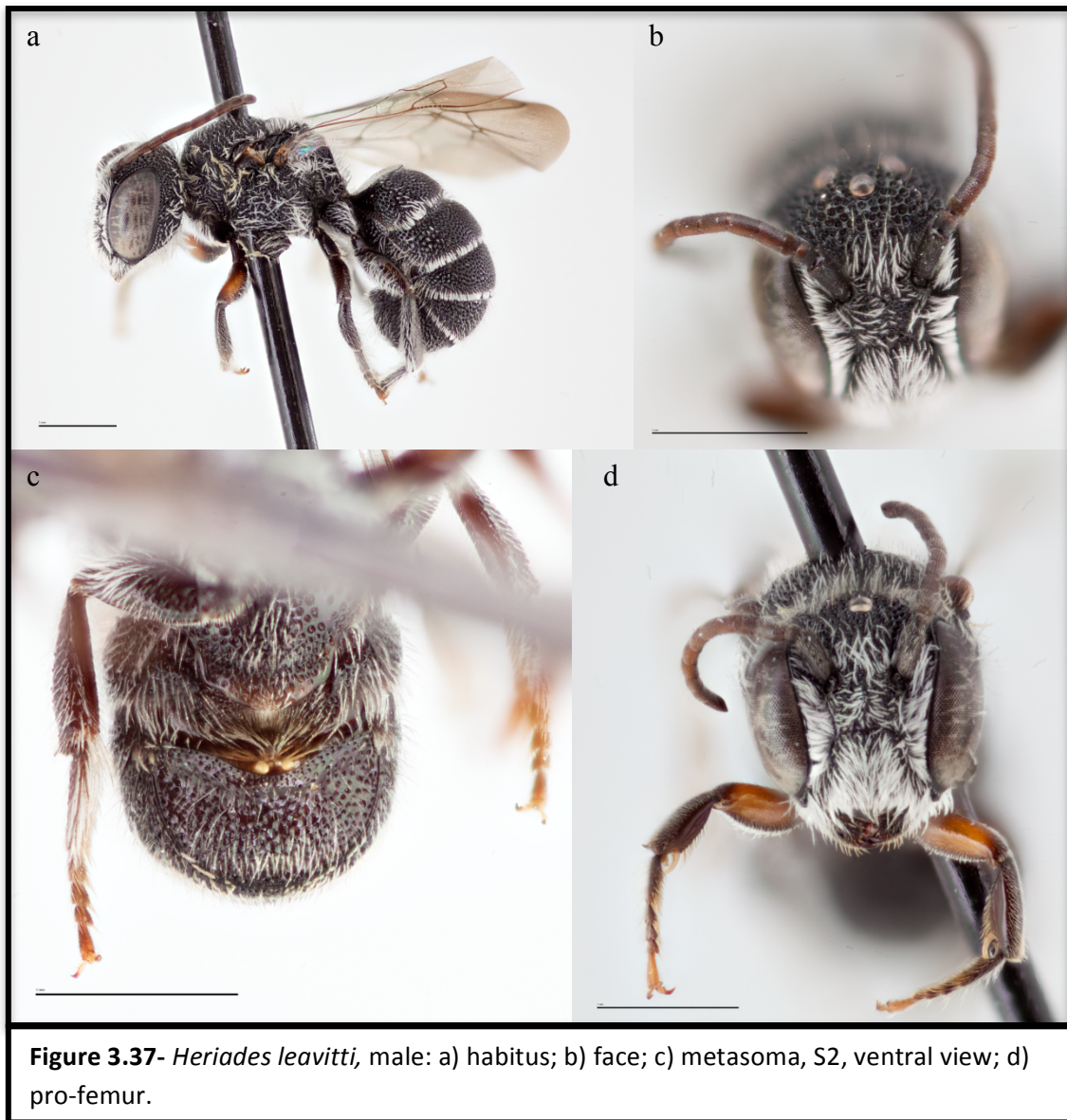


Figure 3.36- *Heriades leavitti*, female: a) habitus; b) mandible, anterior view; c) mandible, lateral view; d) face; e) metasoma, T6 and S6, pubescence.



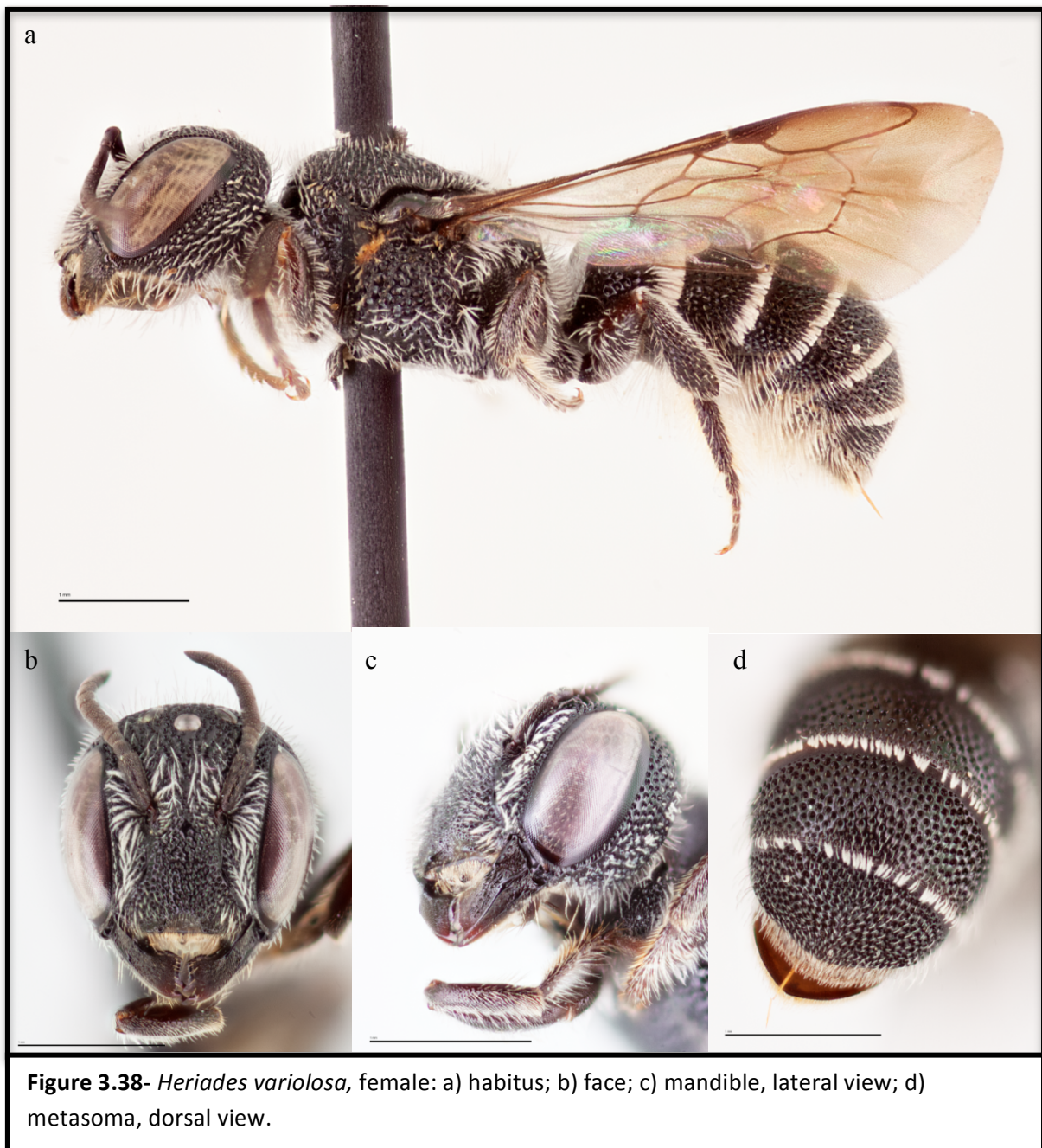




Figure 3.39- *Heriades variolosa*, male: a) habitus; b) head, antenna; c) metasoma, S2, lateroventral view; d) face; e) metasoma, ventral view.

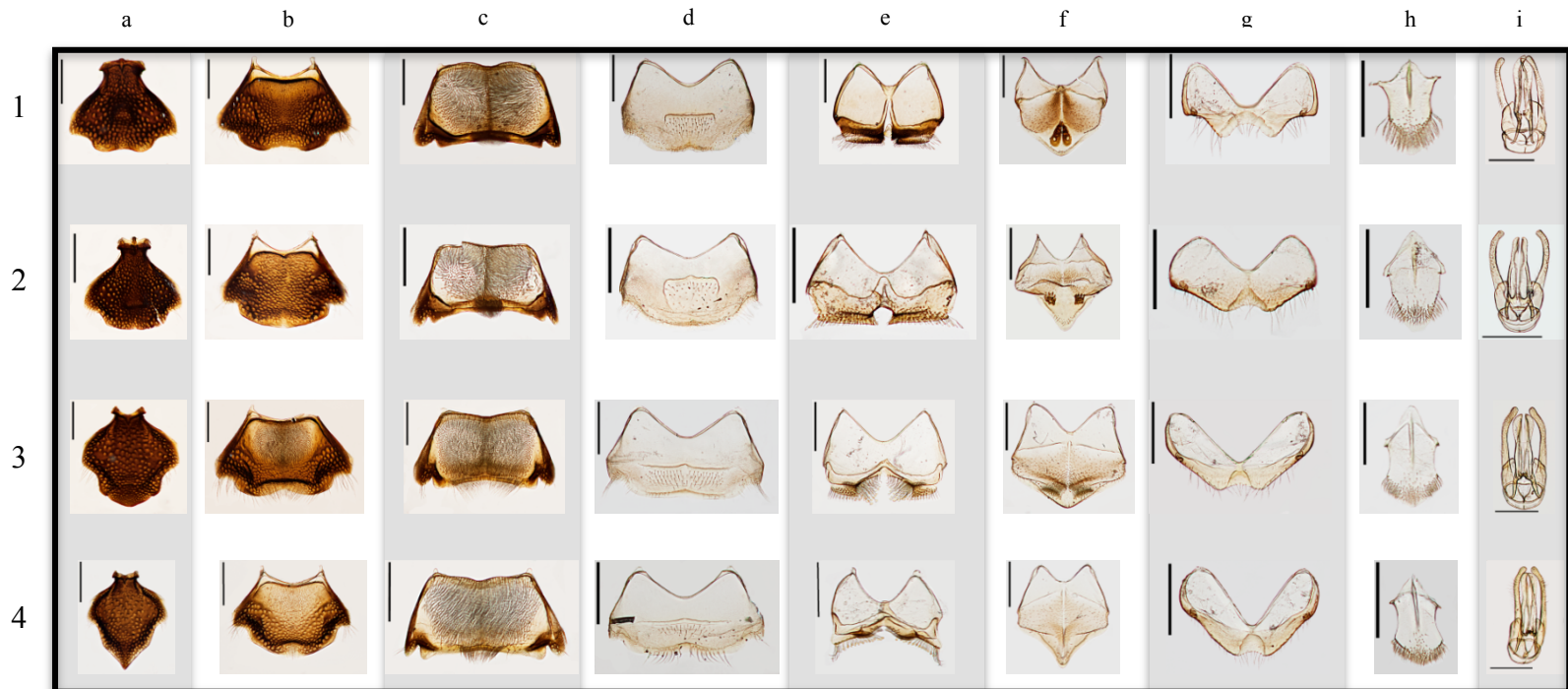
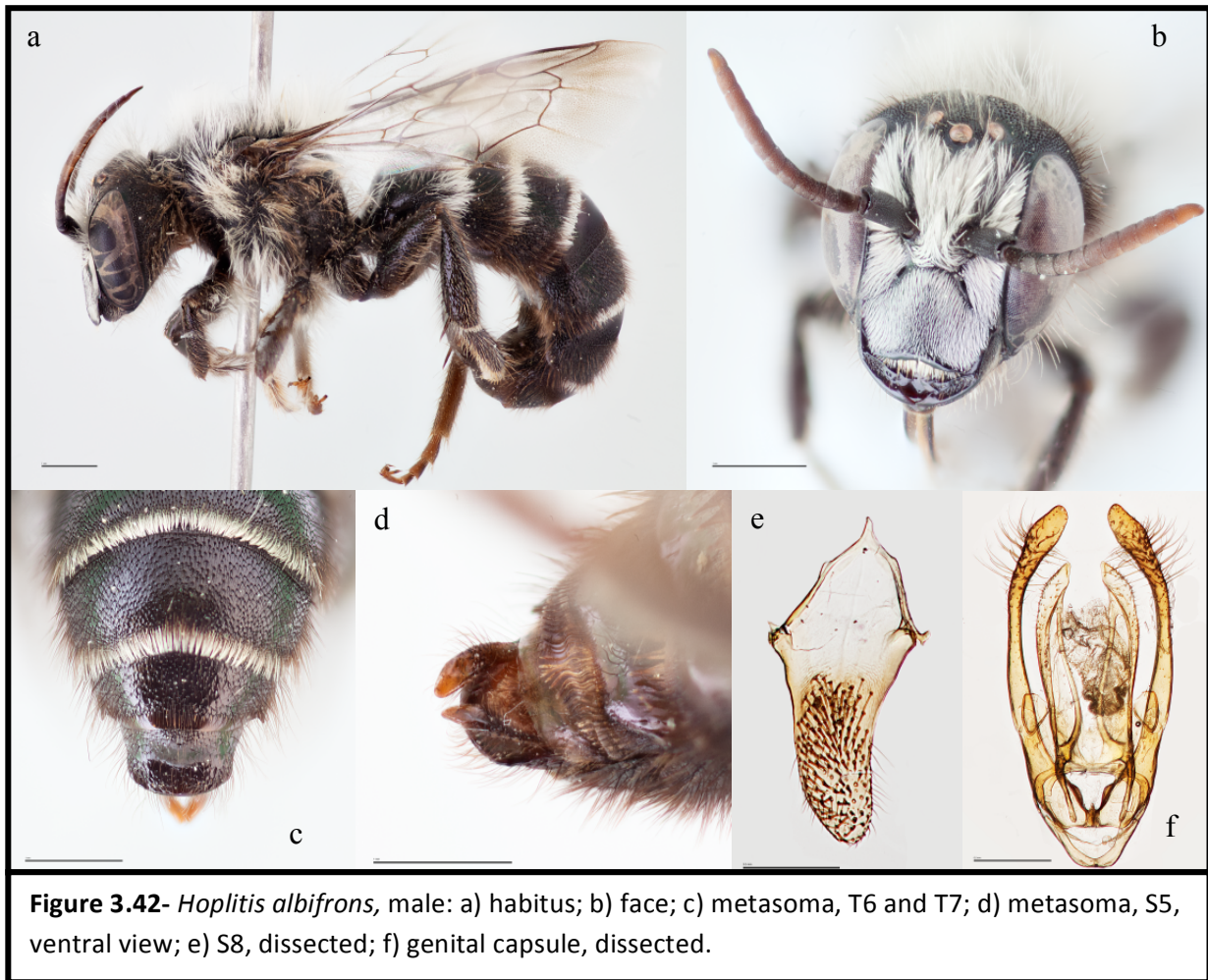
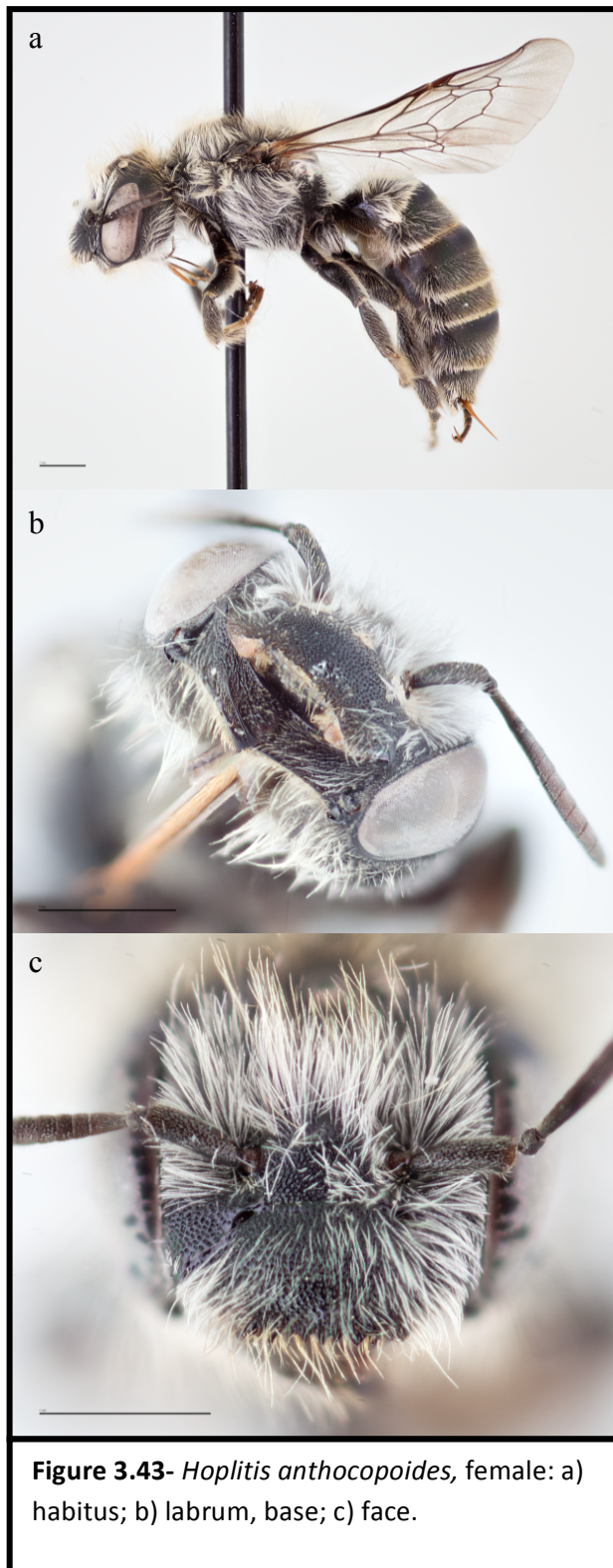


Figure 3.40- *Heriades* male, dissected sterna, S1 through S8 and genital capsule (column a-i, respectively): Row 1: *Heriades carinata*; Row 2: *Heriades cressoni*; Row 3: *Heriades leavitti*; Row 4: *Heriades variolosa*.







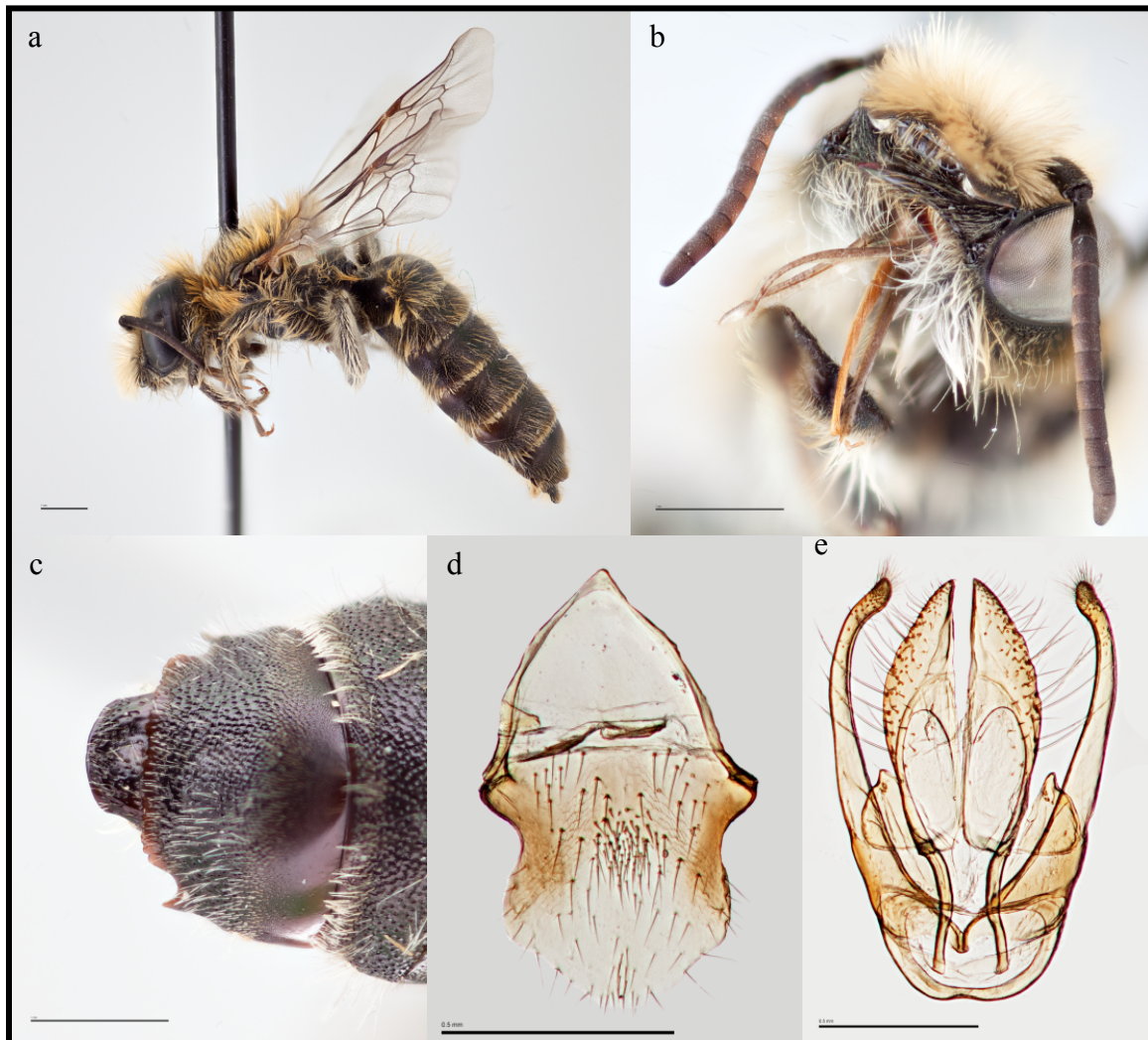


Figure 3.44- *Hoplitis anthocopoides*, male: a) habitus; b) labrum, base; c) metasoma, T6 and T7, dorsal view; d) S8, dissected; e) genital capsule, dissected.



Figure 3.45- *Hoplitis fulgida*, female: a) habitus; b) head, laterodorsal view; c) head, lateral view; d) mesosoma, dorsal view; e) metasoma, lateral view; f) forewing.

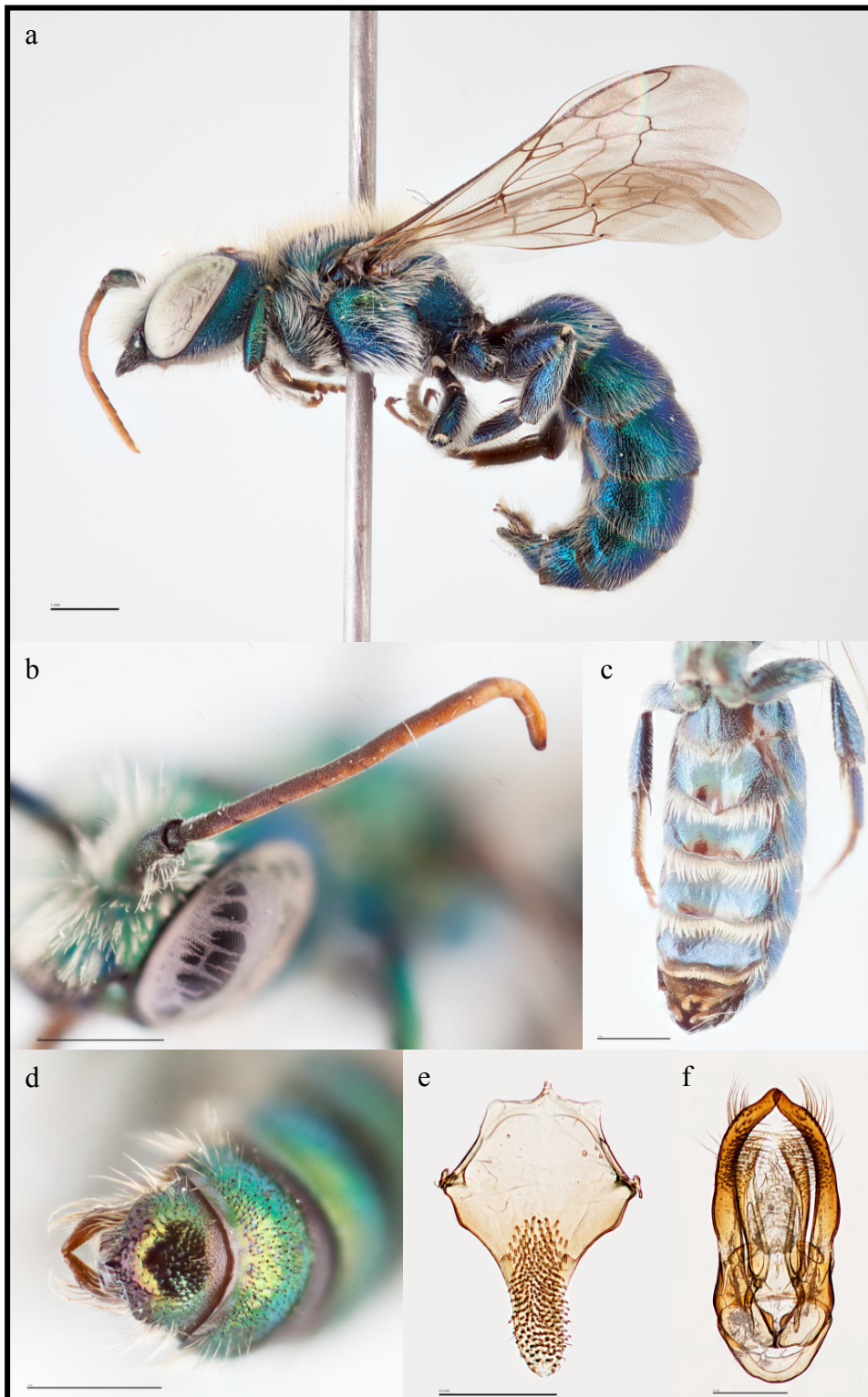


Figure 3.46- *Hoplitis fulgida*, male: a) habitus; b) antenna; c) metasoma, sterna, ventral view; d) metasoma, T7, dorsal view; e) S8, dissected; f) genital capsule, dissected.

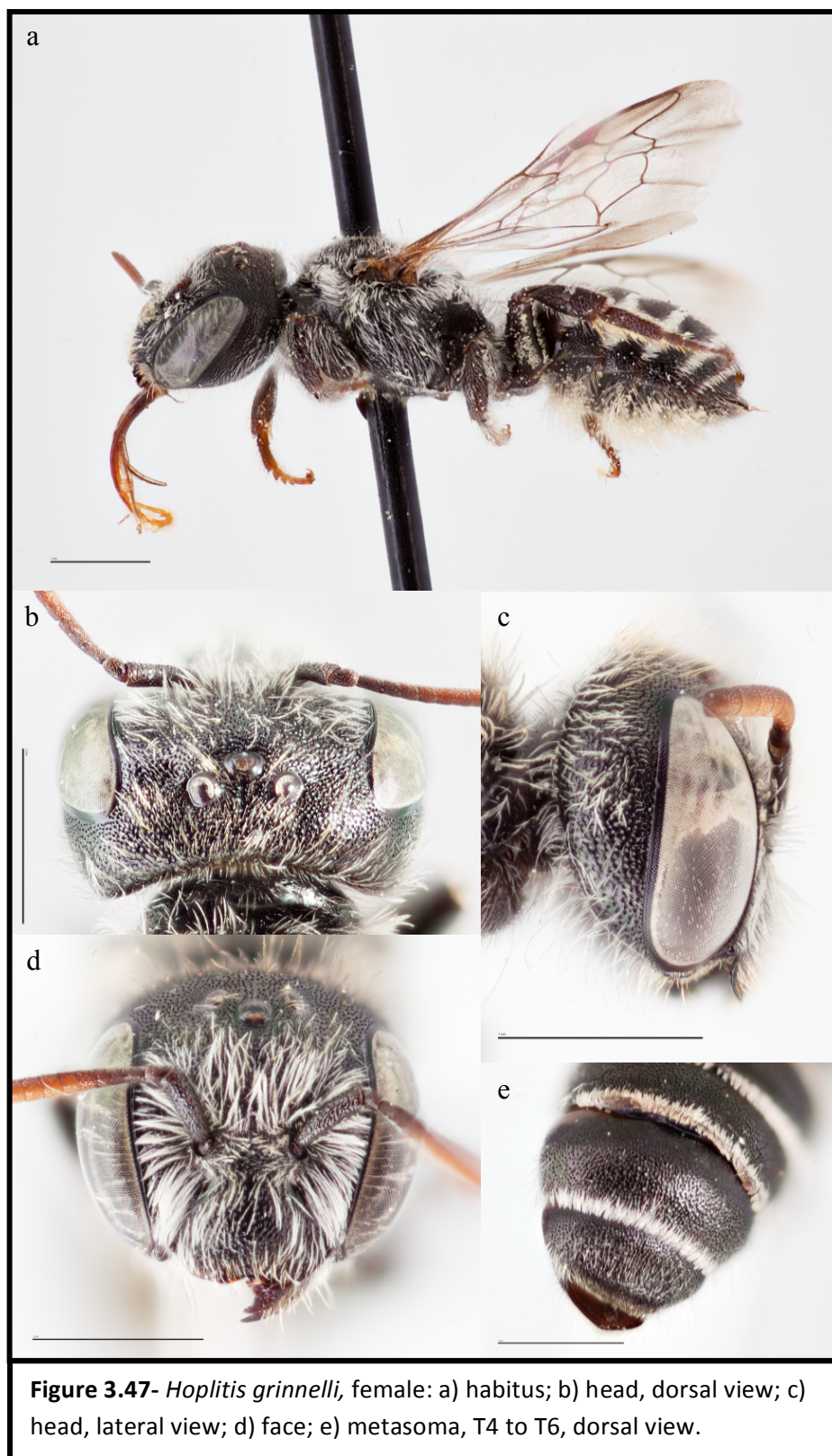


Figure 3.47- *Hoplitis grinnelli*, female: a) habitus; b) head, dorsal view; c) head, lateral view; d) face; e) metasoma, T4 to T6, dorsal view.

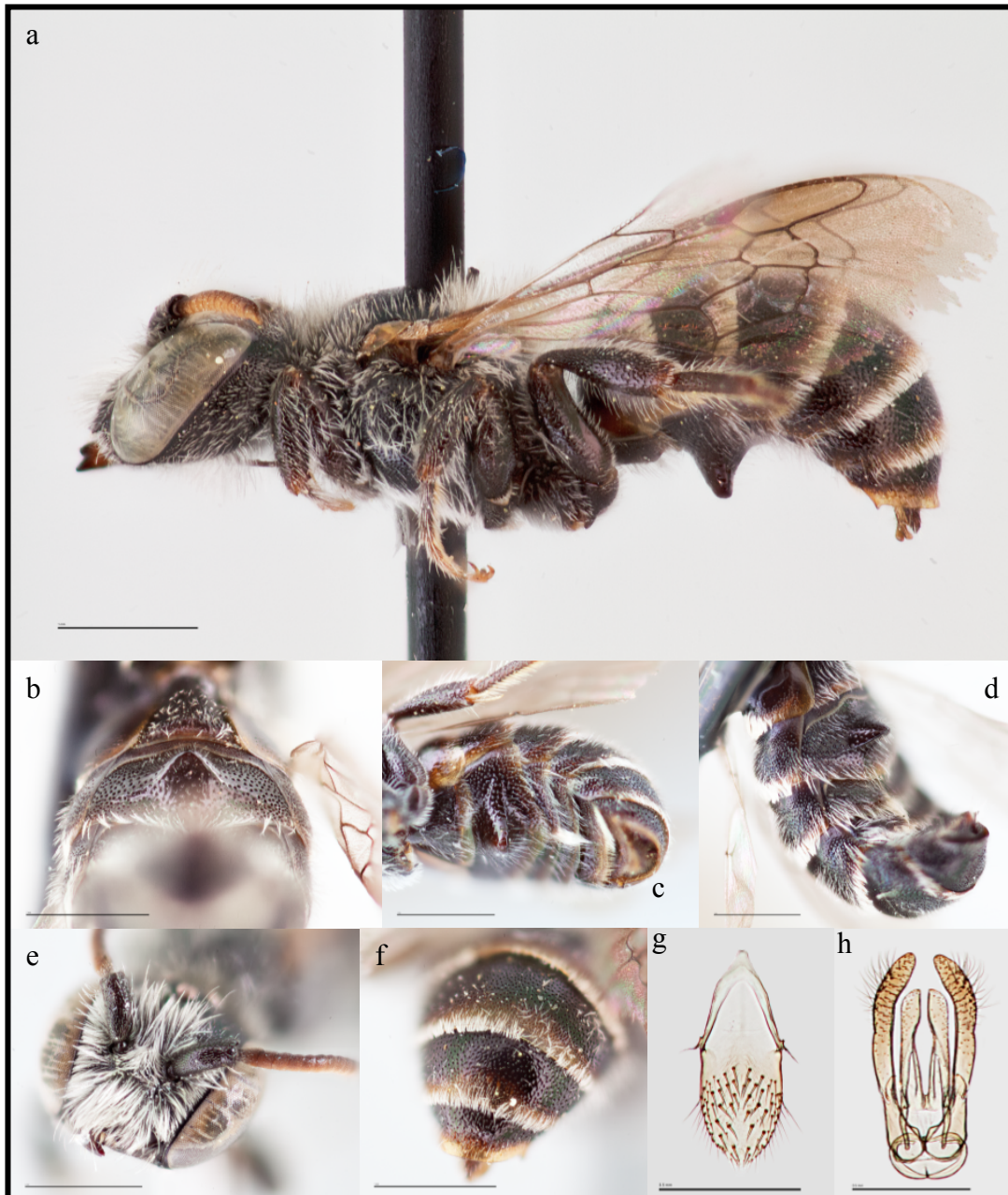


Figure 3.48- *Hoplitis grinnelli*, male: a) habitus; b) S2, posterior view; c) metasoma, sterna, ventral view; d) metasoma, sterna, vetrolateral view; e) face; f) metasoma, T4 to T7, dorsal view; g) S8, dissected; h) genital capsule, dissected.



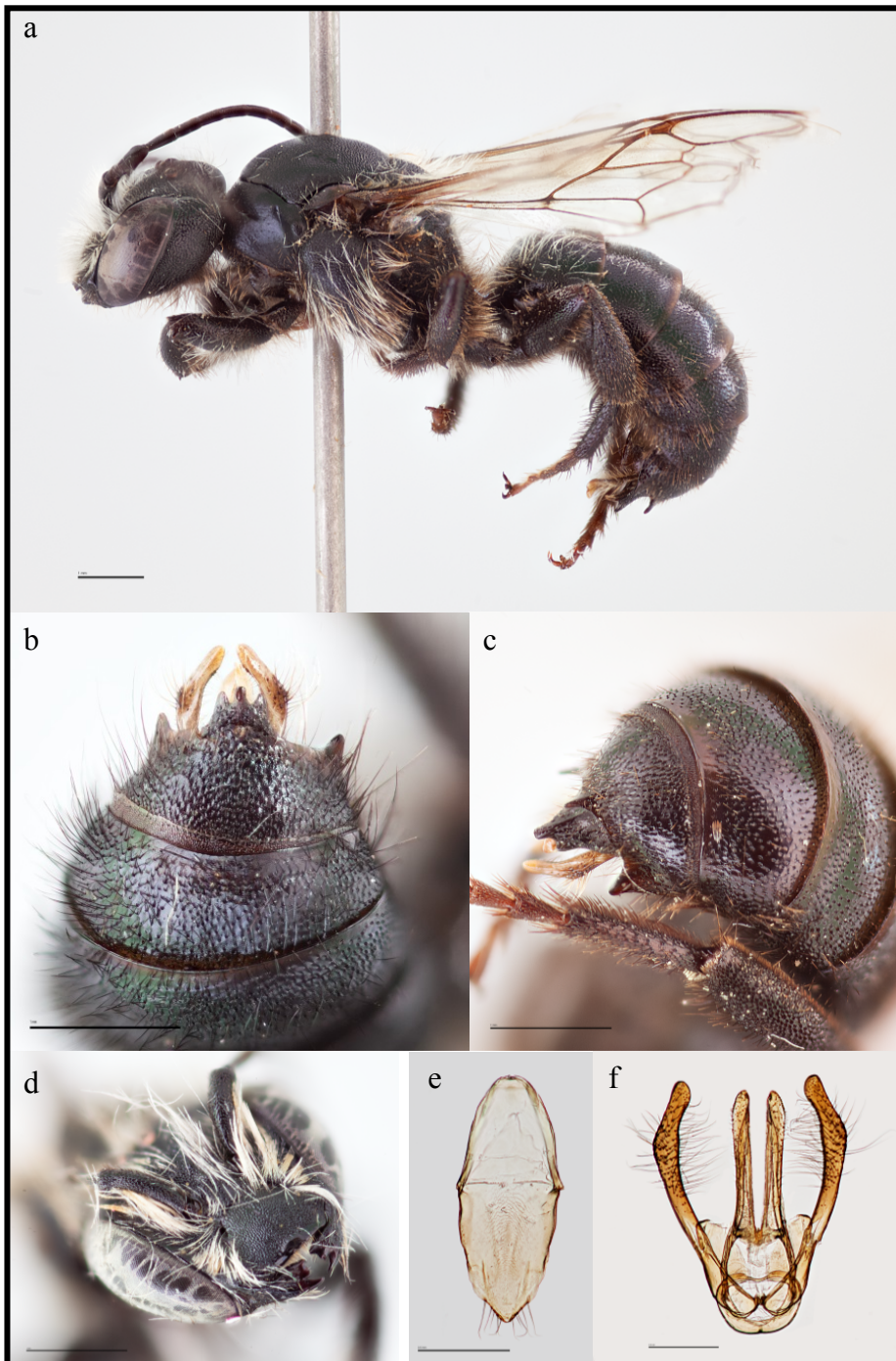


Figure 3.50- *Hoplitis hypocrita*, male: a) habitus; b) metasoma, T5 to T7, dorsal view; c) metasoma, T5 to T7, dorsolateral view; d) face; e) S8, dissected; f) genital capsule, dissected.

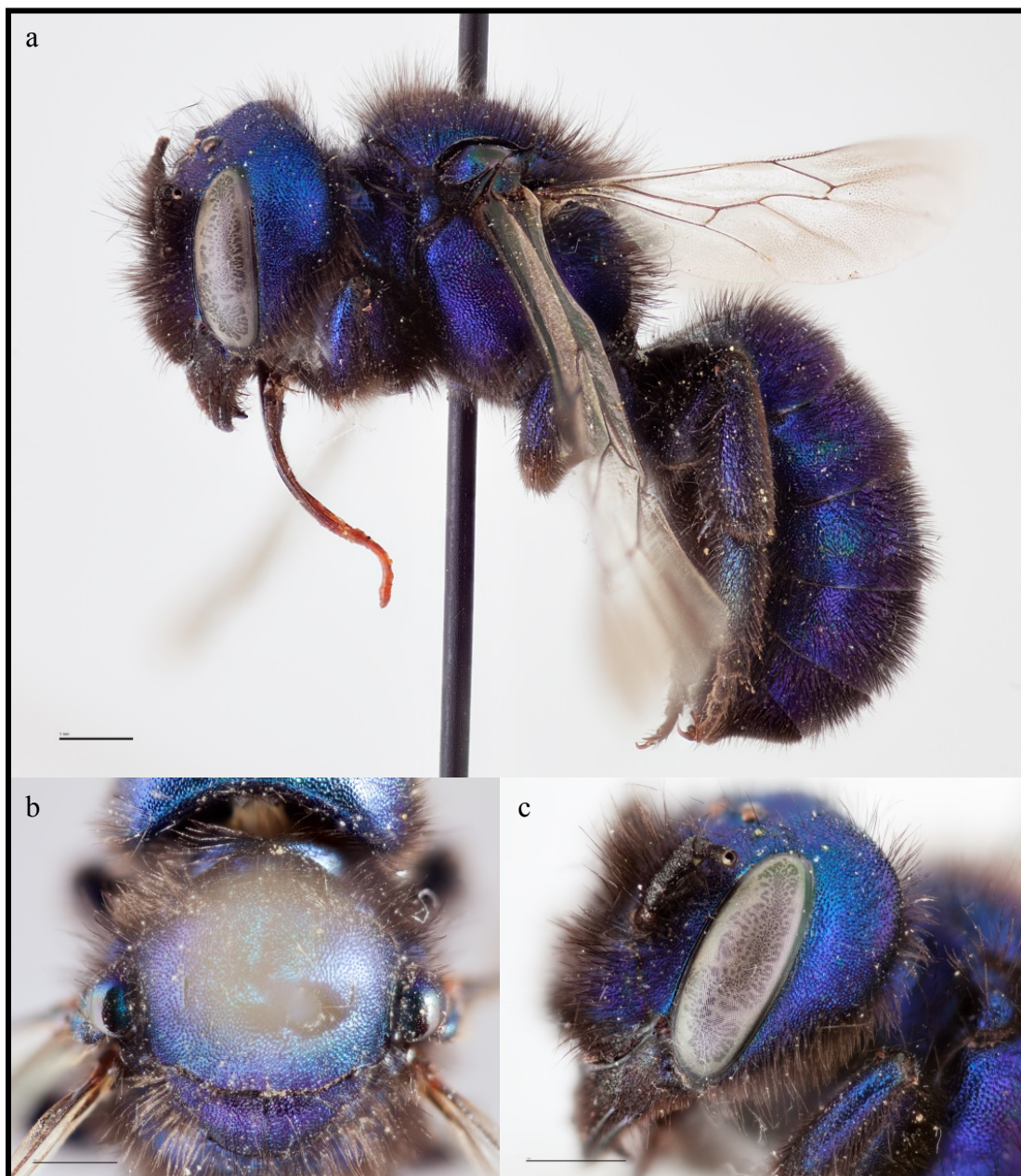


Figure 3.51- *Hoplitis louisae*, female: a) habitus; b) mesosoma, dorsal view; c) head, compound eye.

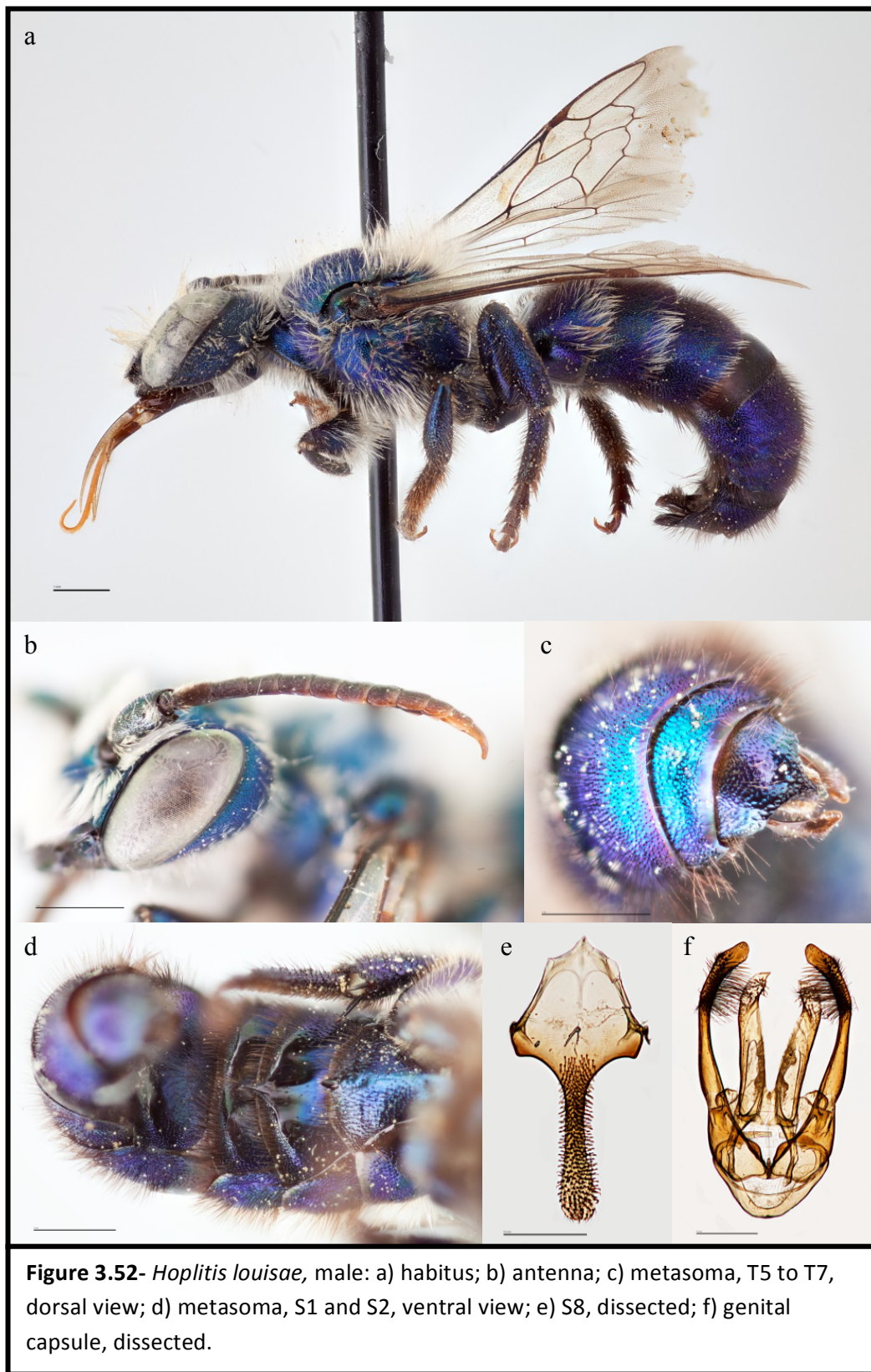


Figure 3.52- *Hoplitis louisae*, male: a) habitus; b) antenna; c) metasoma, T5 to T7, dorsal view; d) metasoma, S1 and S2, ventral view; e) S8, dissected; f) genital capsule, dissected.





Figure 3.54- *Hoplitis pilosifrons*, male: a) habitus; b) metasoma, S2, posterior view; c) metasoma, T5 to T7, dorsolateral view; d) metasoma, sterna, ventrolateral view; e) S8, dissected; f) genital capsule, dissected.



Figure 3.55- *Hoplitis producta*, female: a) habitus; b) face; c) propodeum; d) metasoma, T1 and T2, dorsal view; e) mesosoma, dorsal view.

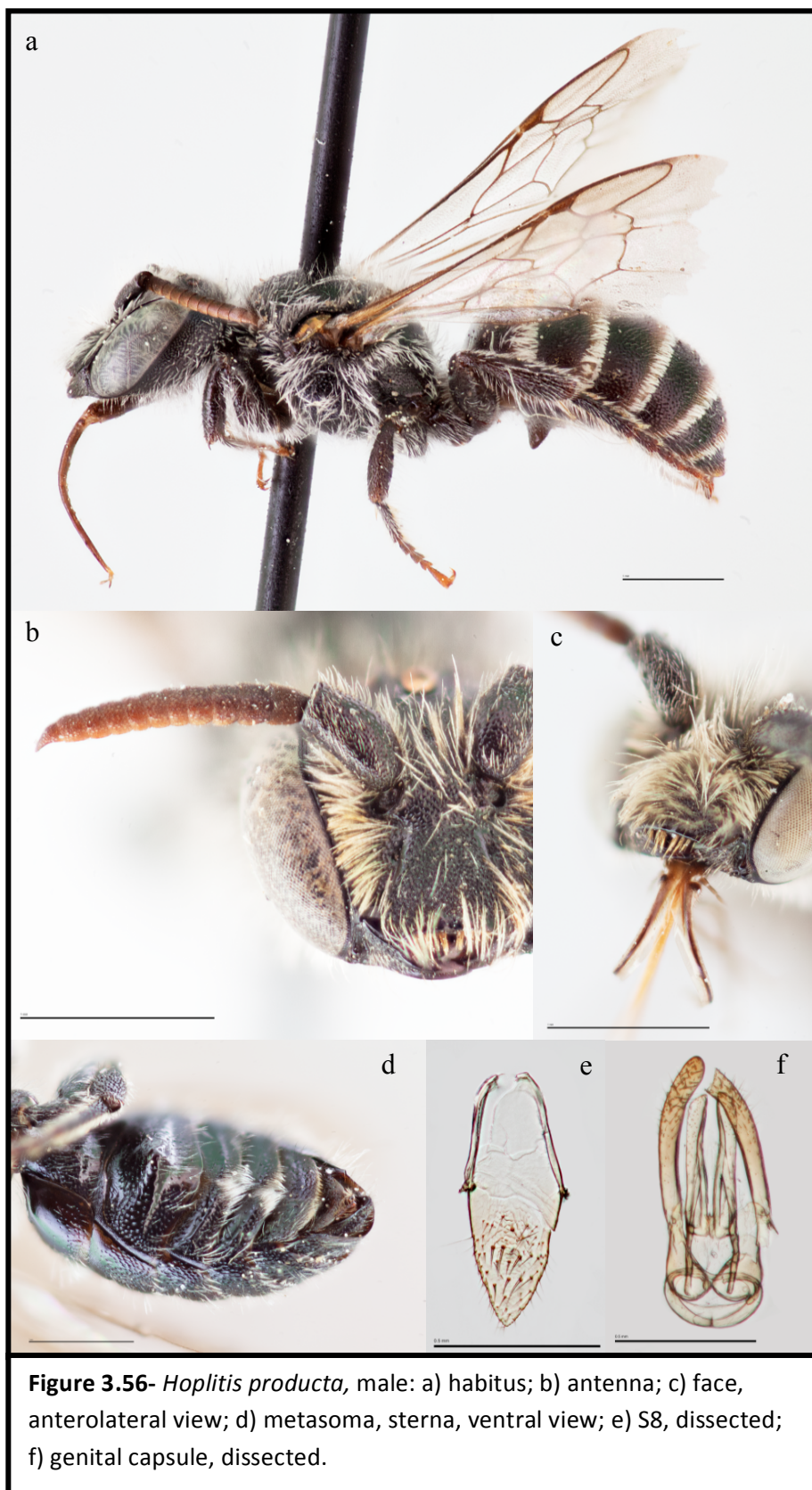




Figure 3.57- *Hoplitis robusta*, female: a) habitus; b) head, dorsal view; c) head, laterodorsal view.

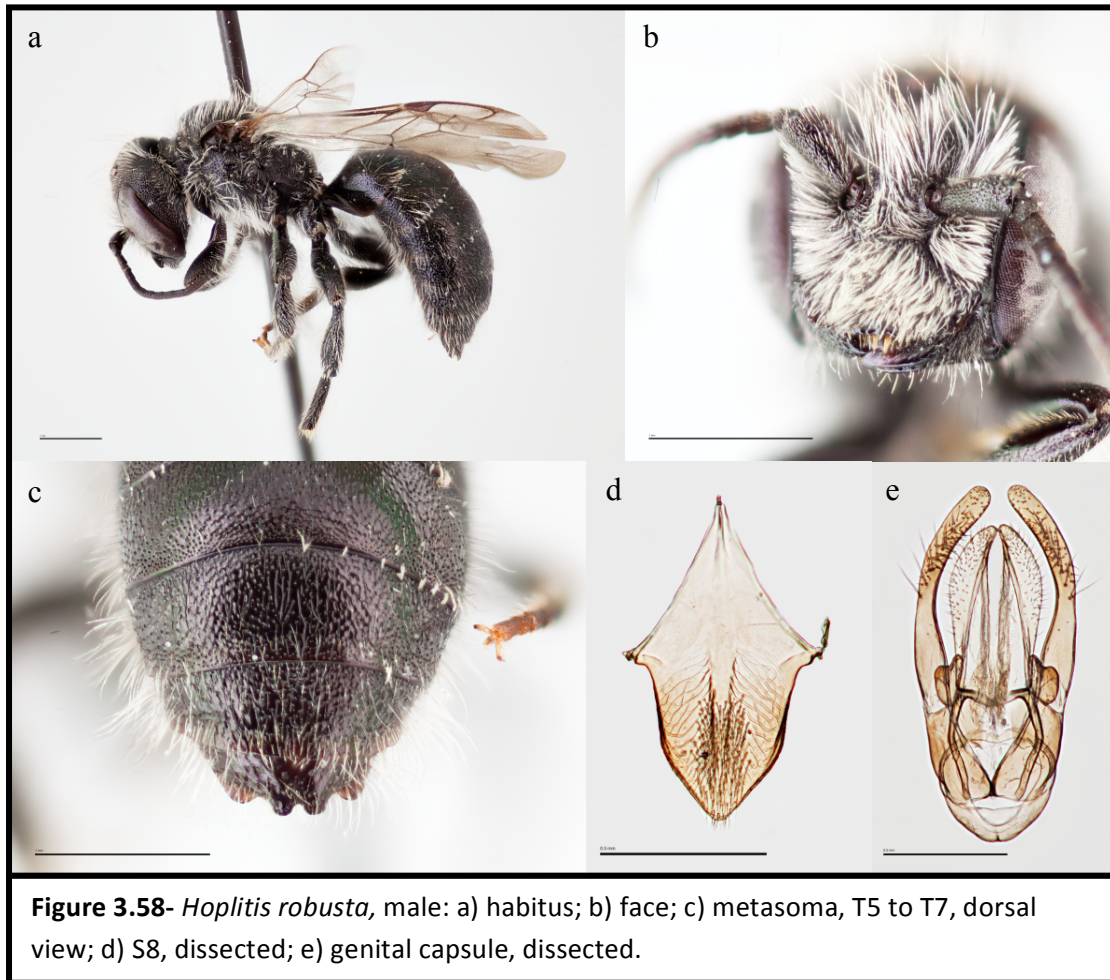


Figure 3.58- *Hoplitis robusta*, male: a) habitus; b) face; c) metasoma, T5 to T7, dorsal view; d) S8, dissected; e) genital capsule, dissected.



Figure 3.59- *Hoplitis sambuci*, female: a) habitus; b) head, anterior view; c) face; d) propodeum; e) metasoma, lateral view.



Figure 3.60- *Hoplitis sambuci*, male: a) habitus; b) metasoma, T5 to T7, dorsal view; c) mandible, anterior view; d) metasoma, S2 and S3, ventral view; e) S8, dissected; f) genital capsule, dissected.



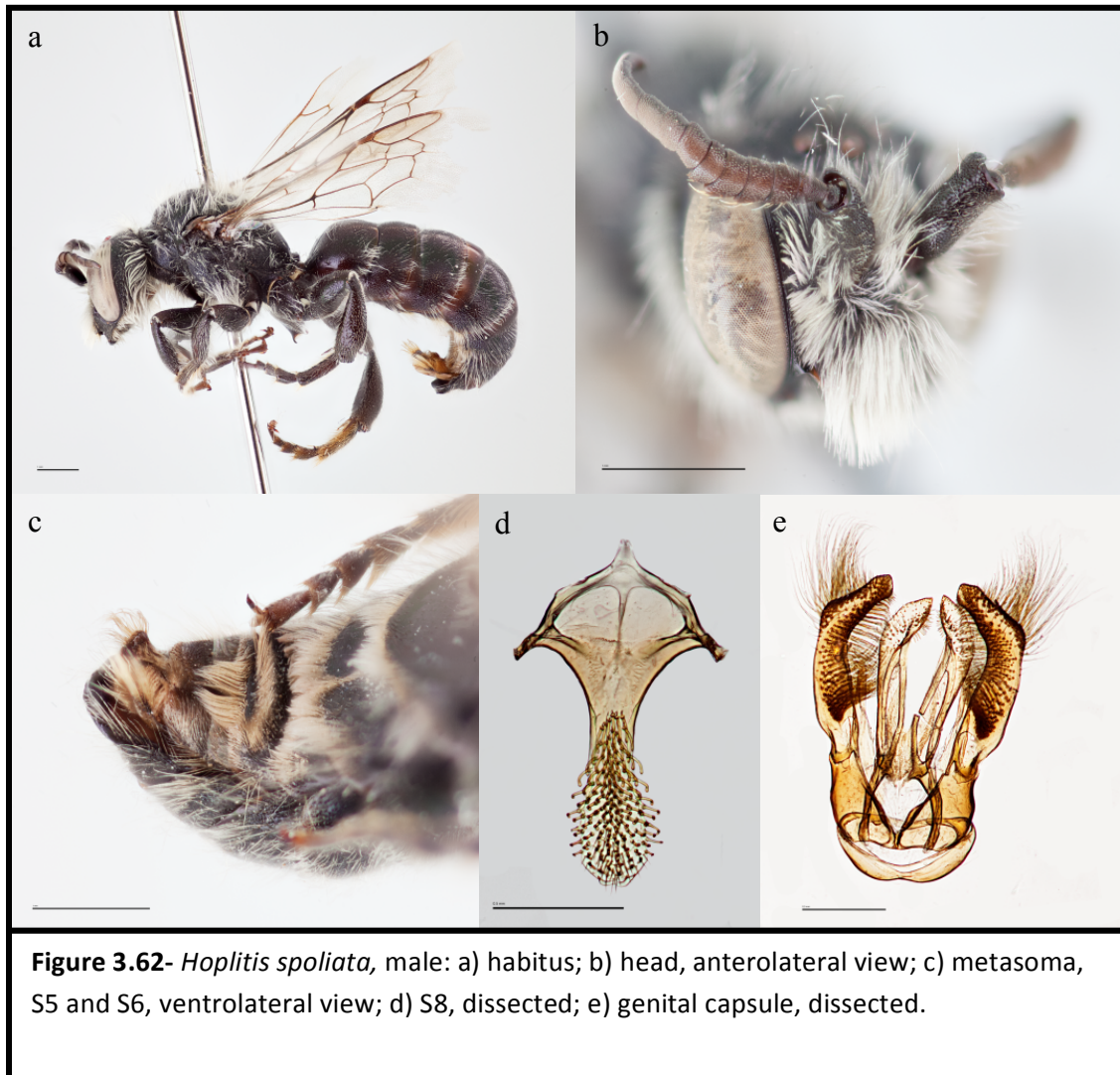




Figure 3.63- *Hoplitis truncata*, female: a) habitus; b) head, dorsolateral view; c) head, anterolateral view; d) face; e) propodeum; f) hind leg, tibial spurs; g) metasoma, dorsolateral view.

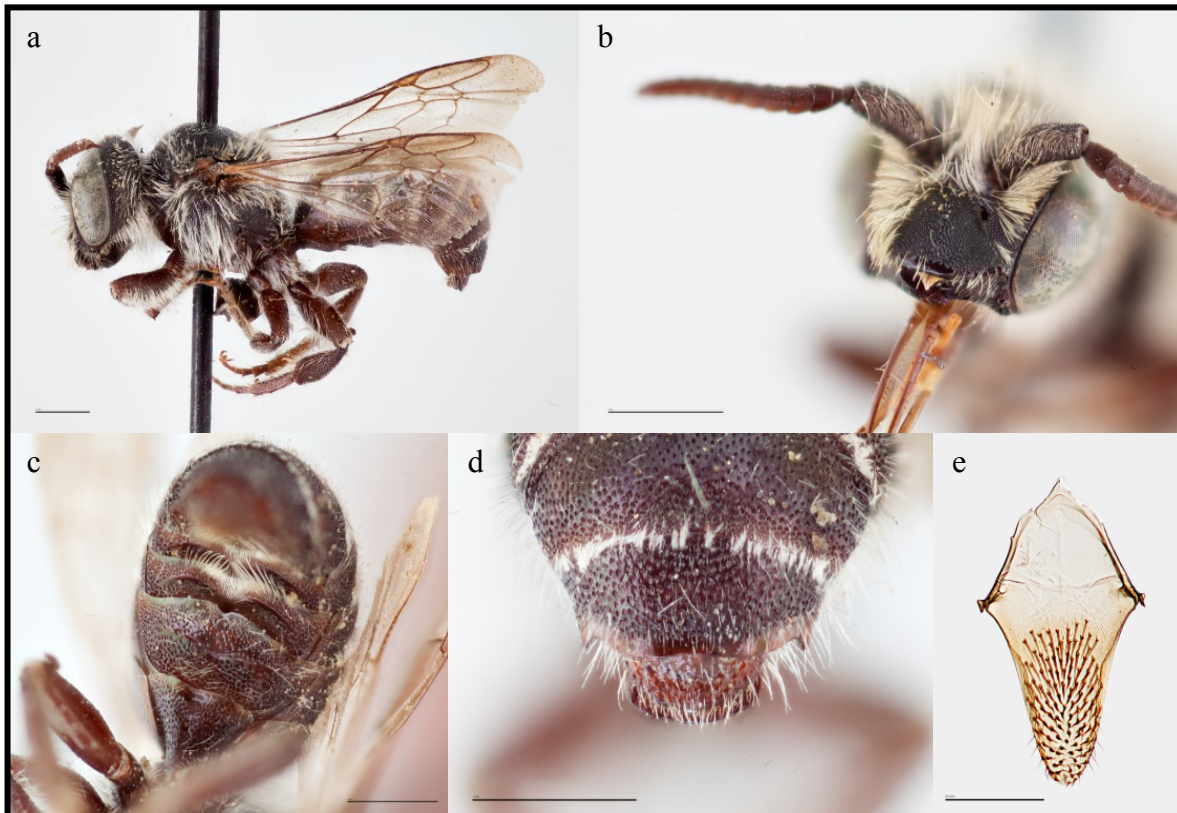


Figure 3.64- *Hoplitis truncata*, male: a) habitus; b) head, anterolateral view; c) metasoma, sterna, ventral view; d) metasoma, T6 and T7, dorsal view; e) S8, dissected. Material not available for genital capsule imaging.

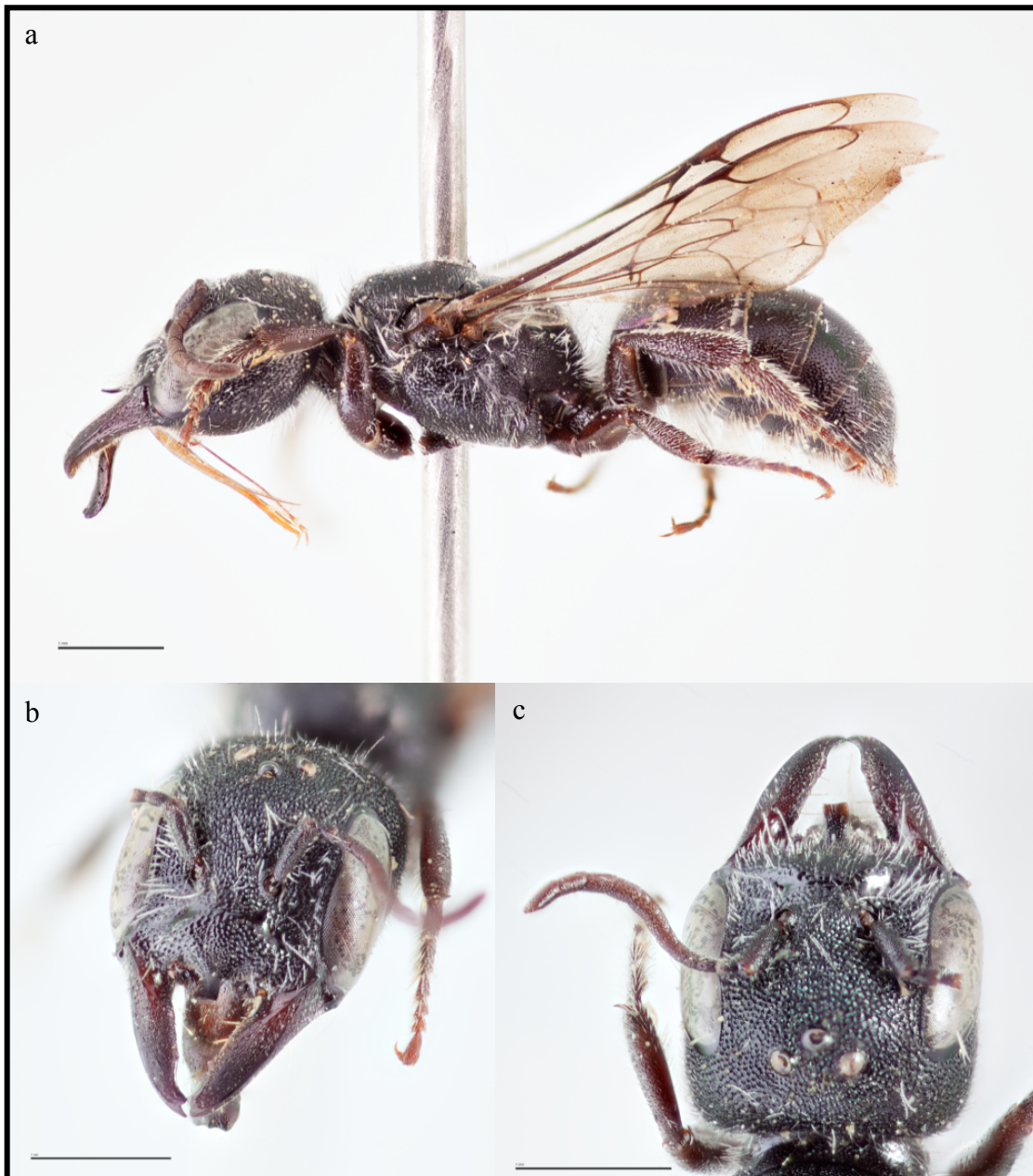


Figure 3.65- *Protosmia rubifloris*, female: a) habitus; b) face; c) head, dorsal view.

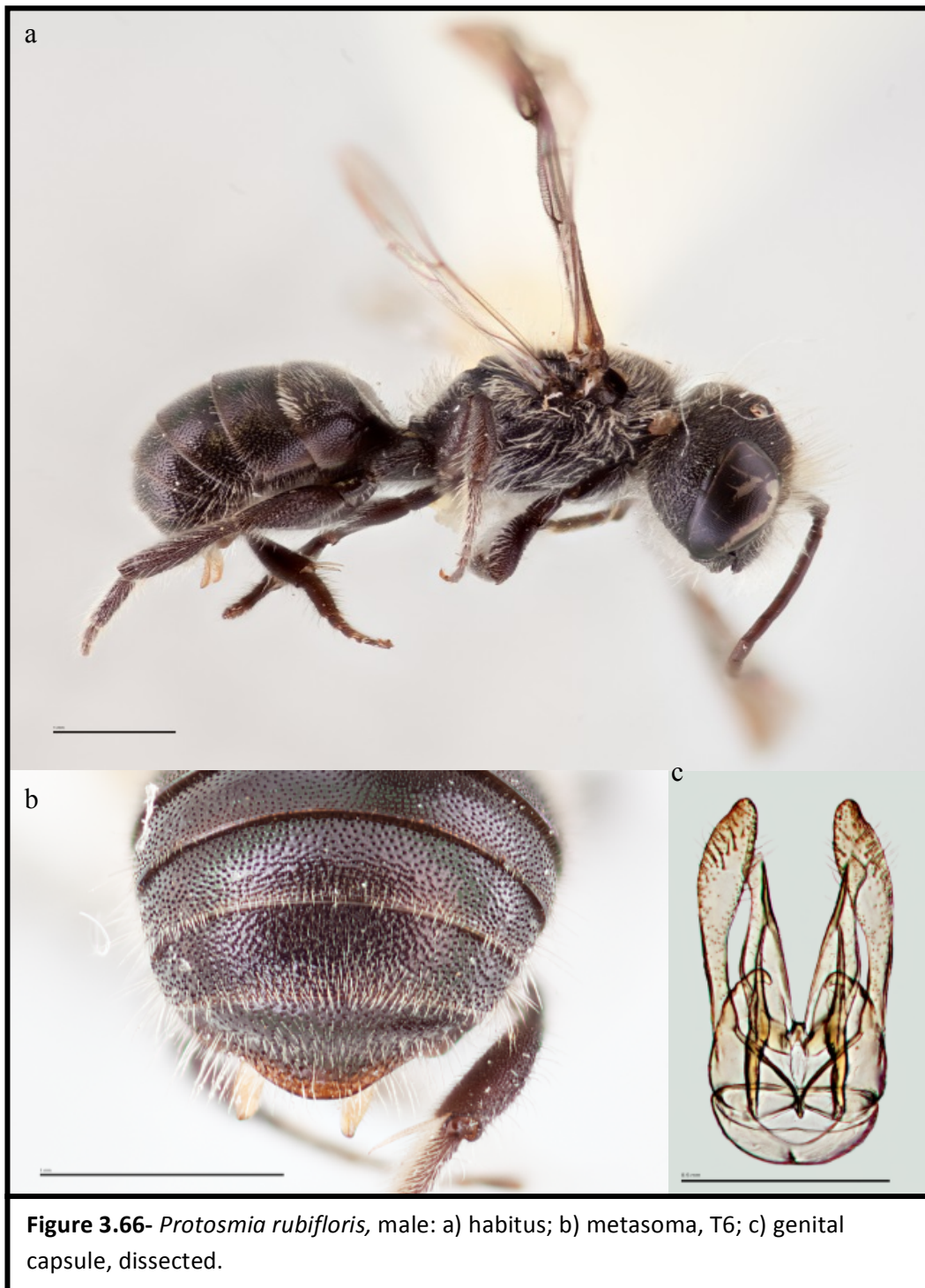




Figure 3.67- *Osmia* sp., female: mesoscutum, dorsolateral view.

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SUPPLEMENTARY MATERIAL: SPECIES DESCRIPTIONS

SM.1 *ASHMEADIELLA*

Ashmeadiella cactorum (Cockerell, 1897)

Heriades cactorum Cockerell, 1897, Ann. Mag. Nat. Hist., 6(20): 140.

Ashmeadiella curriei Titus, 1904, Ent. Soc. Wash., Proc., 6: 100.

Ashmeadiella echinocerei Cockerell, 1911a, Can. Entomol., 43: 132.

Ashmeadiella echinocacti Cockerell, 1931, Ann. Mag. Nat. Hist., 8(10): 543.

Ashmeadiella basalis nigra Michener, 1936c, Amer. Mus. Novitates, 875: 7.

Biology: *Ashmeadiella cactorum* is polylectic and has been recorded foraging on many plant families including Asteraceae, Cactaceae, Hydrophyllaceae and Scrophulariaceae (Wilson et al. 2010; Ascher & Pickering 2016). In Canada it is in flight late in the summer and has been collected from late June (30, Lumby, BC) to mid August (16, Savona, BC).

Diagnosis: The female of *A. cactorum* can be distinguished from all other Canadian *Ashmeadiella* by the punctured apical margin of the clypeus, the margin not shiny as in all other Canadian species. The male of *A. cactorum* is recognized by the combination of face not entirely covered in dense pubescence, scape not more than three times as long as wide, vertexal area short, shorter than frontal area, hardly longer than distance between lateral ocelli, T6 median teeth shorter than their basal width.

Ashmeadiella cactorum redescription

Figures: 3.2; 3.10; 3.11

Female (N=16): length 7mm (4.5 to 8mm); head width 1.5mm (1.5 to 2mm); ITW 1mm (1 to 1.5mm); forewing length 4mm (3 to 4mm).

Colouration: integument black, except as follows: flagellomeres brown, at least ventrally; cap of rutellum of mandible dark testaceous to piceous; wings hyaline; middle and hind legs sometimes dark testaceous to piceous, lightest in older specimens and in those collected in southern localities; tarsi and tarsal claw on all legs rufescent; metasoma with T1 and T2 reddened laterally in specimens collected in California.

Pubescence: hairs mostly white; head, mesosoma and metasoma with sparse, erect pubescence (1MOD), except as follows: paraocular area with dense, subappressed pubescence (1MOD); dorsal surface of pronotal collar and pronotal lobe with suberect pubescence ($<1.5\text{MOD}$); lateral surface of mesepisternum fringed with suberect pubescence at anterior and posterior margins ($<1.5\text{MOD}$); posterior margin of mesoscutellum fringed with long, erect hairs ($>2\text{MOD}$); dorsolateral angle of propodeum with dense, suberect pubescence ($<2\text{MOD}$); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1-T6, that of T5 inconspicuous or nearly absent ($\sim 1\text{MOD}$); sternal scopa suberect, straw-coloured, oriented posteroventrally, arising from the disc ($>2\text{MOD}$).

Surface sculpture: head, including mandible and antenna, punctures large and dense ($i=0.5d$), except as follows: mandible finely punctate ($i<0.25d$), except along carinae where it is impunctate; basal portion of clypeus with punctures large, becoming finer apically ($i<0.5d$); paraocular area narrowly impunctate posterior to antennal socket; mesosoma and metasoma with punctures large and dense ($i<0.5d$), except as follows: tegula finely punctured, the punctation not dense ($i<2d$); axilla more densely punctured ($i=1/3d$) than in mesoscutum and mesoscutellum; mesoscutum with finer, denser punctation ($i\sim 0.5d$) than those of mesoscutellum ($i<d$); punctation of metanotum obscure, roughened, somewhat dull; metapostnotum impunctate, shiny, except for narrow basal zone where it is roughened, dull; dorsolateral angle of propodeum with punctures large ($i\sim 0.5d$); metasoma evenly and moderately punctate ($i=0.5d$), except for the following: T1 anterior surface impunctate; T6 with punctation deeper than that of T1 to T5.

Structure: scape 3x as long as wide ($L:W=9:3$); pedicel longer than wide ($L:W=6:4$); head width and length roughly equal ($L:W=75:73$); mandible tridentate, the teeth sharp, well defined, distance from the tooth of the rutellum to the second tooth of the pollex half the greatest width of the compound eye ($9:18$); clypeus truncate, the apical margin between lateral angles of truncation concave; $IAD:AID=19:9$; frontal area with small tubercle at midpoint between

antennal sockets; supraantennal depression deep; IOC subequal OOC (11:12); IOC > OV (11:9); median ocellus posterior to midpoint between antennal socket and posterior margin of vertexal area (FAL:VAL= 21:16); compound eyes convergent below (UOD:LOD= 25:22); compound eye wider than genal area in lateral view (24:17); mesosoma hardly longer than wide (L:W= 76:72); wings with first recurrent vein meeting posterior margin of second submarginal cell such that the proximal portion of the posterior margin of the second submarginal cell is roughly a fifth its total length (5:28); metasoma longer than wide (L:W= 71:44).

Male (N=6): length (5 to 6mm); head width (1.5 to 1.75mm); ITW (1 to 1.25mm); forewing length (3 to 3.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: integument somewhat lighter than in female, dark brown to black, except as follows: T1 to T5 with apical impressed margin brown to golden; T6 with apical half of apical teeth brown.

Pubescence: integument sparsely pubescent (<1MOD), pubescence denser on the following: hypostomal area with dense, erect pubescence (1MOD); clypeus with subappressed pubescence laterally and at apical margin (1MOD); paraocular area with appressed pubescence (<1MOD); genal area with subappressed pubescence (1MOD); T5 not apically fasciate; S1 to S3 with apical fringe (1.5MOD), oriented posteriorly and arising submarginally; S4 with somewhat denser, suberect pubescence in disc (<1.5MOD).

Surfacesculpture: lower paraocular area with punctures finer punctation than those of basal zone of clypeus; tegula more sparsely punctate ($i > 3d$); metepisternum with punctures finer than those of mesepisternum, punctation as dense as mesepisternum ($i > 0.5d$); metapostnotum roughened more narrowly in basal zone than in female; T6 apical margin of teeth impunctate; S1 to S4 with narrow apical margin and pregradular area finely punctate ($i < d$).

Structure: head wider than long (L:W= 63:57); scape nearly 3x longer than wide (L:W= 20:7); ultimate flagellomere flattened ventrally, longer than wide (L:W= 8:5); mandible bidentate, distance from the tooth of the rutellum to the first tooth of the pollex less than a

quarter the greatest width of the compound eye (6:27); clypeus weakly truncate, the lateral margins of clypeal truncation feebly convex, lateral angles of clypeal truncation broadly rounded, not well defined, the margin between lateral angles of truncation sinuate, produced to an angulate projection on either side of the longitudinal midline, the margin between projections concave; frontal area with two tubercles, vertically stacked with about two tubercle diameters between them, the anterior tubercle centred between antennal sockets; IOC=OOC; IOC > OV (10:8); median ocellus behind midpoint between posterior margin of antennal socket and posterior margin of vertexal area such that vertexal area is $\frac{3}{4}$ the length of the frontal area (FAL:VAL= 15:20); IAD:AID= 12:5; compound eye 2x wider than genal area in lateral view (22:11); T1 anterior surface deep; gradular furrow of at least T1 to T3 deepened; T6 quadridentate, median teeth about as long as their basal widths and with the lateral margins evenly tapered to a rounded apex, lateral teeth about $\frac{1}{2}$ the length of the median teeth, the apices rounded; S5 to S8 retracted.

Genitalia: as in Fig. 3.11h.

Distribution: *A. cactorum* is primarily a western species and is most abundant in the more arid parts of North America. It has been collected west of the Great Plains from southern Saskatchewan south through South Dakota, Colorado and Texas, throughout most of Mexico, and west to the Pacific coast (Fig. 3.2b). [CAN: AB, SK; USA: AR, AZ, CA, CO, GA, ID, IL, IN, KS, MI, MO, MT, NC, ND, NE, NM, NV, OR, SD, TX, UT, WA, WI, WY; MEX: CA, DU, HI, MX, PU, QE, SL, SO.]

Specimens examined: CAN: **British Columbia:** *Okanagan-Similkameen Reg. Dist.:* 2 ♀ Camp McKinney Rd., Sandy Cut, 01.viii.2009 (LR Best) [Barcoded]; ♂ Summerland, Garnet Lk., 17.viii.2008 (LR Best) [Barcoded]; ♀ *North Okanagan Reg. Dist.*, Lumby, Twin Crks., 30.vi.2008 (LR Best) [Barcoded]; *Thompson-Nicola Reg. Dist.:* ♀ Savona, 16.viii.2008 (LR Best) [Barcoded]; ♀ Cherryville, Monashee P.P., Little Peter Lk., 20.vii.2008 (LR Best) [Barcoded]; USA: **Arizona:** ♀ White Mountains, 19.vi.1950 (LD Beamer); ♀ Carrizo Cr., 16.vi.1950 (RH Beamer); USA: **California:** ♂ *Riverside Co.*, Alpine Village, 04.vi.2002, (ME Irwin) [Barcoded]; ♀ *San Diego Co.*, Pine Valley, 30-31.v.2002 (FD Parker & ME Irwin) [Barcoded]; ♀ *San Bernardino Co.*, Sheep Creek, 18-21.viii.2011 (ME Irwin) [Barcoded]; ♀ *Kern Co.*,

Canebrake Creek, 15-30.vii.2010 (ME Irwin) [Barcoded]; ♂ *Tuolumne Co.*, 10.vii.1953 (JG Rozen); **USA: Nevada:** ♀ *Clark Co.*, Meadow Valley Wash, 07.v.2004 (S Higbee) [Barcoded]; **USA: New Mexico:** ♀ Hidalgo Peloncillo Mountains, Skeleton Canyon, 01-08.v.2004 (FD Parker & ME Irwin) [Barcoded]; **USA: South Dakota:** ♂ *Jackson Co.*, 29.vii.2010 (Iberte & Stillson) [Barcoded]; **USA: Texas:** ♀ *Brewster Co.*, Big Bend National Park, 01.ix.1999 (SE Wallace) [Barcoded]; **USA: Utah:** ♀ *Garfield Co.*, Henry Mountains, Pearl Flat, 30.vii.2008 (TL Griswold) [Barcoded]; ♂ *Kane Co.*, Lick Wash, 05.viii.2003 (S Higbee) [Barcoded]; **MEX: Coahuila:** ♀ nr. Dolores, 30.iii.1992 (R Brooks); **MEX: Durango:** ♂ San Bernardo, 29.vi.1935 (unk. collector).

Type depository: Female, from Santa Fe, New Mexico, USA; lectotype in the US National Museum [Examined].

***Ashmeadiella californica* (Ashmead, 1897)**

Chalicodoma californica Ashmead, 1897, Proc. South. Calif. Acad. Sci., 1(3): 1.

Ashmeadiella californica Cockerell, 1903b, Psyche, 10: 76.

Ashmeadiella coquilletti Titus, 1904, Ent. Soc. Wash. Proc., 6: 99.

Ashmeadiella crassa Cockerell, 1925, Proc. Calif. Acad. Sci., 4(14): 207. [Misidentification]

Ashmeadiella californica, Michener, 1939, Amer. Midland. Nat., 22: 48-52.

Biology: *A. californica* is polylectic and has been recorded foraging from many plant families including Asteraceae, Boraginaceae and Fabaceae (Ascher & Pickering 2016). In Canada, *A. californica* seems to have a short flight period through the months of July (9, Cranbrook, BC) and August (16, Kamloops, BC).

Diagnosis: The female of *A. californica* can be recognized by the combination of mandible tridentate, vertexal area long, distance from posterior margin of lateral ocellus to posterior margin of vertexal area at least 1.5x distance between lateral ocelli, genal area at least as wide as compound eye in lateral view, but not longer than frontal area, punctuation of supraclypeal area not especially sparse, at least as dense as in basal area of clypeus, apical margin of clypeus feebly concave between lateral angles of truncation. The male of *A. californica* can be

recognized by the apical margin of T6, median teeth longer than basal breadth and median teeth nearer to lateral teeth than to one another.

Ashmeadiella californica **redescription**

Figures: 3.2; 3.12; 3.13

Female (N=6): length 7mm (6 to 9mm); head width 2.5mm (2 to 3mm); ITW 1.5mm (1 to 2mm); forewing length 4mm (4 to 5mm).

Colouration: integument black, except as follows: flagellomeres brown, at least ventrally; mandible mostly testaceous to piceous, especially cap of rutellum; tegula dark amber to ferruginous; wings hyaline, faintly infuscated along costal margin; all legs brown to dark brown.

Pubescence: hairs white to light ochraceous; head, mesosoma and metasoma with sparse, erect pubescence ($<1\text{MOD}$), except as follows: hypostomal area with suberect pubescence (1.5MOD); clypeus with suberect pubescence laterally (1MOD); appressed pubescence in paraocular area (1MOD); frontal area and supraantennal area with suberect hairs (1.5MOD); subappressed pubescence dense in dorsal surface of pronotal collar and in pronotal lobe ($<1.5\text{MOD}$); lateral surface of mesepisternum fringed with suberect pubescence at anterior and posterior margins ($<1.5\text{MOD}$); posterior margin of mesoscutellum fringed with long, erect pubescence ($>2\text{MOD}$); dorsolateral angle of propodeum with erect pubescence (1.5MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1-T6 (1.5MOD), usually medially effaced on T1; sternal scopa suberect, straw-coloured, oriented posteroventrally, arising from the disc ($>2\text{MOD}$).

Surface sculpture: head, including mandible and antenna, with punctures large and dense punctate ($i < 0.5d$), except as follows: mandible finely and unevenly punctate ($i < d$), except along carinae where it is impunctate; hypostomal area and genal area less densely punctured ($i < d$); clypeus with a narrow, impunctate apical margin between lateral angles of truncation; mesosoma with punctures large and dense ($i < 0.5d$), except as follows: tegula sparsely punctured ($i < 2.5d$); punctation of mesepisternum not dense ($i < d$); axilla and posterior margin of mesoscutellum densely punctate ($i = 1/3d$); metepisternum finely and shallowly punctate ($i < 0.5d$); metapostnotum scrobiculate in narrow basal zone, the pits vertically elongate, separated by weak

carinae, otherwise impunctate; propodeum with punctures of dorsal declivous surface large and dense ($i=0.25d$); metasoma finely and less densely punctate ($i<d$), except as follows: T1 anterior surface impunctate; T5 with denser punctation ($i<0.5d$); T6 with deeper punctures ($i<d$); S6 with punctures in disc larger than rest of segment, though similarly spaced ($i<0.5d$).

Structure: head hardly wider than long (L:W= 60:63); scape 3x as long as wide (L:W= 12:4); pedicel longer than wide (L:W= 10:6); mandible tridentate, the teeth sharp, well defined, distance from the tooth of the rutellum to the second tooth of the pollex nearly one third the greatest width of the compound eye (19:31); clypeus truncate, apical margin of clypeal truncation weakly concave between well defined lateral angles of truncation; IAD:AID=15:7; compound eyes convergent below (UOD:LOD=73:83); supraantennal depression shallow; IOC = OOC; IOC < OV (10:13); median ocellus at midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL = VAL); width of genal area subequal width of compound eye in lateral view (18:19); mesosoma wider than long (L:W= 56:62); wings with first recurrent vein meeting posterior margin of second submarginal cell such that the proximal portion of the posterior margin of the second submarginal cell is equal to, or greater than a third its total length (6:21); metasoma longer than wide (L:W= 86:60).

Male (N= 4): length (5 to 6mm); head width (1.5 to 2mm); ITW (1 to 1.25mm); forewing length (3 to 4mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: scape and flagellomeres lighter than in female, brown to ferruginous; mandible more conspicuously reddened; tegula ferruginous; all legs testaceous, tarsi and tarsal claw of all legs rufescent; T1 to T5 with apical impressed margin brown; T6 with apical half of median apical teeth brown.

Pubescence: pubescence denser than that of female, especially dense on the following, or different from female as follows: T6 not apically fasciate; S1 with dense, suberect pubescence in disc (~1MOD); S2 and S3 submarginally fringed, pubescence oriented posteriorly (~2MOD); S4

with denser, cinereous pubescence arising from premarginal line and in middle $\frac{1}{4}$ of marginal area, oriented posteromedially into a subtuft formation (2MOD).

Surface sculpture: head, including mandible and antenna, and mesosoma with punctures large ($i < 0.5d$), except as follows: punctation becoming increasingly finer from frontal area to apical margin of clypeus where it is very finely punctate ($i < 0.25d$) before a narrow, impunctate apical margin that is broadest laterally; genal area with finer, sparser punctation ($i < d$); punctures of mesoscutellum and axilla deeper, as dense; metanotum with denser punctation ($i < \frac{1}{3}d$); metapostnotum not scrobiculate in horizontal basal zone, impunctate; propodeum with punctures of dorsal declivous surface shallow, about as dense as rest of mesosoma ($i \sim 0.5d$); metasoma more finely and less densely punctate ($i = d$), except as follows: denser punctation on T5 and T6 ($i = 0.5d$); sterna with large punctation in disc, largest at submarginal line, and fine punctation in marginal zone ($i < 0.5d$).

Structure: head wider than long ($L:W = 59:67$); scape more than 2x as long as wide ($L:W = 12:5$); mandible bidentate, distance from the tooth of the rutellum to the first tooth of the pollex nearly $\frac{1}{4}$ the greatest width of the compound eye ($6:25$); $IAD:AID = 12:7$; compound eye 2x wider than genal area in lateral view ($25:12$); IOC hardly greater than OOC ($10:9$); $IOC < OV$ ($10:13$); median ocellus anterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 17:15$); lateral teeth of T6 acutely pointed, median teeth of T6 distinctly longer than their basal width, parallel-sided, truncate at the apex and nearer to the lateral teeth than to each other; concavity between lateral and median tooth of T6 wider, shallower, than concavity between median teeth; S5 to S8 retracted.

Genitalia: as in Fig. 3.13f.

Distribution: Like many in the subgenus, *A. californica* is contained west of the Great Plains to the Pacific coast. It has been collected along the Pacific coast from southern British Columbia to Mexico and east to the foothills of the Rocky Mountain Range from Wyoming south through Colorado to New Mexico and Arizona (Fig. 3.2c). [CAN: BC; USA: AZ, CA, CO, ID, NM, NV, OR, UT, WA, WY; MEX: BN.]

Specimens examined: **CAN: British Columbia:** ♀ *East Kootenay Reg. Dist.*, nr Cranbrook, Pine Butte Ranch, 09-10.vii.2013 (G Rowe & L Graham) [Barcoded]; ♀ *Thompson-Nicola Reg. Dist.*, Kamloops, Bachelor Lk., 16.viii.2008 (LR Best) [Barcoded]; **USA: California:** ♂ *Mariposa Co.*, 03.viii.2005 (E Stephens) [Barcoded]; ♀ *San Diego Co.*, 30-31.v.2002 (FD Parker & ME Irwin) [Barcoded]; ♀ *Los Angeles Co.*, Tanbark Flat, 13.vii.1950 (PD Hurd); ♂ *Los Angeles Co.*, Eagle Rock Hills, 14.iv.1933 (CD Michener); **USA: Oregon:** ♂ Surin, nr. Gov't Camp, Mount Hood, 25.vii.1937 (EC VanDyke); ♀ Crater Lake Park, 15.viii.1930 (HA Scullen); **USA: Utah:** ♀ *Kane Co.*, 02.vii.2003 (H Ikerd) [Barcoded]; **USA: Wyoming:** ♂ *Sublette Co.*, Palmer Draw, 16.viii.2004 (Laske & Eckrich) [Barcoded].

Type depository: Female, from near Los Angeles, California, USA, in the US National Museum [Examined].

***Ashmeadiella cubiceps* (Cresson, 1879)**

Heriades cubiceps Cresson, 1879 Trans. Am. Ent. Soc., 7: 205.

Eriades cubiceps Dalla Torre, 1896, Cat. Hymen., 10: 375.

Titusella cubiceps Cockerell, 1908a, Ann. Mag. Nat. Hist., 8(2): 331.

Titusella clypeata Michener, 1936a, Bul. South. Calif. Acad. Sci., 35: 93.

Ashmeadiella cubiceps Michener, 1939, Amer. Mid. Nat., 22: 55.

Biology: *Ashmeadiella cubiceps* is polylectic and has been recorded visiting flowers from Asteraceae and Polygonaceae (Wilson et al. 2010; Ascher & Pickering 2016). It's phenology in Canada is unknown—the only two Canadian records were collected July 29 at Twin Lake, Keremeos, BC.

Diagnosis: The female of *A. cubiceps* can be recognized among Canadian *Ashmeadiella* by the combination of quadridentate mandible and a sparsely punctate clypeus. The male can be recognized by the combination of vertexal area longer than frontal area, longer than distance between lateral ocelli, punctuation of genal area denser than that of mesepisternum, metasoma apically fasciate only on T1, T6 median teeth shorter than, or only as long as basal breadth.

Ashmeadiella cubiceps **redescription**

Figures: 3.2; 3.14; 3.15

Female (N= 2): length 7mm (5.5 to 8mm); head width 2mm (1.5 to 2.5mm); ITW 1.5mm (1 to 2mm); forewing length 4mm (4 to 4.5mm).

Colouration: integument dark brown to black, except as follows: flagellomeres light brown, especially ventrally; tegula brown; wings hyaline, dusky; tarsi and tarsal claw on all legs brown; terga with apical impressed margin light brown.

Pubescence: hairs mostly white; head, mesosoma and metasoma all with very sparse, erect pubescence (~1MOD), except as follows: dorsal surface of pronotal collar and pronotal lobe with denser pubescence (2MOD); lateral surface of mesepisternum fringed with long, erect pubescence at anterior and posterior margins (2MOD); posterior margin of mesoscutellum fringed with long, erect hairs (3MOD); propodeum with dorsolateral angle with dense, erect pubescence (2MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1-T6 (1MOD), medially effaced on most terga; sternal scopa suberect, straw-coloured, oriented posteroventrally, arising from the disc (>2MOD).

Surface sculpture: head, including mandible and antenna, variably punctate: mandible finely punctate ($i < 2d$), except along carinae where it is impunctate; hypostomal area, genal area and vertexal area similarly, evenly punctate ($i = d$); clypeus impunctate along longitudinal middle 1/3 and narrowly along apical margin, punctures in lateral thirds similar to those of paraocular area ($i < 0.5d$); supraclypeal area impunctate adjacent impunctate zone of clypeus, punctured laterally and posteriorly into frontal area ($i < 0.5d$); frontal area with denser punctation ($i < 0.5d$) than that of vertexal area, and with punctures becoming finer laterally to paraocular area ($i < 0.5d$); mesosoma with even punctation, moderately large ($i < 0.5d$), the punctures generally larger than those of head, except as follows: punctures of mesoscutellum less dense medially ($i < 2d$); tegula impunctate, or with very sparse, very shallow punctures anteriorly ($i > d$); axilla more densely punctate ($i = 1/2d$) than mesoscutellum; metanotum roughened, dull, but without distinct punctures; metapostnotum impunctate, shining; metasoma with finer punctures than those

of mesosoma, variably dense: T1 anterior surface impunctate, disc with somewhat dense punctation as in T2 to T4 ($i \sim d$); T5 with punctation denser ($i \sim 0.5d$) than that of T4; T6 with deeper punctures, punctation less dense ($i < 0.75d$) than that of T5.

Structure: head length to width equal ($L=B$); scape over 2x as long as wide ($L:W=21:9$); pedicel longer than wide ($L:W=11:7$); mandible quadridentate, the teeth sharp, well defined, widened apically, distance from tooth of rutellum to third tooth of pollex greater than the greatest width of the compound eye ($37:34$), distance from the tooth of the rutellum to the first tooth of the pollex less than half the distance from the tooth of the rutellum to the third tooth of the pollex ($14:37$); clypeus truncate, the apical margin four-lobed, paired, broadly rounded lobes on either side of a deep, median emargination, the truncation dorsally reflexed; supraclypeal area with tubercle at midpoint between antennal sockets; paraocular carina high; $IAD:AID=23:18$; compound eyes divergent below ($UOD:LOD=24:28$); $IOC < OOC$ ($14:17$); $IOC < OV$ ($14:24$); median ocellus at midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL=VAL$); genal area wider than compound eye in lateral view ($15:11$); T1 to T4 with gradular furrows somewhat deepened.

Male (N=2): length (5 to 6.5mm); head width (1.5 to 2mm); ITW (1 to 1.5mm); forewing length (4 to 4.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: cap of rutellum of mandible testaceous to brown; terga with apical impressed margin not lightened; T6 with median apical teeth brown.

Pubescence: generally denser than that of female, especially as follows; clypeus and genal area with denser pubescence ($>1MOD$) than rest of head; paraocular area with dense, subappressed pubescence ($1MOD$); S1 to S3 submarginally fringed, pubescence oriented posteriorly ($>2MOD$).

Surface sculpture: clypeus entirely punctate, punctures largest basad ($i < 1/2d$); mesoscutellum with an impunctate, narrow, longitudinal midline; metapostnotum finely punctate ($i < d$), interspaces somewhat shining; T4 to T6 with somewhat denser punctation ($i \sim 1/2d$) than that of T1 to T3 ($i < d$), punctures of T6 more obscure, deeper.

Structure: head longer than wide (L:W= 73:64); scape more than 3x as long as wide (L:W=13:4); mandible bidentate, distance from the tooth of the rutellum to the first tooth of the pollex less than a third the greatest width of the compound eye (8:28); clypeus truncate, the apical margin feebly, broadly undulate, lateral angles of truncation broadly rounded; IAD:AID= 13:8; compound eye wider than genal area in lateral view (23:20); compound eyes convergent below (UOD:LOD= 45:40); IOC subequal OOC (9:10); IOC < OV (9:14); T6 with median teeth with the lateral margins gradually sloping to an evenly rounded apex, hardly longer than their basal width (L:W= 5:4), lateral teeth much wider than long (5:2), rounded, the margin between median teeth distinctly concave, that between lateral and median teeth broadly concave; S5 to S8 retracted.

Genitalia: as in Fig. 3.15k.

Distribution: *A. cubiceps* is restricted to the West side of the Rocky Mountain Range, from Southern British Columbia, Canada, south as far as Baja California, Mexico. It extends east along the foothills of the Rockies through Arizona, New Mexico and Texas, USA. Canadian records are restricted to two specimens collected in British Columbia in 1953 (Fig. 3.2d). [CAN: BC; USA: AZ, CA, NV, OR, UT, TX; MEX: BN]

Specimens examined: CAN: **British Columbia:** *Okanagan-Similkameen Reg. Dist.*, 2 ♀ Keremeos, Twin Lk., 29.vii.1953 (DF Hardwick); USA: **California:** ♀ *Mariposa Co.*, 12.viii.2004 (E Stephens) [Barcoded]; ♂ *Tuolumne Co.*, Hetch Hetchy Dome, 02.vi.2005 (HW Ikerd) [Barcoded]; ♂ *Riverside Co.*, Alpine Village, 7.5km W, 04.vi.2002 (FD Parker & ME Irwin) [Barcoded]; USA: **Utah:** ♀ *Kane Co.*, Boy Scout Spr., Navajo Lk., 20.viii.2002 (L Topham) [Barcoded].

Type depository: Female, from western Nevada, USA, in the Philadelphia Academy of Sciences [Examined].

***Ashmeadiella gillettei* Titus, 1904**

Ashmeadiella gillettei Titus, 1904, Proc. Ent. Soc. Wash., 6: 100.

Ashmeadiella coloradensis Cockerell, 1934a, Am. Mus. Nov., 732: 4.

Biology: *Ashmeadiella gillettei* is polylectic and has been recorded foraging from many plant families including Asteraceae, Cactaceae and Hydrophyllaceae (Ascher & Pickering 2016). Canadian records of *A. gillettei* are scarce leading to a little known phenology for the species. Of the records that exist, *A. gillettei* is in flight in July in both Alberta and Saskatchewan, though it is likely that, like most *Ashmeadiella* in Canada, it persists through the early parts of August.

Diagnosis: The female of *A. gillettei* can be recognized by the combination of mandible tridentate, clypeus impunctate only narrowly along apical margin between distinct lateral angles of truncation, compound eye at least one and a half times wider than genal area, S6 with a deep, distinct transverse submarginal depression in the disc. The male of *A. gillettei* can be recognized by the combination of scape elongate, at least three times longer than wide, face entirely covered in dense pubescence between compound eyes, vertexal area short, shorter than frontal area, hardly longer than distance between lateral ocelli, T6 median teeth not longer than wide.

***Ashmeadiella gillettei* redescription**

Figures: 3.2; 3.16; 3.17

Female (N=10): length (5.5 to 7mm); head width (1.5 to 2mm); ITW (1 to 1.5mm); forewing length (3.5 to 5mm).

Colouration: integument black, except as follows: flagellomeres brown, at least ventrally, lightest toward ultimate segment; apex of rutellum of mandible piceous; tegula darkest anteriorly, testaceous posteriorly; wings hyaline, clear; tarsi and tarsal claw on all legs rufescent; hind femur and hind tibia reddish in specimens south of the Canadian/US border; metasoma reddened at least in T1 and T2 in specimens from the United States and Mexico, black in Canadian specimens.

Pubescence: hairs white to lightly ochraceous; head, mesosoma and metasoma all variably pubescent but where pubescence is not especially dense it is erect (1MOD), pubescence denser on the following: clypeus with suberect hairs ($<1.5\text{MOD}$); paraocular area with subappressed pubescence ($<1\text{MOD}$); frontal area and supraantennal area with erect hairs ($<1.5\text{MOD}$); dorsal surface of pronotal collar and pronotal lobe with suberect pubescence (2MOD); mesoscutum anteriorly with a pair of distinct patches of pubescence ($<1\text{MOD}$) at roughly the midpoint between the admedian line and the lateral margin of the mesoscutum; posterior margin of mesoscutum fringed with appressed pubescence ($<1\text{MOD}$); lateral surface of mesepisternum fringed with long, erect pubescence at anterior and posterior margin (2MOD); posterior margin of mesoscutellum fringed with long, erect hairs (3MOD); metepisternum with subappressed pubescence (1.5MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1-T6 (1MOD), usually medially effaced on T1; sternal scopa suberect ($>3\text{MOD}$), straw-coloured, oriented posteroventrally, arising from the disc.

Surface sculpture: head, including mandible and antenna, with punctures large and dense ($i < 0.5d$), except as follows: mandible finely punctate ($i < 0.25d$), except impunctate along carinae; clypeus with narrow, impunctate apical margin between lateral angles of truncation, which extends narrowly posteriorly along the midline of the clypeus for nearly 1MOD; supraclypeal more densely punctate ($i = 0.25d$); mesosoma and metasoma with punctures large and dense ($i < 0.5d$), except as follows: tegula impunctate or with few, fine punctures anteriorly ($i < d$); axilla more finely and densely punctate ($i < 1/3d$) than mesoscutum or mesoscutellum; metapostnotum impunctate except for weakly scrobiculate narrowly in lateral thirds of horizontal basal zone; propodeum with dorsolateral angle less densely punctate, the punctures somewhat large ($i = d$); metepisternum with finer, denser punctation ($i < 0.5d$) than in mesepisternum; T1 anterior surface impunctate; punctation of T1 denser than that of T2 ($i < d$; $i = d$); T4 larger ($i < 3/4d$) than that of T3, the latter of which is as in T2; T5 somewhat finer than T4, about as dense ($i < 3/4d$); T6 punctures large and dense ($i < 0.5d$); S6 with conspicuously large punctation in disc ($i < 1/3d$).

Structure: head width and length nearly equal (L:W = 48:47); scape nearly 4x as long as wide (L:W = 15:4); pedicel longer than wide (L:W = 9:5); mandible tridentate, distance from the tooth of the rutellum to the second tooth of the pollex nearly three quarters the greatest width of

the compound eye (11:16); clypeus truncate, lateral angles of truncation well defined, apical margin weakly concave between lateral angles of truncation and narrowly reflexed medially between lateral angles of truncation; IAD:AID=21:14; compound eyes convergent below (UOD:LOD= 33:30); IOC = OOC; IOC subequal OV (16:17); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 30:25); compound eye wider than genal area in lateral view (32:25); wings with first recurrent vein meeting posterior margin of second submarginal cell such that the proximal portion of the posterior margin of the second submarginal cell is equal to, or greater than, a third its total length (8:17); mesoscutum as wide as long (L=B); metasoma longer than wide (L:W= 44:30); S6 with a deep, transverse submarginal depression in the disc.

Male (N=8): length (5 to 7mm); head width (1 to 1.5mm); ITW (1mm); forewing length (3.5 to 4.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: mandible red to piceous; flagellomeres, basitarsi and tarsi of all legs all lighter than in female, ochraceous to rufescent; apical margins of terga dark amber.

Pubescence: less densely pubescent than in female, except as follows: clypeus with dense subappressed pubescence ($<1\text{MOD}$); patches of pubescence anteriorly on mesoscutum absent; terga not apically fasciate; S2 and S3 submarginally fringed, the pubescence oriented posteriorly (2.5MOD); S4 with denser, cinereous pubescence arising from premarginal line and in marginal area, oriented posteromedially into a subtuft formation (2MOD).

Surface sculpture: hypostomal area punctured as in genal area ($i < d$); clypeus finely and closely punctate, much more finely so than rest of head ($i = 0.5d$), except for the narrow, impunctate apical margin as is the case in the female, but differing in that it extends along the lateral margin; punctation of mesoscutellum somewhat finer ($i = d$) than that of mesoscutum, and increasingly finer so posteriorly ($i < 0.5d$); metapostnotum with horizontal basal zone, punctured as is anterior zone; punctures of T1 to T6 similar ($i < d$).

Structure: head hardly wider than long (L:W= 80:83); scape more than 3x longer than wide (L:W= 16:5); pedicel length to width equal; mandible bidentate, distance from the tooth of the rutellum to the first tooth of the pollex nearly a third the greatest width of the compound eye (7:24); clypeus weakly truncate, the lateral margins of clypeal truncation feebly convex, lateral angles of clypeal truncation broadly rounded, not well defined, the margin between lateral angles of truncation sinuate, produced to an angulate projection on either side of the longitudinal midline, the margin between projections concave; IAD:AID= 14:10; compound eyes convergent below (UOD:LOD= 51:46); compound eye wider than genal area in lateral view (30:18); IOC > OOC (13:10); IOC > OV (13:12); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 22:19); mesosoma longer than wide (L:W= 75:65); metasoma longer than wide (L:W= 95:70); median teeth of T6 subtruncate, nearly parallel-sided, with the apical margin of median teeth angled toward the lateral margin such that the margin of the median tooth nearest the longitudinal midline of T6 extends further posteriorly than does the margin of the median tooth nearest the lateral margin of T6, median teeth hardly wider than long (L:W= 5.5:6), apical width hardly less than basal width (5.5:6), concavity between median teeth broadly concave; S5 to S8 retracted.

Genitalia: as in Fig. 3.17h.

Distribution: *Ashmeadiella gillettei* is found primarily in the arid regions of the United States and Mexico. It has been collected as far north as southern Alberta and Saskatchewan and south along the eastern foothills of the Rocky Mountain Range through North Dakota, Colorado, Texas and into Mexico. It is absent along the Pacific coast north of California but is present throughout Nevada and Idaho and along the Rocky Mountain Range (Fig. 3.2e). [**CAN:** AB, SK; **USA:** AZ, CA, CO, ID, MT, NE, ND, NM, NV, SD, TX, WY; **MEX:** DU, CH.]

Specimens examined: **CAN: Alberta:** ♀ *Newell Co.*, Dinosaur Prov. Pk., 21.vii.2013 (G Rowe & L Graham) [Barcoded]; **CAN: Saskatchewan:** ♀ ♂ East Block GNP, 07.vii.2013 (Killdeer Bioblitz Team) [Barcoded]; 1 ♀, 2 ♂ Gt. Sand Hills, Bowie Ranch, nr. Piapot, 11.vii.2010 (D Larson) [Barcoded]; **USA: Arizona:** ♀ *Cochise Co.*, Peloncillo, Skeleton Canyon Rd., 01.v.2004 (FD Parker & ME Irwin) [Barcoded]; **USA: California:** ♂ *San Benito Co.*, Pinnacles Nat. Mon., 23.vii.1998 (C Schultz) [Barcoded]; ♂ *Inyo Co.*, Mazourka Canyon, 17.iv.2014 (TL Griswold) [Barcoded]; **USA: Colorado:** ♀ *Mesa Co.*, 24-25.viii.2011 (col. unk.) [Barcoded]; **USA:**

Nevada: ♂ *Clark Co.*, nr. Jean Lk., 14.iv.2004 (E Rentz & L Saul) [Barcoded]; ♀ *Clark Co.*, nr Indian Ridge, 23.v.2005 (R Andrus) [Barcoded]; **USA: New Mexico:** ♂ *Chavas Co.*, Sagebrush Valley Rd., 01-10.v.2004 (ME Irwin) [Barcoded]; **USA: South Dakota:** ♀ *Pennington Co.*, 28.vi.2010 (B Iberte & D Stiltson) [Barcoded]; **USA: Utah:** ♀ ♂ *Uintah Co.*, 03.v.2012 (SC Clark) [Barcoded]; ♀ *Tooele Co.*, Little Granite Mtn., (J Wilson) [Barcoded]; **USA: Wyoming:** ♀ *Lincoln Co.*, 13-14.viii.2012 (col. unk.) [Barcoded].

Type depository: Female, from Fort Collins, Colorado, USA, in the United States National Museum. [Examined]

SM.2 *ATOPOSMIA*

Atoposmia copelandica (Cockerell, 1908)

Osmia copelandica Cockerell, 1908b, Entom., 41: 59.

Osmia besseyae Cockerell, 1910, Entom., 43: 9.

Osmia albomarginata Cockerell, 1935, Pan-Pac. Ent., 11: 49.

Osmia arefacta Cockerell, 1935, Pan-Pac. Ent., 11: 42.

Atoposmia (Hexosmia) copelandica albomarginata Cockerell, 1935, Pan-Pac. Ent., 11: 49.

Atoposmia (Hexosmia) copelandica arefacta Cockerell, 1935, Pan-Pac. Ent., 11: 42.

Biology: *Atoposmia copelandica* is a specialist on *Phacelia* (Hydrophyllaceae) (Wilson et al. 2010). In Canada it is rarely collected through the months of June and July in southern British Columbia.

Diagnosis: Both sexes of *A. copelandica* can be distinguished from other Canadian *Atoposmia* by the combination of a blue-green, metallic hue of the integument and lightly coloured hind tibial spurs. The female can be distinguished from other Canadian *Atoposmia* by pale scopa, and the male by bidentate mandible and a hidden T7.

Atoposmia copelandica **redescription**

Figures: 3.3; 3.20; 3.21

Female (N=47): length 7mm (5 to 8mm); head width 3.5mm (1.75 to 2.25mm); ITW 2mm (1.25 to 2mm); forewing length 5mm (3.5 to 5mm).

Colouration: integument weakly metallic with a blue-green hue, except as follows: scape and pedicel piceous; flagellomeres brown; cap of rutellum and pollex of mandible piceous; tegula brown; wings hyaline, dusky, marginal cell darkest; all legs piceous, except tarsi and tarsal claw rufescent; hind tibial spur straw-coloured; terga and sterna with apical impressed margin golden brown.

Pubescence: hairs mostly white; head, mesosoma and metasoma sparsely pubescent with erect, plumose hairs (1MOD), except as follows: hypostomal area pubescence erect (>2MOD); apical margin of clypeus with short tufts of ochraceous setae on either side of midline, arising from beneath the clypeal truncation, oriented anteromedially (<0.5MOD); paraocular area with dense, subappressed pubescence (1MOD); pronotal lobe with short, dense tomentum on lateral and posterior margins (<1MOD), rest of pronotal lobe with hairs suberect (>1MOD); posterior margin of mesoscutellum and metanotum with long, erect pubescence (>2MOD); metapostnotum nearly glabrate; dorsolateral angle of propodeum with suberect pubescence (>2MOD), metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, usually medially effaced (1MOD); sternal scopa white or straw-coloured, oriented posteroventrally, arising from the disc (>2MOD).

Surface sculpture: head and its appendages, evenly and finely punctate ($i=1/2d$), interspaces shining, except as follows: hypostomal area less densely punctate ($i<3d$); mandible more finely punctate ($i\sim d$), except along carinae where it is impunctate; clypeus less densely punctate, punctures finest apicad ($i\sim d$), with apical margin narrowly impunctate between lateral margins of truncation, shiny; frontal area and genal area with punctation finer, less dense ($i<1/2d$); mesosoma moderately punctate ($i>d$), except as follows: pronotumpunctulate, the punctures large and shallow, not well defined ($i>2d$), the interspaces foveolate; punctation of mesoscutellum larger than that of mesoscutum, similarly dense ($i>d$); punctures of axilla finer, denser ($i<0.5d$); metanotum as in mesoscutum; mesepisternum less densely and regularly punctate than genal area ($i>0.5d$); punctation of metepisternum obscure ($i<d$); tegula sparsely

punctate ($i > d$); metapostnotum divided into a roughened, somewhat alveolate anterior zone and an impunctate posterior zone, dorsolateral angle of propodeum irregularly punctate ($i > 0.5d$); metasoma with fine punctation ($i < d$), except as follows: T1 anterior surface impunctate, disc with punctation fine, not dense ($i > 2d$); T2 and T3 with punctures somewhat larger and denser ($i = 2d$); T4 to T6 puncticulate, punctures fine and dense ($i \sim 1/2d$), interspaces somewhat dull; punctation of sterna large in disc ($i \sim 0.5d$), narrowly impunctate at apical impressed margin.

Structure: head length to width roughly equal (73:71); scape 3x as long as wide; pedicel and F1 longer than wide (L:W = 6:4; L:W = 6:3, respectively); F10 longer than wide (L:W = 7:6); flagellomeres ventrally flattened; hypostomal carina high; mandible tridentate, teeth sharp, margins between them acutely angled, distance from tooth of rutellum to first tooth of pollex subequal to distance between two teeth of pollex (6:7), slightly widened at apex, apical width much less than greatest width of compound eye (6:21); clypeus convex, truncate, margin between lateral angles of truncation feebly concave, lateral angles of truncation well defined ($\sim 110^\circ$), lateral margins of truncation straight; IAD:AOD = 15:10; supraantennal depression moderately deep; paraocular carina moderately high; inner margins of compound eyes subparallel (UOD:LOD = 34:32); IOC = OOC; IOC < OV (11:15); median ocellus behind midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL = 24:19); genal area wider than compound eye in lateral view (19:16); mesosoma slightly wider than long (L:W = 68:73); metacoxa with inner ventral carina weak;; metasoma longer than wide (L:W = 46:31); marginal zone of T6 feebly reflexed dorsally.

Male (N=31): length (5.5 to 8.5mm); head width (1.5 to 2.25mm); ITW (1.5 to 2mm); forewing length (3.5 to 5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: generally darker than female but patterning remains consistent; apical impressed margin of terga paler amber.

Pubescence: apical lip of clypeus with fringe of white setae between lateral angles of truncation, hairs oriented anteriorly (0.5MOD); clypeus with subappressed pubescence at lateral

margin of truncation (1MOD); vertexal area with erect pubescence posteriorly (~1MOD); pronotal lobe and anterior third of mesoscutum with suberect pubescence (<1.5MOD); T6 not apically fasciate; S1 and S2 densely pubescent throughout (>2MOD); S3 conspicuously fringed along apical margin of concave emargination, the hairs long, oriented toward midline (~1.5MOD), disc with dense, suberect pubescence along midline (1MOD).

Surface sculpture: head and mesosoma with finer and denser ($i=1/3d$) punctation than in female, patterning agrees with female, except as follows: punctures of hypostomal area not less dense than?, somewhat shallow, less well defined ($i=1/2d$); outer interspace of mandible with punctures fine, less dense than those of rest of head ($i>1/2$); clypeus densely punctured, the punctures becoming finer toward an impunctate apical margin between lateral angles of truncation ($i\sim 1/3d$); punctures of genal area not finer than rest of head, less dense ($i=1/2d$); mesosoma moderately punctate ($i>d$), except as follows: mesoscutellum with punctures as large as those of mesoscutum, less dense medially ($i>d$); T2 as for T1 ($i>2d$); T3 punctures larger, somewhat denser ($i<2d$); T4 and T5 somewhat imbricate, the punctures larger and denser ($i<1/2d$); T6 somewhat densely punctate medially ($i\sim 1/2d$), less dense toward lateral margins ($i>d$), interspaces conspicuously shining; discs of S1 to S3 somewhat densely ($i\sim d$) but shallowly punctate, apical impressed margins impunctate.

Structure: head wider than long (L:W=50:45); scape 2x longer than wide; pedicel as long as wide; F11 longer than wide (L:W= 11:6); mandible bidentate, short and robust, tooth of rutellum slightly longer than tooth of pollex (5:4); clypeal truncation more strongly convex than in female, apical margin between lateral angles somewhat thickened, deeply concave, lateral angles of truncation distinct, almost tuberculate, lateral margins of clypeal truncation broadly rounded, convex; anterior tentorial pits wide and deep; median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL=22:20); mesosoma wider than long (L:W= 89:76); metasoma longer than wide (L:W= 68:30); T6 apical margin very feebly reflexed dorsad, nearly straight in profile, apical margin feebly sinuate at lateral 1/6 of tergal width, margin between sinuations rounded; T7 broadly rounded, hidden by T6; S1 short, truncate; S2 produced apicomediaally, covering most of S3, apical margin narrowed to truncate apex, truncation not more than 1/6 the total width of the segment; apical margin of S3 with a broad, median emargination at least $\frac{1}{2}$ the total width of the

sternum,; disc of S4 conspicuously depressed, hidden by S3, apical margin thickened, weakly convexfeebly rounded; S5 to S8 retracted.

Genitalia: as in Fig. 3.21f.

Distribution: This is a widely distributed species of *Atoposmia*, extending along the Pacific coast from California to southern British Columbia. It is mainly distributed along the foothills of the Rocky Mountain Range, and extends east as far as New Mexico, Colorado and Wyoming (Fig. 3.3b). [CAN: BC; USA: AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY.]

Specimens examined: CAN: **British Columbia:** *Okanagan-Similkameen Reg. Dist.:* ♂ ♀ Oliver, 26.vii.2008 (LR Best) [Barcoded]; 2 ♂ 2 ♀ Oliver, 01.vii.2009 (LR Best) [1 ♂ 1 ♀ Barcoded]; ♀ Oliver, 26.vi.2008 (LR Best) [Barcoded]; 2 ♀ Oliver, 29.vii.2008 (LR Best); ♀ Keremeos, 21.vi.1923 (CB Garrett); *Thompson-Nicola Reg. Dist.*, ♀ Clapperton, 01-05.vi.2010 (LR Best) [Barcoded]; USA: **Colorado:** ♀ *Roult Co.*, Steamboat Springs, 10.viii.1964 (RM Bohart); 2 ♂ Boulder, 16.vii.1939 (UN Lenham); USA: **California:** *Trinity Co.:* ♂ 14.vii.1955 (RM Bohart); 3 ♀ Coffee Creek, 14.vii.1955 (RM Bohart); *Nevada Co.:* 24.vi.1954 (RM Bohart); ♂ Boca, 26.vi.1973 (B Villegas); 2 ♀ Boca, 28.vi.1954 (EI Schlinger); ♂ Boca, 28.vi.1954 (EL Schlinger); ♀ Boca 03.vii.1954 (RM Bohart); ♀ Boca, 28.vi.1954 (RM Bohart); 2 ♀ Boca 05.vii.1954 (RC Bechtel); *Sagehen Creek:* ♂ 29.v.1954 (RM Bohart); ♂ 15.vii.1964 (JA Froebe); ♂ 25.vi.1966 (RM Bohart); ♂ 15.vii.1966 (RL Brumley); ♂ 04.vii.1971 (RM Bohart); ♂ 05.vii.1972 (SF Casey); ♂ 19.vi.1974 (RM Bohart); 2 ♀ 25.vi.1966 (RL Brumley); ♀ 05.vii.1962 (ME Irwin); 3 ♀ 18.vii.1973 (B Villegas); ♀ 15.vii.1966 (RL Brumley); ♀ 29.vi.1962 (FD Parker); 2 ♀ 15.vii.1964 (RM Bohart); ♀ 25.vii.1954 (RM Bohart); ♀ 20.vi.1962 (ME Irwin); ♀ 08.vii.1964 (RM Bohart); *San Bernardino Co.:* ♀ ♂ Mid Hills Campground, 29.iv.2009 (TL Griswold) [♀ ♂ Barcoded]; *Kramer Hills:* 3 ♀ 11.iv.1964 (RM Bohart); ♂ 11.iv.1964 (PM Marsh); 3 ♂ 11.iv.1964 (RM Bohart); 2 ♂ 11.iv.1964 (FD Parker); *Santa Ynez Mountains:* ♀ 24.vi.1959 (RW Spore); ♀ Red Mountain, 04.iv.1968 (RM Bohart); *Tuolumne Co.:* ♀ Dodge Ridge, 15.vii.1951 (AT McClay); ♀ Mill Cr. Camp, 13.vii.1951 (RO Bechtel); *Shasta Co.:* ♀ Old Station, 22.vi.1955 (K Bowers); *Sierra Co.:* ♀ Yuba Pass, 05.vii.1966 (RM Bohart); ♀ Independence Lake, 27.vii.1956 (RM Bohart); USA: **Idaho:** ♂ *Valley Co.*, McCall, 22.vii.1971 (RM Bohart); ♀ *Butte Co.*, Craters of

the Moon, 20.vi.1952, (EI Schlinger); ♂ *Butte Co.*, nr Craters of the Moon, 24.vi.2007 (J Gibbs and S Sheffield); ♀ *Blaine Co.*, 10km E Craters of the Moon, 27.v.2007 (J Gibbs and S Sheffield); **USA: Nevada:** *Washoe Co.*: 2 ♀ Verde, 10.vi.1960 (FD Parker); ♀ Verde, 25.vi.1954 (RM Bohart); ♂ Mount Rose, 07.vii.1972 (ML Kok); **USA: Oregon:** *Deschutes Co.*: 2 ♀ Tumalo Res., 22-23.vi.1954 (EI Schlinger); ♂ ♀ Tumalo Res. 22-23.vi.1954 (AA Grigarick); ♀ Tumalo Res. 22-23.vi.1954 (JC Downy); ♂ *Klamath Co.*, Ft. Klamath, 17.vii.1971 (B Villegas); 2 ♂ *Sherman Co.*, Rufus, 20.vi.1955 (RM Bohart); ♂ *Lassen Co.*, Susan R Camp, 12.vii.1954 (AA Grigarick); **USA: Utah:** ♂ *Cache Co.*, Mt. Naomi, 24.vii.2008 (TL Griswold) [Barcoded]; ♀ *Washington Co.*, Goose Creek, 13.vi.2007 (H Ikerd) [Barcoded]; **USA: Wyoming:** ♂ *Teton Co.*, Flagg Ranch, 04.vii.1971 (SL Clement).

Type depository: Female, from Boulder Co., Colorado, in the California Academy of Sciences, #15665. [Examined]

SM.3 *CHELOSTOMA*

Chelostoma minutum Crawford, 1916

Chelostoma minuta Crawford, 1916, Insecutor Inscitiae Menstruus, 4: 102.

Chelostoma minutum Cockerell, 1935, Pan-Pac. Ent., 11: 52.

Biology: Originally considered a pollen specialist on *Phacelia* (Boraginaceae) (Moldenke & Neff 1974), *C. minutum* was subsequently considered a pollen generalist (Krombein et al. 1979) after being recorded visiting many plant families including *Phacelia* (Boraginaceae), *Allium* (Amaryllidaceae) (Parker 1988) and *Sedum* (Crassulaceae) (Parker 1988; Wilson et al. 2010). *C. minutum* was most recently found to be one of only two species of polylectic *Chelostoma* in a large-scale study on host-plant choice (Sedivy et al. 2008). *C. minutum* has been collected in Canada in southern British Columbia from June (17, Okanagan-Similkameen Reg. Dist.) to August (1, Okanagan-Similkameen Reg. Dist.).

Diagnosis: The female of *C. minutum* can be recognized by the combination of base of labrum unmodified, without yellowish membranes, clypeus with apical margin distinctly straight

between lateral angles of truncation, supraantennal depression strong in paraocular area, and compound eye at least as wide as genal area in lateral view. The male can be recognized by the combination of T6 apical margin unmodified, not dorsally reflexed, T7 with apical margin produced to four long, slender processes, S2 with disc feebly swollen submarginally, and S5 with apical fringe not transverse, only in middle half its width.

Chelostoma minutum **redescription**

Figures: 3.4; 3.24; 3.25

Female (N=3): length 5mm (4.5 to 5mm); head width 1mm (1 to 1.25mm); ITW 0.75mm (0.5 to 1mm); forewing length 4mm (3 to 4mm).

Colouration: integument black, except as follows: cap of rutellum of mandible piceous; flagellomeres dark brown; distitarsus and tarsal claw of hind leg testaceous; hind tibial spur straw-coloured to honey-coloured; wings hyaline, dusky, with stigma and veins dark; tegula piceous posteriorly; apical impressed margin of terga dark brown; apical impressed margin of sterna golden.

Pubescence: integument sparsely pubescent with erect hairs, hairs mostly white (1MOD), except as follows: pubescence of hypostomal area longer, somewhat denser (1.5MOD); posterior margin of mesoscutellum fringed with long, erect, somewhat ochraceous hairs (<2MOD); T6 with apical fascia, the hairs short, arising from the premarginal line (~1MOD); sternal scopa suberect (2MOD), oriented posteroventrally, arising from the disc.

Surface sculpture: head, including mandible and antenna, and mesosoma with fine, even punctation ($i=1/2d$), except as follows: hypostomal area sparsely and variably punctate ($i<2d$); clypeus, supraclypeal area and paraocular area less densely punctate ($i<d$), paraocular area with a small, distinct impunctate region posterior to the antennal socket; frontal line somewhat impunctate anterior to median ocellus; mesepisternum variably punctate ($i<d$); axilla more densely punctate ($i<1/2d$); tegula very sparsely punctate, if at all ($i>2d$); metapostnotum with horizontal basal zone scrobiculate, otherwise finely punctate ($i\sim 1/2d$); propodeum with punctures of lateral surface large ($i\sim 1/2d$), dorsal surface with punctures larger and less dense ($i>1/2d$) than

in lateral surface; metasoma with punctures finer than those of head and mesosoma, the punctures less dense ($i < d$); punctation of T1 finer than that of T2; punctation of T2 finer than that of T3; punctation of T4 finer than that of T3, but larger than that of T5, which is larger than that of T6; sterna with moderate punctation in disc, the punctures somewhat shallow, less well defined ($i < d$), impunctate in narrow marginal zones.

Structure: head wider than long (L:W= 58:65); scape nearly 3x as long as wide (L:W= 14:5), pedicel longer than wide (L:W= 6:4), ultimate flagellomere (F10) longer than wide (L:W= 11:6), the apex rounded; labrum thickened along apical margin; mandible tridentate, the tooth of the rutellum and the first tooth of the pollex sharp, well defined, the second tooth of the pollex weak, distance from tooth of rutellum to first tooth of pollex hardly greater than the distance from first tooth of pollex to second tooth of pollex (9:8); distance from tooth of rutellum to second tooth of pollex roughly 1/2 total length of clypeus measured along its greatest length (17:33); hypostomal carina high; clypeus convex, except at extreme lateral margins where the apical margin is subtruncate, the truncation broadly rounded, covering less than 1/4 the width of the apical margin, the margin between rounded truncation straight; frontal line thickened, tubercle-like between antennal sockets; clypeoantennal distance less than half the total length of the clypeus (7:20); IAD:AID= 13:8; supraantennal depression deep; IOC < OOC (9:11); IOC > OV (9:7); distance from posterior margin of antennal socket to median ocellus more than 2x the distance from posterior margin of median ocellus to posterior margin of vertexal area (FAL:VAL= 21:10); compound eyes convergent below (UID:LID= 45:39); compound eye wider than genal area in lateral view (19:17); T1 anterior surface convex with a distinct longitudinal furrow.

Male (N=2): length (3 to 5mm); head width (1 to 1.25mm); ITW (0.5 to 1mm); forewing length (3 to 5mm).

As in female, except for usual secondary sex characters and as follows:

Colouration: all legs light to dark brown; tegula wholly dark brown to piceous; apical margins of terga more conspicuously lightened than in female, brown; apical margins of S1-S4 light brown, S5 and S6 wholly brown.

Pubescence: pubescence somewhat denser and more ochraceous than that of female ($>1\text{MOD}$), especially as follows; apical half of clypeus densely pubescent, the hairs subappressed (1MOD); mesoscutellum entirely covered with somewhat dense, erect pubescence (2MOD); S5 with median tuft of large, testaceous pubescence, the hairs erect, oriented ventrally for their basal half then bent and oriented posteriorly for apical half (2MOD).

Surface sculpture: head, including mandible and antenna, finely and closely punctate ($i < 1/2d$), except as follows: suture between clypeus and supraclypeal area narrowly impunctate; mesosoma finely and evenly punctate ($i = 1/2d$), except as follows: metepisternum with finer punctation, though similarly spaced ($i = 1/2d$); tegulae finely and sparsely punctate ($i < 2d$); metasoma punctured as in mesosoma, though less densely so ($i < d$), except as follows: T1 anterior surface less densely punctate ($i < 2d$); punctation of terga similar.

Structure: head as long as wide ($L=B$); scape nearly 3x as long as wide ($L:W = 15:6$), ultimate flagellomere (F11) longer than wide ($L:W = 10:7$); labrum thickened at base; mandible bidentate, distance between teeth roughly $1/5$ the total length of the clypeus ($5:19$); frontal line deep posteriorly from posterior margin of antennal socket to the median ocellus; paraocular carina high; compound eyes convergent below ($UID:LID = 48:38$); compound eyes wider than genal area in lateral view ($22:15$); apical margin of T7 produced to four long, slender processes, the apex of lateral processes somewhat oriented toward midline, marginal area with a median, subapical excavation, the excavation circular, deep and distinct; disc of S2 to S4 feebly swollen at least submarginally, usually transversely in disc, the swelling interrupted at longitudinal midline of S4; apical margin of S4 concave, produced posteriorly in lateral thirds; disc of S5 with a deep, circular depression; S6 to S8 retracted.

Genitalia: as in Fig. 3.25d.

Distribution: *C. minutum* extends narrowly west of the Rocky Mountain range along the Pacific coast from southern British Columbia to California east to the western foothills of the Rocky Mountain range through Nevada, Utah and Idaho (Fig. 3.4b). [CAN: BC; USA: CA, ID, NM, NV, OR, UT, WA.]

Specimens examined: CAN: **British Columbia:** *Okanagan-Similkameen Reg. Dist.:* ♀ Camp McKinney Rd., Sandy Cut, 01.viii.2009 (LR. Best) [Barcoded]; ♀ ♂ Oliver, 17.vi.2013 (G. Rowe & L. Graham) [♀ ♂ Barcoded]; USA: **California:** ♀ *Tuolumne Co.*, WNW Sheep Pk., 28.vii.2006 (E. Stephens) [Barcoded]; ♂ *Mariposa Co.*, WbyS Andrews Pk., 14.vii.2005 (T. Griswold) [Barcoded].

Type material: Holotype, female, from Tuolumne Meadows, California, in the US National Museum. [Examined]

***Chelostoma phaceliae* Michener, 1938**

Chelostoma phaceliae Michener, 1938b, Pan-Pac. Ent., 14: 38.

Biology: *C. phaceliae* is oligolectic for pollen resources (on *Phacelia*: Boraginaceae), but presumably visits a variety of floral taxa for nectar resources (Moldenke & Neff 1974; Krombein et al. 1979; Sedivy et al. 2008). In Canada it has been collected in southern British Columbia throughout the month of June (3, Vancouver Island; 19, Osoyoos).

Diagnosis: The female of *C. phaceliae* can be recognized by the combination of scape elongate, at least two and a half times longer than wide, base of labrum unmodified, without yellowish membranes, clypeus apical margin feebly undulate, not distinctly crenulate or straight, compound eye at least as wide as genal area, and T1 to T3 apically fasciate. The male of *C. phaceliae* can be recognized by the combination of S2 with a high, distinct protuberance in disc, T7 apical margin with three processes, S3 without modified pubescence, without patches of bristle like setae submarginally and S5 apical margin with a median apical tuft of pubescence, the pubescence sinuate in profile with apices oriented dorsally.

***Chelostoma phaceliae* redescription**

Figures: 3.4; 3.26; 3.27

Female (N=2): length (6 to 7.5mm); head width (1 to 1.5mm); ITW (0.75 to 1mm); forewing length (4 to 5mm).

Colouration: integument black, except as follows: apex of rutellum of mandible piceous; flagellomeres dark testaceous; tegula dark brown posteriorly; basitarsus and distitarsus of all legs testaceous or amber-coloured; tibial spurs straw-coloured to honey-coloured; wings hyaline, infuscated, stigma and veins dark; apical impressed margin of terga narrowly testaceous, lateral surfaces more conspicuously so.

Pubescence: hairs mostly straw-coloured; integument sparsely pubescent with erect hairs ($<1/2$ MOD), except as follows: paraocular area with denser, subappressed pubescence ($<1/2$ MOD), the hairs white; frontal area with somewhat denser, ochraceous pubescence (>1 MOD); pronotum with denser pubescence in pronotal collar, sometimes patch-like (1MOD); mesoscutum and mesoscutellum more densely pubescent, especially at anterior and posterior margins (1MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of at least T1 to T4, sometimes that of T5 and T6, and only sometimes completely transverse ($1/2$ MOD); sternal scopa dense and suberect (3MOD), oriented posteroventrally and arising from the disc.

Surface sculpture: integument finely and evenly punctate ($i=1/2d$), except for as follows: hypostomal area mostly impunctate; paraocular area narrowly impunctate posterior to antennal socket; mesoscutum and mesepisternum with punctation larger and denser ($i<d$) than that of vertexal area and genal area, respectively; tegula sparsely punctate, punctures present only anteriorly, fine and sparse ($i>d$); metanotum with punctures larger ($i=d$); metapostnotum with horizontal basal zone weakly scrobiculate, not bordered posteriorly by a distinct carina, not fully defining the pits, otherwise finely punctate ($i\sim 1/2d$); punctation of metasoma finer than in mesosoma; anterior surface of T1 impunctate, disc moderately punctate ($i=1/2d$) as in T2 and T3; T4 with punctures somewhat sparser ($i>1/2d$) than those of T3; T5 finer and sparser ($i<d$) than T4; T6 finest, denser ($i<1/2d$) than T5; sterna with punctures large and dense in disc, impunctate in marginal zone on T1 to T5, marginal zone of T6 punctured as in disc.

Structure: head hardly longer than wide (L:W= 54:52); scape 2.5x as long as wide (L:W= 25:9), pedicel longer than wide (L:W= 7:5), ultimate flagellomere (F10) longest, longer than wide (L:W= 9:8), flattened ventrally; proboscis elongate, reaching beyond anterior coxa in repose; mandible tridentate, the teeth sharp, well defined, distance from tooth of rutellum to first tooth of pollex equal to distance from first tooth of pollex to second tooth of pollex, and distance

from tooth of rutellum to second tooth of pollex $1/3$ the total length of the clypeus (10:29); hypostomal carina high; apical margin of clypeus produced laterally to broadly rounded lobes, the lobes widely separated, the margin between them at least twice their basal width, the margin straight, feebly undulate; clypeoantennal distance nearly $1/3$ the length of the clypeus (6:20); supraantennal depression deep; paraocular carina moderately high; IAD:AID= 15:10; IOC < OOC (9:11); IOC = OV; median ocellus behind midpoint between posterior margin of antennal socket and posterior margin of vertexal area such that the frontal area is longer than vertexal area (FAL:VAL= 24:18); compound eyes convergent below (UID:LID= 52:40); compound eye wider than genal area in lateral view (25:16); parapsidal line more than $2/3$ as long as tegula (22:32); admedian line somewhat raised anteriorly; T1 anterior surface with shallow, longitudinal median depression.

Male (N=2): length 6mm (6 to 7mm); head width 1.5mm (1 to 1.5mm); ITW 1mm (0.75 to 1mm); forewing length 3.5mm (3.5 to 4.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres dark brown; basitarsus and distitarsus of all legs lighter than in female, honey-coloured; apical impressed margin of terga golden; apical impressed margin of sterna testaceous.

Pubescence: hypostomal area with somewhat denser, erect pubescence ($>1\text{MOD}$); pubescence denser on the following: clypeus, frontal area and paraocular areas all with subappressed pubescence (1MOD); mesoscutum, mesoscutellum and metanotum without dense pubescence (1MOD); apical fascia usually absent on metasomal terga, or, if present, only narrowly at lateral margins of T1 to T4 ($<1\text{MOD}$); S5 with tuft of long, large, white pubescence medially (2MOD) extending out perpendicularly from apical margin for half its length then bent at a right angle and extending posteriorly for the other half.

Surface sculpture: hypostomal area sparsely and finely punctate ($i < 2d$); clypeus and genal area with slightly finer punctation than rest of head ($i \leq 1/2d$); paraocular area without impunctate region; metanotum with punctures not larger than elsewhere; tegula sparsely punctate

but more evenly so than in female ($i < 2d$); punctation of T5 and T6 finer than in others ($i = 1/2d$); processes of T7 with impunctate apical margin.

Structure: head wider than long (L:W= 53:60); pedicel as long as wide (5:5), ultimate flagellomere (F11) not so tapered and pointed as in female (F10), longer than wide (L:W= 9:7); labrum thickened basad, thickest in middle 2/3 of exposed portion when mandibles closed; mandible bidentate, the distance from the tooth of rutellum to the first tooth of the pollex $\frac{1}{4}$ the total length of the mandible (6:24); apical margin between lateral lobes of clypeus concave, the lateral lobes hardly produced; clypeoantennal distance nearly $\frac{1}{3}$ length of clypeus (7:19); IAD:AID= 19:8; compound eye wider than genal area in lateral view (27:15); compound eyes convergent below (UID:LID= 49:42); apical margin of T7 produced to three long, slender processes, the median one of which is longest and somewhat more ventral than the lateral ones, the lateral ones somewhat curved toward the midline, the marginal area with a median, subapical excavation, the excavation tear-drop shaped, rounded anteriorly and tapering toward posterior, the excavation deep and distinct; S2 with a high, distinct protuberance in longitudinal third of the disc, the protuberance broadly rounded at the apex, the apical margin feebly emarginate; S3 with a low transverse submarginal swelling in disc, the apical margin straight; S4 with a low submarginal swelling in middle third, the apical margin somewhat produced posteriorly, feebly emarginate; disc of S5 depressed submarginally at midline, the apical margin distinctly concave for middle third its width; S6 to S8 retracted.

Genitalia: as in Fig. 3.27e.

Distribution: *C. phaceliae* is restricted to the Pacific coast, west of the Rocky Mountain Range. It has been collected throughout California and north to southern British Columbia and east as far as the western foothills of the Rocky Mountain Range (Fig.3.4c). [CAN: BC; USA: CA, ID, NV, OR, UT, WA.]

Specimens examined: CAN: British Columbia: Okanagan-Similkameen Reg. Dist.: 2 ♀ 2 ♂ Osoyoos, Strawberry Crk. Rd., 19.vi.2010 (LR. Best) [2 ♀ 2 ♂ Barcoded].

Type material: Holotype, male, from Altadena, California, in the California Academy of Sciences (No. 4491) [Examined], and allotype, female, in the California Academy of Sciences (No. 4492) [Examined].

***Chelostoma philadelphi* (Robertson, 1891)**

Heriades philadelphi Robertson, 1891, Trans. Am. Ent. Soc., 18: 64.

Chelostoma philadelphi Robertson, 1900, Trans. Acad. Sci. St. Louis, 10: 52.

Prochelostoma philadelphi Robertson, 1903, Trans. Am. Ent. Soc., 29: 171.

Biology: *Chelostoma philadelphi* is oligolectic on *Philadelphus* (Saxifragaceae) for pollen resources (Michener 2007; Sedivy et al. 2008) but visits other floral taxa for nectar (Ascher & Pickering 2016). In Canada it has been collected in Ontario throughout the month of June (Guelph).

Diagnosis: The female of *C. philadelphi* can be recognized by the combination of genal area wider than compound eye in lateral view and base of labrum with yellowish membranes at lateral extremes, membranes visible when mandibles closed. The male of *C. philadelphi* can be recognized by T7 apical margin produced to four short processes, processes hardly longer than their basal widths, S2 without a distinct protuberance in disc, and S5 without an apical fringe.

***Chelostoma philadelphi* redescription**

Figures: 3.4; 3.28; 3.29

Female: length (7 to 8mm); head width (1.5 to 2mm); ITW (1 to 1.5mm); forewing length (5.5 to 6.5mm).

Colouration: integument black, except as follows: apex of rutellum of mandible brown to piceous; antenna brown, gradually lighter from scape to ultimate flagellomere; tegula honey-coloured to testaceous; all legs brown; tarsal claw straw-coloured; wings hyaline, dusky, marginal cell darkest; apical impressed margin of sterna rufescent.

Pubescence: hairs mostly white; head, including mandible and antenna, mesosoma and metasoma sparsely pubescent, the hairs short, suberect ($<0.5\text{MOD}$), except as follows: mandible with erect, ochraceous pubescence along the upper margin, the hair oriented dorsomedially ($<1.5\text{MOD}$); pubescence of mesepisternum long and dense, sometimes only in fresher specimens (1.5MOD); metasoma with weak apical fascia laterally, arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T3; T6 with ochraceous apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margin (1MOD); sternal scopa suberect, straw-coloured ($>2\text{MOD}$), oriented posteroventrally, arising from the disc; apical margin of S6 fasciate (1MOD).

Surface sculpture: head, including mandible and antenna, finely but deeply punctate ($i=0.5d$), except as follows: mandible impunctate along carinae; hypostomal area less closely punctured ($i>d$); clypeus less closely punctured ($i<d$), with a narrow, nearly impunctate apical margin ($i>2d$); supraantennal depression narrowly impunctate posterior to antennal socket; mesosoma moderately punctate ($i=d$), except as follows: dorsal surface of pronotum less densely punctate ($i=2d$); tegula sparsely punctate, any punctures are only at anterior $1/3$ ($i<2d$); metanotum and dorsolateral angle of propodeum with punctures large ($i<1/2d$); metepisternum less densely punctate, and punctures less deep, less well defined ($i<1.5d$); metapostnotum with basal zone scrobiculate, rest of metapostnotum very finely punctate ($i<0.5d$); metasoma less densely punctate, the punctures moderate ($i=1.5d$), except as follows: T5 with finer punctation ($i<1.5d$); T6 more densely punctate ($i<0.5d$); terga narrowly impunctate at apical margins; sterna with large punctures in disc ($i=d$), otherwise finely punctate ($i<0.25d$).

Structure: head as long as wide; scape 3x longer than wide ($L:W=15:5$); pedicel longer than wide ($L:W=7:5$), ultimate flagellomere (F10) longer than wide ($L:W=8:6$); labrum elongate, nearly the greatest length of the mandible ($30:36$), bearing a distinct median tubercle at its apical margin, thickened at its base and bearing yellow, circular membranes at lateral extremes; mandible tridentate, distance between tooth of rutellum and first tooth of pollex greater than distance from first tooth of pollex to second tooth of pollex ($8:5$), distance from tooth of rutellum to second tooth of pollex over $1/4$ the total length of the mandible measured along its greatest length ($13:40$); hypostomal carina moderate; clypeus convex, highest at base, sloping to a flat apical margin, apical margin produced to short, truncate tubercles laterally, the tubercles

shorter than their greatest width, the margin between them feebly concave and with a tiny tubercle at the midline, the tubercle inconspicuous; clypeoantennal distance $\frac{1}{3}$ the length of the clypeus at its midline (5:15); IAD:AID= 13:8; frontal line deep in anterior half of area between antennal socket and anterior margin of median ocellus; paraocular carina high; supraantennal depression deep; IOC subequal OOC (9:10); IOC < OV (9:11); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 21:15); inner margins of compound eyes subparallel (UID:LID= 51:49); genal area wider than compound eye in lateral view (24:15); parapsidal lines elongate, as long as tegula (17:17); T1 anterior surface feebly concave.

Male: length (5.5 to 7mm); head width (1 to 1.5mm); ITW (0.5 to 1mm); forewing length (4.5 to 5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: rutellum of mandible piceous; metasoma piceous, especially T1 and T2; terga with apical impressed margin amber coloured.

Pubescence: pubescence generally longer than in female (<1MOD), except as follows: mandible without dense pubescence on upper margin; hypostomal area with erect hairs (1.5MOD); paraocular area and frontal area with subapressed pubescence (<1.5MOD); posterior margin of mesoscutellum fringed with long, erect, white to ochraceous hairs (2MOD).

Surface sculpture: head, including mandible and antenna, moderately punctured ($i=d$), except as follows: hypostomal area shallowly punctate ($i<1.5d$); apical margin of clypeus impunctate; supraclypeal, frontal and supraantennal areas more densely punctate ($i=0.5d$); paraocular area with finer, sparser punctation ($i<1.5d$); mesosoma less densely punctured ($i<2d$), except as follows: mesoscutellum and axilla finely punctate anteriorly ($i<d$); metasoma finely but less densely punctate ($i<2d$), except as follows: T1 more densely punctate ($i<1.5d$); T5 with finer punctation ($i<d$); T7 unevenly punctate, impunctate in some areas ($i>d$).

Structure: head longer than wide (L:W= 80:75); scape more than twice as long as wide (L:W= 17:7), pedicel length and width equal, ultimate flagellomere (F11) twice as long as wide

(L:W= 10:5);labrum not thickened apically; mandible bidentate, the distance between teeth less than $\frac{1}{4}$ the greatest length of the mandible (9:46);clypeus less convex than in female, though more evenly so to apical margin, truncate, lateral angles of truncation distinct, the margin between them concave; labrum not truncate apically, and without membranous projections; hypostomal carina high; clypeoantennal distance nearly half the shortest distance of the clypeus (19:8); IAD:AID= 12:7; paraocular carina moderately high; IOC subequal OOC (10:11); IOC < OV (10:15); median ocellus nearly at midpoint between posterior margin of antennasocket and posterior margin of vertexal area (FAL:VAL= 21:22); compound eyes wider than genal area in lateral view (22:20); T7 produced to four short, rounded apical projections, the median projections as long as their basal width, the margin between them concave, the lateral projections wider than lon (L:W= 3:6), the margin between the lateral projection and the median projection weakly concave, feebly undulate; S1 and S2 with a low, transverse submarginal swelling in disc, with that of S2 higher; apical margin of S4 deeply emarginate, each lateral lobe triangulate; S5 to S8 retracted.

Genitalia: as in Fig. 3.29e.

Distribution: *C. philadelphia* is a Nearctic species of *Prochelostoma* primarily distributed east of the Great Plains. It has been collected as far west as Colorado but primarily ranges from southern Ontario south through Iowa and Missouri to Louisiana and east throughout the Atlantic coast south of New Jersey and Pennsylvania (Fig. 3.4d). [CAN: ON; USA: AL, CO, CT, DE, GA, IA, IL, IN, KS, KY, MD, MI, MO, MS, NC, NJ, OH, PE, SC, TN, VA, WI, WV.]

Specimens examined: CAN: Ontario: 2 ♀ Guelph, 19-22.vi.2006 (V MacPhail & H Taki) [2 ♀ Barcoded]; USA: Kansas: ♀ Lawrence, 01.vi.1952 (CD Michener); ♀ Lawrence, 24.v.1952 (CD Michener); ♂ Lawrence, 24.v.1952 (CD Michener); ♂ Douglas Co., 27.v.1983 (CD Michener); USA: New York: ♂ Buffalo, 16.vi.1908 (MCV); USA: Ohio: ♂ Summit Co., 12.vi.1937 (JL Lipovsky).

Type depository: Male and female, from Carlinville, Illinois, in the Robertson collection, Illinois. [Not examined]

***Chelostoma rapunculi* (Lepeletier, 1841)**

Apis fuliginosa Panzer, 1798, Faunae Insectorum Germanicae, 56: 16. [Homonym]

Heriades rapunculi Lepeletier, 1841, Histoire Naturelle des Insectes, 2: 406.

Heriades nigricornis Nylander, 1848, Notiser ur Sällskapetets pro Fauna et Flora Fennica
Förhandlingar, 1: 269.

Chelostoma inerme Eversmann, 1852, Bull. Soc. Imp. Nat. Moscou, 25: 74.

Heriades casularum Chevrier, 1872, Mittheilungen der Schweizerischen Entomologischen
Gesellschaft, 3: 505.

Chelostoma proximum Schletterer, 1889, Zool. Jahr. Syst., 4: 591-691.

Eriades proximus Schletterer, 1889, Zool. Jahr. Syst., 4: 591-691.

Osmia (Acanthosmia) archanensis Cockerell, 1928, Ann. Mag. Nat. Hist. 10(1): 353.

Osmia (Acanthosmia) platyodonta Cockerell, 1928, Ann. Mag. Nat. Hist. 10(1): 352.

Heriades confusa Benoist, 1934a, Bull. Soc. Ent. France, 39: 158-160.

Chelostoma (Gyrodromella) confusum Benoist, 1934b, Bull. Soc. Ent. France, 39: 158-160.

Chelostoma (Gyrodromella) proximum Schletterer, 1889, Zool. Jahr. Syst., 4: 591-691.

Biology: North American and European species are oligolectic on *Campanula* (Campanulaceae) and possibly also on closely related genera, at least for nectar (Westrich 1989; Eickwort 1980; Amiet et al. 2004; Sedivy et al. 2008). In Canada, *Chelostoma rapunculi* has been collected throughout southern Ontario from May 28 (Haldimand-Norfolk) to July 9 (Kinburn).

Diagnosis: Both sexes of *Chelostoma rapunculi* can be recognized by the combination of a strong preoccipital carina and T1 with a broadly concave anterior surface. The female of *C. rapunculi* can be distinguished from all other Canadian *Chelostoma* by the distinctly crenulate apical margin of the clypeus, and the male of *C. rapunculi* can be distinguished from all other Canadian *Chelostoma* by the combination of S2 with a high, distinct protuberance in longitudinal middle third of disc, T7 apical margin produced to three short, truncate lobes, S3 with distinct patches of short, bristle-like setae submarginally on either side of midline and S5 with transverse apical fringe, the pubescence modified, hairs long and distinctly crimped.

Chelostoma rapunculi **redescription**

Figures: 3.4; 3.30; 3.31

Female (N=6): length (9 to 11mm); head width (2 to 2.5mm); ITW (1.5 to 2mm); forewing length (6 to 6.5mm).

Colouration: integument black, except as follows: cap of rutellum of mandible piceous; tegula dark testaceous posteriorly; hind tibial spurs straw-coloured; tarsal claw rufescent; wings hyaline, dusky, darkest along costal margin, stigma and veins dark, nearly black; sterna with apical impressed margin amber-coloured.

Pubescence: hairs mostly white; integument sparsely pubescent with erect hairs (<1MOD), except as follows: paraocular area with appressed pubescence (1MOD); frontal area with erect pubescence (1.5MOD); pronotal lobe with appressed pubescence along posterior margin (<0.5MOD); mesepisternum and metepisternum with subappressed pubescence along dorsal and posterior margins (<2MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, though that of T5 is often much effaced, those of T5 and T6 more ochraceous (<1MOD); sternal scopa suberect (3MOD), oriented posteroventrally and arising from the disc.

Surface sculpture: head, including mandible and antenna, with punctures large and dense ($i=1/3d$), except as follows: hypostomal area finely punctate ($i<1/2d$); clypeus with finer punctation ($i=1/2d$), apical margin impunctate along lateral margins of truncation; impunctate region medially at anterior margin of supraclypeal area, and again in supraantennal depression, immediately posterior to antennal socket; genal area finely and less densely punctate ($i<d$); mesosoma with larger, less dense punctation ($i=1/2d$), except as follows: lateral margins of mesoscutum finely and densely punctate ($i<0.5d$); tegula impunctate, except for narrowly finely punctate anteriorly ($i<0.5d$); axilla more finely punctate than mesoscutum and mesoscutellum ($i<1/2d$); metepisternum impunctate anteroventrally; metapostnotum with horizontal basal zone weakly scrobiculate, not bordered posteriorly, not fully defining pits, otherwise finely punctate ($i\sim 1/2d$); metasoma with larger, less dense punctation ($i=1/2d$), except as follows: T1 anterior surface sparsely punctate ($i<2d$), disc with punctures becoming finer toward apical margin ($i=1/2d$) to a narrow, impunctate apical margin; T2 as in T1; T3 less densely punctate

than T2 ($i=d$), but more densely so than T4 ($i<1.5d$); T5 and T6 more finely punctate ($i<d$), with punctures finest basad, becoming large apically; sterna with punctures large in disc ($i\sim 1/3d$), and impunctate in narrow marginal zone.

Structure: head longer than wide (L:W= 70:65); scape 3x as long as wide (L:W= 24:8), pedicel longer than wide (L:W= 4:3), ultimate flagellomere (F10) longest, longer than wide (L:W= 8:5), ventrally flattened; mandible tridentate, distance from tooth of rutellum to first tooth of pollex hardly greater than distance from first tooth of pollex to second tooth of pollex (11:10), distance from tooth of rutellum to second tooth of pollex less than half the total length of the mandible measured along its greatest length (11:41); hypostomal carina high; apical margin of clypeus with crenulations slender, distinct, mostly evenly spaced; clypeoantennal distance roughly 1/3 the greatest length of the clypeus (7:18); IAD:AID= 14:10; paraocular carina moderately high; supraantennal depression moderately deep; IOC < OOC (10:12); IOC < OV (10:12); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 22:19); preoccipital carina strong; compound eyes convergent below (UID:LID= 42:37); width of compound eye and genal area equal in lateral view; parapsidal line 3/5 as long as tegula (30:50); T1 anterior surface broadly concave.

Male (N= 8): length (8 to 10mm); head width (2 to 2.5mm); ITW (1.75 to 2mm); forewing length (6 to 6.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres brown; terga with apical impressed margin piceous; sterna with gradulus conspicuously lightened.

Pubescence: more densely pubescent than in female (1.5MOD), especially as follows: hypostomal area with erect pubescence (1MOD); margins of clypeus with subappressed pubescence (2MOD); paraocular area with appressed pubescence (1MOD); frontal and supraantennal area with suberect pubescence (2MOD); S4 fringed with large, white pubescence (2MOD) arising from apical margin and oriented posteriorly; S5 fringed with long (<4MOD), large, ochraceous, crimped hairs arising from the apical margin, oriented posteriorly for first 1/4

of their length, then bent at a 90 degree angle and continuing ventrally until the last $\frac{1}{4}$ where they bend again at 90° and end oriented posteriorly.

Surface sculpture: mandible moderately punctate ($i \sim 1/2d$), except along impunctate carinae; hypostomal area punctures larger than in female, similarly dense ($i < 1/2d$); apical margin of clypeus impunctate along lateral margins rather than between them as in female; supraclypeal area and anterior frontal area with finer punctation, as in clypeus ($i = 1/2d$) and without impunctate area; vertexal area somewhat finer, as in genal area ($i < d$); mesoscutum and metepisternum less densely punctate ($i < 1.5d$); mesepisternum and mesoscutellum more densely punctate ($i < d$), though mesepisternum with a conspicuous impunctate region at its posterior dorsal margin; axilla more finely and densely punctate ($i = 1/2d$); punctures of metanotum obscure but dense ($i < 1/2d$); metasomal terga variably punctate, medially with a narrow zone of very sparse punctation, nearly impunctate, punctures largest and densest laterally on all terga; punctures finest on disc of T1, becoming coarser with each tergum, disc of T6 coarsest, T7 only as large as T4; sterna punctures large in disc ($i = 1/2d$), marginal zones impunctate, except as follows: protuberance in disc of S2 impunctate on anterior surface, posterior surface punctures of basal half large ($i < d$) and apical half finely punctate ($i \sim d$); S3 narrowly impunctate along longitudinal midline of disc.

Structure: head length to width roughly equal ($L:W = 92:96$); scape 2.5x as long as wide ($L:W = 35:12$); pedicel length to width equal; ultimate flagellomere flattened ventrally at apex, longer than wide ($L:W = 12:8$); mandible bidentate, distance between teeth about a fifth the greatest length of the mandible ($16:72$); hypostomal carina high; apical margin of clypeus thickened along lateral margins, unevenly crenulate and weakly concave between lateral margins; clypeoantennal distance nearly $\frac{1}{4}$ the length of the clypeus ($28:7$); $IAD:AID = 20:12$; supraantennal depression moderately deep; preoccipital carina strong; $IOC < OOC$ ($12:16$); $IOC < OV$ ($12:18$); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 29:27$); compound eyes convergent below ($UID:LID = 60:50$); compound eye wider than genal area in lateral view ($29:21$); parapsidal line half as long as tegula ($15:30$); T7 tri-lobed, lobes wide and squared off, middle lobe offset, shorter than, and ventral to lateral lobes (width of median lobe: width of lateral lobe: $14:16$); T7 depressed at premarginal line such that the marginal zone is a posterior facing surface; S1 with a

low, inconspicuous, transverse submarginal swelling in disc; disc of S2 with a large, semi-circular protuberance, its anterior and dorsal planes meeting at an acute angle in profile, the apex rounded in ventral view, protuberance occupying the middle 1/3 of the disc; apical margin of S3 with median emargination; apical margin of S4 straight; S5 to S8 retracted.

Genitalia: as in Fig. 3.31d.

Distribution: *C. rapunculi* is widely distributed throughout Europe and has been collected from Northern Africa, Northern and Southwest Asia and North America. In North America its range is narrow expanding only through southern Ontario and Quebec, New York and east through Connecticut, Massachusetts and Vermont (Fig. 3.4e). [CAN: ON, QC; USA: CT, MA, NY, VT.]

Specimens examined: CAN: Ontario: ♂ Dunrobin, 9.vii.2009 (J Phillips) [Barcoded]; ♂ Kinburn, 9.vii.2009 (J Phillips) [Barcoded]; ♀ Kinburn, 21.vii.2009 (J Phillips) [Barcoded]; 4 ♀ 1 ♂ Toronto Nestboxes, Apr-Oct.2011, (Reared: JS MacIvor); ♂ North York, 25.vii.2009 (YORKU PCYU:KA-18); CSR: ♀ Stúrovo, 28.vii.1959 (Z Pádr); CAN: Quebec: ♂ 3km SW Manseau, 05.vii.2013 (M Chagnon); CZE: Praha: ♂ Pedbaba, 12.vi.1963 (Z Pádr); ♂ Pedbaba, 13.vi.1963 (Z Pádr); RUS: Moscow: ♂ Voinova Gora, 16.vi.2008 (TV Levchenko).

Type material: Holotype, female, from France. Depository unknown. [Not examined]

SM.4 *HERIADES*

Heriades cressoni Michener, 1938

Heriades (Physostetha) cressoni Michener, 1938a, Ann. Ent. Soc. Amer., 31: 529.

Biology: *H. cressoni* is polylectic and has been recorded visiting a number of plant families including Asteraceae, Fabaceae and Polemoniaceae (Ascher & Pickering 2016). In Canada, *Heriades cressoni* has been collected from June (24, Vaseux Lake, BC) through August (17, Mahoney Lake, BC).

Diagnosis: The female of *H. cressoni* can be distinguished from other Canadian *Heriades* by the U-shaped tubercle at the base of the labrum which can appear as two small tubercles on either

side of midline when mandibles closed. The male of *H. cressoni* can be recognized by the combination of forelegs not lightened, S1 short, not extending out and over S2, truncate at apex, not pointed or rounded, not reaching T6 when metasoma recurved and with process slender in profile, its apex emarginate when viewed from posterior.

Heriades cressoni redescription

Figures: 3.5; 3.34; 3.35; 3.40

Female (N=18): length 5mm (5 to 7mm); head width 2mm (1.25 to 1.75mm); ITW 2mm (1 to 1.25mm); forewing length 5mm (3.5 to 4.25mm).

Colouration: integument black except as follows: cap of rutellum of mandible piceous; flagellomeres and pedicel dark brown; tarsal claw brown to rufescent; wings hyaline, dusky, marginal cell darkest; tegula dark brown; terga with apical impressed margin brown to rufescent; sterna with apical impressed margin golden.

Pubescence: hairs mostly white; head, mesosoma and metasoma sparsely pubescent with suberect hairs (0.5MOD), except as follows: clypeus with a thin fringe of ochraceous setae in median concavity of apical margin of clypeal truncation, hair erect, oriented anteriorly and arising from the apical margin beneath the truncation (~1MOD); paraocular area with denser, subappressed pubescence (<1MOD); posterior margin of mesoscutellum fringed with long, erect pubescence (~2MOD); dorsal declivous surface of propodeum with moderately dense, suberect pubescence (1.5MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, usually interrupted in middle third of T1 (~0.5MOD); sternal scopa white or straw-coloured, oriented posteroventrally and arising from the disc (>3MOD).

Surface sculpture: head, including mandible and antenna, and mesosoma with punctures large and dense ($i < 1/3d$), the punctures deep and well defined, interspaces shining, except as follows: punctures of scape fine ($i \sim 1/2d$); punctation of mandible fine in outer groove ($i \sim 1/2d$), the space dull, punctation of acetabular interspace moderate basad ($i < d$), becoming finer and denser toward apex of pollex ($i \sim 1/2d$), impunctate along carinae; hypostomal area very finely

punctate, the punctures somewhat shallow ($i=d$); punctures of clypeus somewhat finer than rest of head, largest at posterior margin, becoming finer toward apical margin ($i\sim 1/3d$); lower paraocular area and supraclypeal area with punctures somewhat finer, less dense in lower paraocular area ($i>1/2d$), those of supraclypeal area as dense as those of basal zone of clypeus; pronotum with interspace diameter and puncture size variable, sparsely punctate on anterior surface; punctures of mesoscutum and mesepisternum larger than those of vertexal area and genal area, respectively, similarly dense ($i<1/3d$); tegula impunctate, entirely strigate; punctures of axilla finer than those of mesoscutellum, about as dense as those of vertexal area ($i\sim 1/3d$); punctures of mesoscutellum less dense ($i>1/3d$) than those of mesoscutum, posterior margin, narrowly declivous laterally the posterior surface scrobiculate; metanotum obscure, strigate-rugose, somewhat dull, with a few somewhat obvious punctures ($i>d$); punctation of metepisternum finer than that of mesepisternum, similarly dense; propodeum with lateral surface somewhat finely punctate, less dense ($i\sim 1/2d$) than in mesepisternum, declivous dorsal surface with punctures somewhat fine, well defined, well spaced ($i>d$); metapostnotum with horizontal basal zone scrobiculate, the pits deep and well defined by carinae, otherwise shiny; T1 anterior surface less densely punctate ($i<2d$) than disc, disc with punctures moderate, as large and as dense as those of T2 ($i>1/2d$); punctures of T3 larger than those of T2, somewhat less dense ($1\sim 1/2d$); punctures of T4 larger and denser ($i<1/3d$) than those of T3, and somewhat larger than those of T5, not denser; T5 with punctures finer than those of T4 and T6, those of T6 densest ($i=1/4d$); sterna moderately punctate in disc ($i<3/4d$), impunctate in apical impressed margins.

Structure: head length to width nearly equal ($L:W=62:65$); scape nearly 3x as long as wide ($L:W=20:7$), flagellomeres mostly unmodified, F1-F6 wider than long, F7 length and width equal, F8 to F10 longer than wide; base of labrum with a U-shaped tubercle, the apices basal and thickened, appearing as two small tubercles on either side of the midline when the mandible are closed; mandible tridentate, the teeth rounded at apex, not especially sharp, distance between tooth of rutellum and first tooth of pollex $2/3$ the distance between first and second teeth of pollex (6:9), condylar ridge and outer ridge meeting nearly at the base of the mandible in the outer interspace, the outer ridge veering ventrally, enclosing the outer groove, the point of intersection of the outer ridge and the condylar ridge not especially thickened, acetabular carina thickened, highest in acetabular interspace, higher than outer ridge; hypostomal carina high; clypeus feebly convex, truncate, the lateral angles of truncation broad, with a small,

inconspicuous tubercle-like projection, the projection feebly reflex dorsad, the apical margin between projections distinctly concave; lateral margins of clypeal truncation straight; IAD:AOD= 6:4; paraocular carina moderately high; supraantennal depression moderately deep; IOC subequal OOC (11:12); IOC subequal OV (11:12); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 22:18); compound eyes convergent below (UOD:LOD= 44:36); compound eyes wider than genal area in lateral view (20:18); mesosoma longer than wide (L:W= 52:40); metanotum with transverse ridge strong along anterior margin, the posterior surface declivous; metapostnotum with a narrow horizontal, pitted basal zone, posterior horizontal carina of basal zone high; T1 transverse carina evenly convex, the carina thickened; marginal zone of T6 feebly reflexed dorsad, feebly concave in profile.

Male (N=8): length (allotype: 6mm) (5 to 6mm); head width (allotype: 1.5mm) (1.25 to 1.5mm); ITW (allotype: 1.5) (0.75mm to 1.5mm); forewing length (allotype: 4.5) (4mm to 4.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: tegula and all legs brown to dark brown; wings only weakly dusky; terga with apical impressed margin not lightened.

Pubescence: more densely pubescent than in female, especially on the following: hypostomal area with erect pubescence (<2MOD); clypeus with subappressed pubescence, densest basad (<1.5MOD); mesepisternum not more densely pubescent than rest of mesosoma; S1 and S2 moderately pubescent in disc, the hairs white or lightly ochraceous, suberect, S1 densest at apex of central mound (~1MOD), S2 denser laterally; S3 with a dense, erect fringe in middle 1/3 of the apical margin, the hairs thick, oriented ventrally (~1MOD); apical margin of S5 with ochraceous, thin setae, the hairs erect, fanning out at apicolateral margins (<1MOD), and with highly papillate, minute dark hairs in marginal zone.

Surface sculpture: punctures of scape finer than in female, the punctures somewhat shallow, less dense (i>d); punctuation of mandible very sparse (i>d), the punctures moderate in size, impunctate along carinae; punctuation of lower paraocular area as dense as that of basal zone

of clypeus; punctures of supraclypeal area larger than those of basal zone of clypeus, less dense ($i < 1/2d$); propodeum with dorsal surface with punctures somewhat larger than in female, the punctures less well defined, somewhat denser ($i < d$); T1 anterior surface less densely punctate ($i < 2d$) than disc, disc with punctures moderate, larger at anterior part of disc and becoming finer toward apical margin, the punctures midway between the carina separating the anterior surface from the dorsal surface and the apical margin larger than those of T2, denser ($i = 1/3d$); punctures of T2 and T3 less dense ($i > 1/2d$) than those of T4 ($i = 1/4d$); punctures of T5 finer than those of T4, similarly dense; punctures of T6 about as large as those of T5, somewhat less dense ($i < 1/3d$); S1 with punctures largest in lateral 1/3 of disc, not dense ($i > d$), moderately large in middle 1/3 of medial projection ($i \sim d$) and in marginal zone; S2 moderately punctate in disc and marginal zone ($i \sim d$) with some larger punctures at lateral extremes of the truncation ($i < d$); S3 punctate only at lateral extremes of apical margin, the few punctures moderately large, not evenly spaced ($i > 1/2d$).

Structure: head wider than long (L:W= 30:35); scape nearly 2x as long as wide (L:W= 17:9); labrum thickened basad and with three small tubercles, one on each side of a median tubercle; mandible bidentate, the tooth of the rutellum sharp, that of the pollex broad apically; IAD:AOD= 11:10; compound eyes convergent below (UOD:LOD= 40:30); compound eyes wider than genal area in lateral view (20:16); T6 with disc feebly swollen and marginal zone somewhat reflexed dorsad, sinuate in profile, the disc a U-shaped bulge in dorsal view; T5 to T7 strongly recurved; S1 short, not covering most of S2, truncate at apex, the apical margin broadly rounded, and bearing a large projection over two thirds the distance from base to apex of sternum, the posterior surface reaching the premarginal line, the apex of the projection slender, the anterior surface sloping gradually and the posterior surface steep in profile, apex with a distinct median emargination when viewed from posterior; disc of S2 feebly swollen, more conspicuously so in lateral 1/3, the marginal zone conspicuously impressed, broadly truncate, and with the apical margin between lateral angles of truncation broadly rounded, narrowly reflexed ventrally along the margin, conspicuously so at narrow midline; S3 to S8 as in Figure 3.40.

Genitalia: as in Fig. 3.40 (2)i.

Distribution: *H. cressoni* is distributed throughout much of the Pacific coast, from southern British Columbia to Arizona, and east to New Mexico and Nebraska (Fig. 3.5b). [**CAN:** BC; **USA:** AZ, CA, CO, ID, NE, NM, NV, OR, UT, WA, WY].

Specimens examined: **CAN: British Columbia:** *Thompson-Nicola Reg. Dist.:* ♀ Savona, 16.viii.2008 (LR Best); *Okanagan, Similkameen Reg. Dist.:* 2 ♂ 1 ♀ Oliver, 31.vii.2010 (L Neame); ♀ Ollala, Yellow Lk., 29.vii.2009 (LR Best); 2 ♀ Okanagan Falls, Mahoney Lk., 17.viii.2008 (LR Best); 2 ♀ Osoyoos, Mt. Kruger, 29.vii.2008 (LR Best); 2 ♂ 3 ♀ Summerland, Garnet Lk., 18.vii.2008 (LR Best); 6 ♀ Okanagan Falls, White Lk., 17.viii.2008 (LR Best); 3 ♂ Vaseux Lk., 8.vii.2009 (L Packer); ♀ Vaseux Lk., 24.vi.2009 (L Packer); ♀ Keremeos, Grist Mill, 30.vi.2013 (G Rowe & L Graham); *Kootenay Boundary Reg. Dist.:* ♂ Jewel Lk., 4.viii.2009 (LR Best).

Type depository: Holotype, female (No. 4600), and allotype (No. 4601), from Bluff Lake, San Bernardino Mountains, California, in the California Academy of Sciences. [Examined]

***Heriades leavitti* Crawford, 1913**

Heriades leavitti Crawford, 1913, Can. Entomol., 45: 270

Heriades crawfordi Graenicher, 1928, Ent. News Phil., 39: 281

Neotrypetes truncatus Robertson, 1929, Ecology, 8(1): 131.

Biology: *H. leavitti* is polylectic and has been recorded foraging from various plant families including Asteracea and Fabaceae (Ascher & Pickering 2016). In Canada, *Heriades leavitti* has been collected from late June (20, Toronto, ON) through early August (6-14, Kingston, ON).

Diagnosis: The female of *H. leavitti* can be recognized by the combination of base of labrum with three small tubercles, T6 apical fascia beige-coloured, more closely matching apical fascia of S6 rather than that of T5 and T5 with punctation distinctly less dense than that of T6. The male of *H. leavitti* can be recognized by the combination of first flagellomere wider than long, distinctly lightened forelegs, at least anteriorly on femur and tibia, S1 large, covering most of S2 and often touching T6 when metasoma is recurved, and with apical margin rounded.

***Heriades leavitti* redescription**

Figures: 3.5; 3.36; 3.37; 3.40

Female (N=14): length (5.5 to 7mm); head width (1.5 to 2mm); ITW (1 to 1.5mm); forewing length (4 to 5.25mm).

Colouration: integument black except as follows: cap of rutellum of mandible piceous; flagellomeres and pedicel dark brown; tarsal claw brown to rufescent; wings hyaline, dusky, darkest along costal margin; terga with apical impressed margin brown to rufescent; sterna with apical impressed margin amber-coloured.

Pubescence: hairs mostly white; head, mesosoma and metasoma sparsely pubescent with erect hairs (0.5MOD), except as follows: clypeus with a thin fringe of ochraceous setae in median concavity of apical margin of clypeal truncation, hairs erect, oriented anteriorly at midline and somewhat toward midline laterally, the hairs arising from the apical margin beneath the truncation (~1MOD); paraocular area with denser, subappressed pubescence (<1MOD); posterior margin of mesoscutellum fringed with long, erect pubescence (~2MOD); dorsal declivous surface of propodeum with moderately dense, suberect pubescence (1MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, usually interrupted in middle third of T1 (~0.5MOD), T1 to T5 with hair bands white, that of T6 distinctly darker, tawny-coloured, as in S6; sternal scopa of S1 to S5 white or straw-coloured, S6 darker, tawny-coloured, oriented posteroventrally, arising from the disc (>3MOD).

Surface sculpture: head, including mandible and antenna, and mesosoma with punctures large and dense ($i < 1/3d$), the punctures deep and well defined, interspaces shining, except as follows: punctures of scape fine ($i < d$), somewhat shallow, not well defined; punctuation of mandible somewhat fine in outer groove ($i \sim 1/2d$), somewhat imbricate-punctate, punctuation of acetabular interspace moderate basad ($i < d$), becoming finer and denser toward apex of pollex ($i \sim 1/2d$), impunctate along carinae; hypostomal area very finely punctate ($i = d$); punctures of clypeus finer than rest of head, largest at posterior margin, becoming finer toward apical margin ($i \sim 1/3d$); lower paraocular area and supraclypeal area with punctures somewhat finer, less dense in lower paraocular area ($i > 1/2d$), those of supraclypeal area as dense as those of basal zone of clypeus; pronotum with interspace diameter and puncture size variable, sparsely punctate in

anterior surface; punctures of mesoscutum and mesepisternum larger than those of vertexal area and genal area, respectively, denser ($i < 1/4d$); tegula impunctate, narrowly strigate along peripheral margins; punctures of axilla finer than those of mesoscutellum, about as dense as those of vertexal area ($i \sim 1/3d$); punctures of mesoscutellum less dense ($i > 1/3d$) than those of mesoscutum, posterior margin, narrowly declivous laterally the posterior surface scrobiculate; metanotum obscure, strigate-rugose, somewhat dull, with a few obvious punctures in longitudinal middle $1/3$ ($i > d$); punctation of metepisternum finer than that of mesepisternum, similarly dense; metapostnotum with horizontal basal zone scrobiculate, the pits deep and well defined by carinae, otherwise shiny, very finely punctate or alveolate ($i < d$); propodeum with lateral surface somewhat finely punctate, less dense ($i < 1/2d$) than in mesepisternum, declivous dorsal surface with punctures moderate, well defined, well spaced ($i > 1/2d$); T1 anterior surface less densely punctate ($i < 2d$) than disc, disc with punctures large, distinctly larger and denser ($i \sim 1/3d$) than those of T2 ($i \sim d$); punctures of T3 somewhat larger than those of T2, somewhat less dense ($i > d$), the interspaces distinctly highly foveolate, somewhat dull; punctation of T4 and T5 as in T3, but somewhat denser ($i < d$); T6 with punctures finer than those of T5, distinctly denser ($i = 1/3d$); sterna moderately punctate in disc ($i < d$), impunctate in apical impressed margins of S1 to S5, S6 marginal zone finely punctate ($i \sim 1/2d$).

Structure: head length to width nearly equal ($L:W = 27:30$); scape 3x as long as wide, flagellomeres mostly unmodified, F1-F4 wider than long, F5 to F7 length and width equal, F8 to F10 longer than wide; base of labrum with a tubercle at midline, visible when the mandible are closed; mandible tridentate, the teeth rounded at apex, not especially sharp, distance between tooth of rutellum and first tooth of pollex over $2/3$ the distance between first and second teeth of pollex (10:14), condylar ridge and outer ridge widely separated in the outer interspace, the ridges produced basad and meeting the abductor swelling at the base of the mandible, the abductor swelling distinct; hypostomal carina high, highest posteriorly; clypeus feebly convex, subtruncate, the lateral angles of truncation broadly rounded, with two small, inconspicuous tubercle-like projections, the projections feebly reflex dorsad, the apical margin between median projections of lateral margins of truncation straight or feebly concave, lateral margins of clypeal truncation straight; $IAD:AOD = 8:5$; paraocular carina moderately high; supraantennal depression moderately deep; $IOC = OOC$; $IOC < OV$ (11:13); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 24:21$);

compound eyes convergent below (UOD:LOD= 26:23); compound eyes hardly wider than genal area in lateral view (11:10); mesosoma longer than wide (L:W= 68:59); metanotum with transverse ridge strong along anterior margin, the posterior surface declivous; metapostnotum with a narrow horizontal, pitted basal zone, posterior horizontal carina of basal zone high; propodeum with dorsal surface entirely declivous; T1 transverse carina inconspicuously sinuate at lateral extremes, the carina thickened; marginal zone of T6 feebly reflexed dorsad, feebly concave in profile.

Male (N=13): length 6mm (5 to 7mm); head width 1.5mm (1.5 to 2mm); ITW 1mm (1 to 1.25mm); forewing length 4mm (4 to 5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: tegula brown to dark brown; fore femur distinctly yellowed anteriorly; terga with apical impressed margins not lightened.

Pubescence: more densely pubescent than in female, especially on the following: hypostomal area with erect pubescence (<2MOD); clypeus with subappressed pubescence, densest basad (<1.5MOD); pubescence of frontal area and along posterior margin of mesoscutellum somewhat infuscated; S1 and S2 moderately pubescent in disc, the hairs white or lightly ochraceous, suberect, S1 densest along longitudinal midline, especially at apical margin (~1.5MOD), S2 denser laterally in discal area, but median emargination of apical margin distinctly fringed, the hairs dense, ochraceous, oriented toward midline (~1.5MOD); S3 densely pubescent in disc (~2MOD) and with a submarginal fringe for the width of the disc, the hairs thick, distinctly ochraceous, oriented ventrally (>2MOD); marginal zone of S5 covered in highly papillate, ochraceous setae, the hairs oriented posteriorly on lateral lobes, and toward the midline in the broad median concavity (<1.5MOD); marginal zone of S6 with dense, subapical patches of white pubescence on either side of the longitudinal midline (1MOD).

Surface sculpture: punctures of scape finer than in female, the punctures less shallow, more well defined ($i \sim d$); punctation of outer interspace of mandible imbricate, npt well defined ($i > d$); punctation of lower paraocular area as dense as that of basal zone of clypeus; punctures of

supraclypeal area larger than those of basal zone of clypeus, denser ($i < 1/4d$); declivous dorsal surface of propodeum with punctures somewhat larger than in female, the punctures somewhat shallow, less well defined ($i < 1/2d$); T1 anterior surface less densely punctate ($i < 2d$) than disc, disc with punctures large, only somewhat larger than those of T2 and T3, distinctly denser ($i \sim 1/3d$) than those of T2 and T3 ($i \sim 1/2d$); punctures of T4 and T5 distinctly denser ($i = 1/4d$) than those of T3; T6 with punctures larger than those of T5, as dense in middle 1/3, less dense in lateral 1/3 ($i > 1/3d$); S1 with punctures largest in lateral 1/3 of disc, moderately dense ($i > 1/2d$), moderately large in middle 1/3 ($i \sim d$) and in marginal zone; S2 moderately punctate throughout disc and marginal zone ($i \sim d$) with some larger punctures in lateral extremes ($i < d$); S3 finely punctate in disc ($i > d$), with a few large punctures at lateral extremes of apical margin ($i \sim d$); S4 very finely and sparsely punctate in marginal zone ($i > 3d$).

Structure: head wider than long (L:W= 63:56); scape over 2x as long as wide (L:W= 14:6), F1 wider than long (L:W= 4:5), F2 to F11 longer than wide, F11 longest (L:W= 9:5) and ventrally flattened; labrum thickened basad, without a tubercle; mandible bidentate, the tooth of the rutellum somewhat sharp, that of the pollex broad apically; clypeus with lateral angles of truncation distinct, angulate, the apical margin between lateral angles straight; IAD:AOD= 13:6; paraocular carina high; supraantennal depression deep; IOC=OOC; IOC subequal OV (10:11); median ocellus behind midpoint between posterior margin of antennal base and posterior margin of vertexal area (FAL:VAL= 20:17); compound eyes convergent below (UOD:LOD= 45:37); compound eyes wider than genal area in lateral view (28:18); T6 with disc feebly swollen in longitudinal middle 1/3, marginal zone feebly concave in lateral 1/3, sinuate in profile, centre of disc high in dorsal view; T5 to T7 strongly recurved; S1 long, covering most of S2, swollen in disc and truncate at apex, the apical margin broadly rounded between sinuate lateral angles of the truncation; disc of S2 concave, swollen submarginally, more conspicuously so in lateral 1/3, the marginal zone conspicuously impressed, somewhat reflexed at apical margin, the margin broadly bilobed; S3 to S8 as if Figure 3.40.

Genitalia: as in Fig. 3.40 (3)i.

Distribution: *H. leavitti* is primarily distributed throughout low coastal regions along the east coast of North America, but extends west to Texas and Nebraska. In Canada it has been collected

from southern Ontario and New Brunswick (Fig. 3.5c). [CAN: ON, NB; USA: AL, AR, FL, GA, IN, IL, KY, LA, MA, ME, MD, MI, MS, NC, NE, NY, SC, TX, WI.]

Specimens examined: CAN: Ontario: ♂Caledon, Gschwendtner Property, 07.viii.2003 (J Gixti) [Barcoded]; 3 ♀ *Frontenac Co.*, Kingston, QUBS, 06-14.viii.05 (L Packer); *North York Co.*: 2 ♂4 ♀ Toronto, 01.vii.2010 (L Packer) [♂4 ♀ Barcoded]; 2 ♂Toronto, 20.vi.2010 (L Packer) [2 ♂Barcoded]; ♂5km NW Almonte, 07.viii.1985 (H Goulet); USA: Illinois: ♂ *Montgomery Co.*, 10 km NE Litchfield, 25.vi.2006 (J Gibbs & C Sheffield); USA: Maryland: 2 ♂ *Caroline Co.*, 03.vi.2011 (SW Droege); 2 ♂ *Wicomico Co.*, 03.vi.2011 (SW Droege); ♂ *Kent Co.*, 06.vi.2011 (SW Droege); ♂ *Pr. George's Co.*, 09.viii.2009 (SW Droege); *Washington Co.*: ♀ 04.ix.2009 (SW Droege); ♀ 18.ix.2009 (SW Droege); ♀ Assateague Isl., 03.vii.2006 (SW Droege); USA: Virginia: 3 ♀ Assateague Isl., 2.vii.2006 (SW Droege); ♀ *Accomack Co.*, 9.vii.2005 (SW Droege).

Type depository: Holotype, male, from Nerepis New Brunswick, in the US National Museum, Washington, D.C., USA. [Examined]

***Heriades variolosa* (Cresson, 1872)**

Megachile variolosa Cresson, 1872, Trans. Amer. Ent. Soc., 4: 270.

Heriades variolosum Cresson, 1876, Proc. Davenport Acad. Sci., 1: 209.

Heriades odontophora Schletterer, 1889, Zool. Jahrb., Abt. f. Syst., 4: 679.

Heriades asteris Cockerell, 1897, Ann. Mag. Nat. Hist., 6(20): 135.

Trypetes barbatus Robertson, 1903, Trans. Am. Ent. Soc., 29: 171.

Trypetes carinatus Robertson, 1903, Trans. Am. Ent. Soc., 29: 171. (Misidentification)

Trypetes productus Robertson, 1905, Can. Entomol., 37: 236.

Heriades carinata purpurascens Cockerell, 1931, Ann. Mag. Nat. Hist., 10(8): 543.

Heriades (Neotrypetes) variolosa purpurascens Cockerell, 1931, Ann. Mag. Nat. Hist., 10(8): 543.

Heriades (Neotrypetes) variolosus purpurascens Cockerell, 1931, Ann. Mag. Nat. Hist., 10(8): 543.

Biology: Like the other Canadian species, *Heriades variolosa* is polylectic and has been recorded visiting many plant families for resources (Ascher & Pickering 2016). In Canada, *Heriades variolosa* has been collected from June (29, Keremeos, BC) through August (26, White Lake, BC).

Diagnosis: The female of *H. variolosa* can be recognized by the combination of labrum with three small tubercles basad, T6 with apical fascia mostly white, more closely matching apical fascia of T5 rather than that of S6 and T5 with punctation at least as dense, or nearly so, as that of T6. The male of *H. variolosa* can be distinguished by the combination of first flagellomere at least as long as wide, forelegs distinctly lightened, S1 large, covering most of S2, apical margin distinctly pointed.

Heriades variolosa **redescription**

Figures: 3.5; 3.38; 3.39; 3.40

Female (N= 58): length 7mm (4.5 to 8mm); head width 1.5mm (1.25 to 2mm); ITW 1mm (1 to 1.5mm); forewing length 4mm (4 to 5mm).

Colouration: integument black except as follows: cap of rutellum of mandible piceous; flagellomeres and pedicel dark brown; tarsal claw brown to rufescent; wings hyaline, dusky, darkest along costal margin and in marginal cell; terga with apical impressed margin brown to rufescent; sterna with apical impressed margin amber-coloured.

Pubescence: hairs mostly white; head, mesosoma and metasoma sparsely pubescent with erect hairs (0.5MOD), except as follows: clypeus with a thin fringe of ochraceous setae in median concavity of apical margin of clypeal truncation, hairs erect, oriented anteriorly at midline and somewhat toward midline laterally, the hairs arising from the apical margin beneath the truncation (~1MOD); paraocular area with denser, subappressed pubescence (<1MOD); posterior margin of mesoscutellum fringed with long, erect pubescence (~2MOD); dorsal declivous surface of propodeum with moderately dense, suberect pubescence (1MOD); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, usually interrupted in middle third of T1 (~0.5MOD);

sternal scopa of S1 to S5 white or straw-coloured, oriented posteroventrally, arising from the disc ($>3\text{MOD}$); S6 apical fascia tawny-coloured ($\sim 0.5\text{MOD}$).

Surface sculpture: head, including mandible and antenna, and mesosoma with punctures large and dense ($i < 1/3d$), the punctures deep and well defined, interspaces shining, except as follows: punctures of scape fine ($i < d$), somewhat shallow, not well defined; punctation of mandible somewhat fine in outer groove ($i \sim 1/2d$), somewhat imbricate-punctate, punctation of acetabular interspace moderate basad ($i < d$), becoming finer and denser toward apex of pollex ($i \sim 1/2d$), impunctate along carinae; hypostomal area very finely punctate ($i = d$); punctures of clypeus somewhat finer than rest of head, largest at posterior margin, becoming finer toward apical margin ($i \sim 1/3d$); lower paraocular area as in basal zone of clypeus, though punctures more evenly rounded; supraclypeal area with punctures somewhat finer than basal zone of clypeus, about as dense, evenly rounded as in rest of head; pronotum with interspace diameter and puncture size variable, sparsely punctate on anterior surface; punctures of mesoscutum and mesepisternum larger than those of vertexal area and genal area, respectively, denser ($i < 1/4d$); tegula impunctate, entirely strigate; punctures of axilla finer than those of mesoscutellum, about as dense as those of vertexal area ($i \sim 1/3d$); punctures of mesoscutellum less dense ($i > 1/3d$) than those of mesoscutum, posterior margin, narrowly declivous laterally the posterior surface scrobiculate; metanotum obscure, strigate-rugose, somewhat dull, with a few obvious punctures in longitudinal middle $1/3$ ($i > d$); punctation of metepisternum finer than that of mesepisternum, similarly dense; metapostnotum with horizontal basal zone scrobiculate, the pits deep and well defined by carinae, otherwise shiny; propodeum with lateral surface somewhat finely punctate, less dense ($i < 1/2d$) than in mesepisternum, declivous dorsal surface with punctures moderate, well defined, well spaced ($i > 1/2d$); T1 anterior surface less densely punctate ($i < 2d$) than disc, disc with punctures large, distinctly larger and denser ($i \sim 1/3d$) than those of T2 ($i \sim d$); punctures of T3 somewhat larger than those of T2, somewhat less dense ($i > d$), the interspaces distinctly highly foveolate; punctation of T4 and T5 as in T3, but somewhat denser ($i < d$); T6 with punctures finer than those of T5, not denser than those of T5; sterna moderately punctate in disc ($i < d$), impunctate in apical impressed margins of S1 to S5, S6 marginal zone finely punctate ($i \sim 1/2d$).

Structure: head length to width subequal (L:W= 27:28); scape nearly 3x as long as wide (L:W= 15:6), flagellomeres mostly unmodified, F1-F5 wider than long, F6 and F7 length and width equal, F8 to F10 longer than wide; base of labrum with a tubercle at midline, visible when the mandible are closed; mandible tridentate, the teeth rounded at apex, not especially sharp, distance between tooth of rutellum and first tooth of pollex about 1/2 the distance between first and second teeth of pollex (5:9), condylar ridge and outer ridge widely separated in the outer interspace, the ridges produced basad and meeting the abductor swelling at the base of the mandible, the abductor swelling distinct; hypostomal carina high, highest posteriorly; clypeus feebly convex, subtruncate, the lateral angles of truncation broadly rounded, the lateral angles undulate or feebly crenulate, the crenulations forming inconspicuous broad, tubercle-like projections, the projections feebly reflex dorsad, the apical margin between projections of lateral margins of truncation straight or feebly concave, lateral margins of clypeal truncation straight; IAD:AOD= 18:12; paraocular carina moderately high; supraantennal depression moderately deep; IOC > OOC (14:11); IOC subequal OV (14:15); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 24:21); compound eyes convergent below (UOD:LOD= 30:25); compound eyes hardly wider than genal area in lateral view (21:19); mesosoma longer than wide (L:W= 62:58); metanotum with transverse ridge strong along anterior margin, the posterior surface declivous; metapostnotum with a narrow horizontal, pitted basal zone, posterior horizontal carina of basal zone high; dorsal surface of propodeum entirely declivous; T1 transverse carina inconspicuously sinuate at lateral extremes, the carina thickened; marginal zone of T6 feebly reflexed dorsad, feebly concave in profile.

Male (N= 23): length (5 to 7mm); head width (1.25 to 1.5mm); ITW (1 to 1.25mm); forewing length (4 to 5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: tegula brown to dark brown; fore femur distinctly yellowed anteriorly; terga with apical impressed margin not lightened.

Pubescence: more densely pubescent than in female, especially on the following: hypostomal area with erect pubescence ($<2\text{MOD}$); clypeus with subappressed pubescence, densest basad ($<1.5\text{MOD}$); pubescence of frontal area and along posterior margin of mesoscutellum somewhat infuscated; S1 and S2 moderately pubescent in lateral extremes of disc, the hairs white or lightly ochraceous, suberect; S2 with median tuft subapically, the hairs somewhat dense, ochraceous, oriented posteriorly ($\sim 1.5\text{MOD}$); S3 densely pubescent in disc ($\sim 2\text{MOD}$) and with a submarginal fringe for the width of the disc, the hairs thick, distinctly ochraceous, oriented ventrally ($>2\text{MOD}$); S4 with a thin, subapical fringe, the hairs sparse, erect, ochraceous ($\sim 2\text{MOD}$); marginal zone of S5 covered in highly papillate, ochraceous setae, the hairs oriented posteriorly on lateral lobes, and toward the midline in the broad median concavity ($<1.5\text{MOD}$); marginal zone of S6 with a few long hairs arising subapically at midline, the hairs subappressed, oriented anteriorly (1.5MOD).

Surface sculpture: punctures of scape finer than in female, the punctures less shallow, more well defined ($i \sim d$); punctation of outer interspace of mandible somewhat imbricate, not entirely well defined ($i < d$); punctation of lower paraocular area as dense as that of basal zone of clypeus; punctures of supraclypeal area larger than those of basal zone of clypeus, denser too ($i < 1/4d$); T1 anterior surface less densely punctate ($i < 2d$) than disc, disc with punctures large, only somewhat larger than those of T2; T3 about as large as T1, larger than T2, about as dense; punctures of T4 and T5 distinctly larger and denser ($i = 1/4d$) than those of T3; T6 with punctures finer than those of T5, as dense; S1 with large punctation in disc, punctures somewhat denser in middle 1/3 of disc ($i > 1/2d$), denser in marginal zone ($i \sim 1/2d$); S2 punctures large in disc and marginal zone ($i < 1/2d$); S3 finely punctate in disc ($i > 2d$), with a few large punctures at lateral extremes of apical margin ($i \sim d$); S4 very finely and sparsely punctate in marginal zone ($i > 3d$).

Structure: head wider than long ($L:W = 36:40$); scape over 2x as long as wide ($L:W = 13:6$), F1 wider than long ($L:W = 9:8$), F2 to F11 longer than wide, F11 longest ($L:W = 17:10$). F10 and F11 ventrally flattened; labrum thickened basad, without a tubercle; mandible bidentate, the tooth of the rutellum somewhat sharp, that of the pollex broad apically; clypeus subtruncate, lateral angles of truncation not distinct, rounded, the apical margin between lateral angles straight; $IAD:AOD = 12:5$; paraocular carina moderately high; supraantennal depression moderately deep; $IOC = OOC$; $IOC < OV$ ($7:9$); median ocellus behind midpoint between

posterior margin of antennal base and posterior margin of vertexal area (FAL:VAL= 16:13); compound eyes convergent below (UOD:LOD= 30:24); compound eyes much wider than genal area in lateral view (21:11); T6 with disc feebly swollen in longitudinal middle 1/3, marginal zone feebly concave in lateral 1/3, sinuate in profile, centre of disc high in dorsal view; T5 to T7 strongly recurved; S1 long, covering most of S2, swollen in disc and truncate at apex, the apical margin produced to a distinct point at midline; disc of S2 swollen submarginally, more conspicuously so in lateral 1/4, the marginal zone conspicuously impressed, the margin truncate, rounded; S3 to S8 as in Figure 3.40.

Genitalia: as in Fig. 3.40 (4)i.

Distribution: *H. variolosa* is distributed from coast to coast through North America, from southern Canada and south through Mexico. While most abundant in the southern parts of the western Canadian provinces, *H. variolosa* has been collected as far north as La Crete, Alberta and east through Ontario (Fig. 3.5d). [CAN: BC, AB, SK, MB, ON; USA: AL, AR, AZ, CO, CT, DE, IA, IL, IN, ID, KS, KY, MA, MD, ME, MI, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NY, OH, OR, PE, TX, UT, VA, WA, WI, WV, WY; MEX: NL; TM; YU].

Specimens examined: CAN: Alberta: ♀ Cypress Co., Cypress Hills P. P., 04-05.viii.2013 (G Rowe & L Graham); CAN: British Columbia: *East Kootenay Reg. Dist.*: ♂ nr Cranbrook, Pine Butte Ranch, 9-10.vii.2013 (G Rowe & L Graham); ♂ Wasa, 9.vii.2013 (G Rowe & L Graham); *Okanagan-Similkameen Reg. Dist.*: 4 ♂ 3 ♀ Keremeos, Grist Mill, 30.vi.2013 (G Rowe & L Graham); 2 ♂ 1 ♀ Keremeos, Grist Mill, 29.vi.2013 (G Rowe & L Graham); 3 ♂ Keremeos, Grist Mill, 28.vi.2013 (G Rowe & L Graham); 23 ♀ Okanagan Falls, Mahoney Lk., 17.viii.2008 (LR Best); ♀ Willowbrook, 23.vii.2008 (LR Best); ♂ 3 ♀ Osoyoos, 26.vii.2008 (LR Best); ♀ Okanagan Falls, White Lk., 17.viii.2008 (LR Best); ♀ Okanagan Falls, White Lk., 23.viii.2008 (LR Best); ♀ Okanagan Falls, White Lk., 26.viii.2008 (LR Best); 3 ♂ Osoyoos, Mt. Kruger, 16.vii.2008 (LR Best); 2 ♀ Osoyoos, Mt. Kruger, 29.vii.2008 (LR Best); 2 ♀ Osoyoos, Willow Beach, 17.viii.2008 (LR Best); 3 ♀ Oliver, Ripley Lk., 12.vii.2008 (LR Best); ♂ Oliver, 13.vii.2008 (LR Best); 6 ♀ Oliver, 2.viii.2009 (LR Best); CAN: Manitoba: ♀ ♂ Tall Grass Prairie Preserve, 27.vii. 2009 (S Semmler); ♀ Tall Grass Prairie Preserve, 6.viii.2009 (S. Semmler); CAN: Saskatchewan: 4 ♂ Wood Mtn. Reg. P., 01.viii.2013 (C Sheffield & K

Sheffield); ♀ Cypress Hills, 13.viii.2013 (D Frier); **USA: Illinois:** ♀ *Montgomery Co.*, 25.vi.2006 (J Gibbs & C Sheffield); **USA: Maryland:** ♂ *Montgomery Co.*, 3.vii.2008 (J Whitaker) ♀ *Kent Co.*, 6.vi.2011 (J Martin); ♀ *Wicomico Co.*, 12.vi.2004 (SW Droege); ♀ Assateague Isl., 3.vii.2006; **USA: New Mexico:** ♀ *Otero Co.*, nr Cloudcroft, 11.viii.2007 (J Gibbs & C Sheffield); **USA: North Carolina:** ♀ *Hyde Co.*, 7.vi.2005 (SW Droege); **USA: Virginia:** ♂ Assateague Isl., 2.vii.2006 (SW Droege); **USA: West Virginia:** ♀ *Hardy Co.*, 7-27.vi.2007 (D Smith).

Type depository: Lectotype, female, from Texas, in the Academy of Natural Sciences of Philadelphia, USA. [Examined]

SM.5 HOPLITIS

***H. anthocopoides* (Schenk, 1853)**

Osmia anthocopoides Schenk, 1853, Jb. Ver. Naturk. Nassau, 9: 181.

Osmia caementaria Gerstaecker, 1869, Stettin. Ent. Ztg., 30: 339.

Osmia clavipennis Schenk, 1870, Stettin. Ent. Ztg., 31: 106.

Osmia hybrid Pérez, 1879, Act. Soc. Linn. Bordeaux, 33: 200.

Osmia romana Morice, 1901, Trans. Ent. Soc. London, 169: 176.

Fertonella algerica Benoist, 1969, Bull. Soc. Ent. France, 74: 244.

Biology: *H. anthocopoides* is oligolectic on Boraginaceae (Eickwort 1970; 1975; Westrich 1989; Gogala 1999; Banaszak & Romashenko 2001; Amiet et al. 2004; Ascher & Pickering 2016). In Canada, *H. anthocopoides* has been collected in southern Ontario in late June (30, near Guelph) and early July (4, near Guelph).

Diagnosis: Both sexes of *H. anthocopoides* can be recognized by the base of the labrum which bears a yellow membrane at lateral extremes, the membrane exposed when mandibles closed. The female of *H. anthocopoides* can be recognized by the crenulate apical margin of the clypeus, and the male of *H. anthocopoides* can be recognized by the irregularly notched apical margin of T6 between lateral teeth.

H. anthocopoides **redescription**

Figures: 3.6; 3.43; 3.44

Female (N=1): length (9mm); head width (3mm); ITW (2.5mm); forewing length (7mm).

Colouration: integument black, except as follows: antennal flagellomeres brownish grey; apex of rutellum of mandible reddish-brown; tegula and all legs dark brown; wings hyaline, dusky, darkest along costal margin; hind tibial spur honey-coloured.

Pubescence: hairs white to light ochraceous, integument covered with moderately dense, suberect pubescence (~2MOD), except for the following: clypeus medially with pubescence less dense or absent, setae arising from apical margin ochraceous (~1.5MOD); supraclypeal area and lower frontal area with somewhat denser pubescence (2MOD); paraocular area with somewhat denser, subappressed pubescence (1.5MOD); tomentum outlining posterior half of pronotal lobe conspicuous (<1MOD); posterior margin of mesoscutellum with long, erect hairs (~3MOD); tegula with a small patch of short hairs anteriorly (<1MOD); metapostnotum without pubescence; setae of basitarsus of all legs dense, suberect, orange (~1MOD); metasomal terga with discal pubescence ochraceous and erect (~1MOD), not dense, with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins, the hairs white to yellowed, densest laterally (<1MOD); sternal scopa suberect, white (<3MOD), oriented posteroventrally, arising from the disc.

Surface sculpture: head, including mandible and antenna, with fine, dense punctation (i~0.25d), except for the following: punctures of supraclypeal area, anteriorly, larger, less dense (i<0.5d); punctures of frontal area slightly smaller, though similarly spaced (i~0.25d); mesosoma with fine, dense punctation (i~0.25d), except for the following: tegula impunctate posteriorly; punctures of mesepisternum larger, larger than those of genal area (i~0.5d); punctures of metanotum and metepisternum obscure, the interspaces roughened, dull; metapostnotum roughened, dull, with narrow basal zone bearing inconspicuous carinulae, oriented anterior-posterior; metasoma with punctation somewhat more shallow than in head and mesosoma, still dense (i~0.5d), except for the following: T1 anterior surface impunctate, shining; interspaces of T5 and T6 not shining as in T1-T4; punctation of T6 very fine, dense (i<0.5d); sterna moderately punctured beneath scopa (i>0.5d), impunctate in marginal zone.

Structure: scape over three times longer than wide (28:8); pedicel length and width equal; flagellomeres unmodified; head wider than long (49:42); hypostomal carina low; mandible tridentate, distance from tooth of rutellum to first tooth of pollex greater than the distance between the first and second teeth of the pollex (10:8); distance from tooth of rutellum to second tooth of pollex less than the greatest width of the compound eye (25:28); clypeus strongly convex, apical margin truncate, with the margin between angles of truncation straight, crenulate, with crenulations longest medially; base of labrum with yellowish membranes at lateral extremities, visible when mandibles closed; anterior tentorial pits deep, well defined; IAD:AOD= 29:19; median ocellus behind midpoint between posterior margin of antennal base and posterior margin of vertexal area (FAL:VAL= 36:19); IOC=OOC; IOC>OV (21:15); frontal area with a small tubercle at midpoint between antennal sockets at the posterior margin of antennal socket; genal area wider than compound eye in lateral view (13:11); compound eyes convergent below (UOD:LOD= 33:30); mesosoma longer than wide (L:W= 55:48); metanotum sloping; T1 with anterior surface moderately deep, sharply delimited from the dorsal surface of the tergum by a strong angle.

Male (N=3): length (9.5 to 11mm); head width (3 to 3.5mm); ITW (2.5mm); forewing length (7 to 7.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: integument darker than that of female, though patterning similar.

Pubescence: denser and more ochraceous than that of female; clypeus with pubescence dense and continuing along the midline; pubescence of genal area ventrally very dense, erect (>3MOD); S1 to S4 with row of white setae, oriented posteriorly and arising from the premarginal zone (~2MOD); S6 with dense tufts of erect setae on the bilobed, median apical projection (~1MOD).

Surface sculpture: head finely and evenly punctured ($i < 0.5d$), except for the following: punctation of clypeus finer still ($i \sim 0.25d$); punctation of hypostomal area obscure, interspaces shining ($i > 0.5d$); mesoscutellum with conspicuous impunctate medial zone, running anterior-posterior in segment; metanotum with interspaces somewhat shiny, not as dull as those of

female, though punctures still obscure; T1 to T5 punctures similar ($i < d$), interspaces shining; T6 with denser punctation ($i \sim 0.5d$), somewhat finer; T7 with larger pits, sparse ($i > 2d$); S2 to S5 with moderate punctation in disc ($i \sim 0.5d$), narrowly impunctate along transverse submarginal swellings.

Structure: scape nearly three times longer than wide (29:10), F1 longer than wide (14:9); pedicel length to width equal; head wider than long (50:43); mandible bidentate, distance from tooth of rutellum to first tooth of pollex roughly a quarter then greatest width of the compound eye (11:40); IAD:AOD= 22:16; compound eyes convergent below (UOD:LOD= 31:28); median ocellus behind midpoint between posterior margin of antennal base and posterior margin of vertexal area (FAL:VAL= 30:19); OOC subequal IOC (19:18); IOC>OV (19:16); compound eye wider than genal area in lateral view (15:12); mesoscutum longer than wide (55:50); metanotum entirely declivous; T6 with lateral teeth, pointed, as long as their basal width, with the margin between the lateral tooth and the truncate apical margin hardly wider than a semicircle, margin of truncation irregularly sinuate, almost crenulated; T7 truncate, rounded, with inconspicuous, rounded teeth at lateral extremities; S1 unmodified, truncate at apex; S2 to S5 with low, transverse submarginal swellings; S6 with a bilobed, median apical projection; S7 and S8 retracted.

Genitalia: as in Fig. 3.44e.

Distribution: Since its introduction to the Nearctic (New York State, USA) from the Palaearctic, *H. anthocopoides* has spread north into southern Ontario, and south through Pennsylvania, Maryland, Virginia and West Virginia (Fig. 3.6b). [**CAN:** ON; **USA:** MD, NY, PE, VA, WV.]

Specimens examined: **CAN: Ontario:** ♀ nr. Guelph, 3.vii.2008 (M Horn) [Barcoded]; ♂ nr. Guelph, 4.vii.2008 (M Horn) [Barcoded]; ♂ nr. Guelph, 30.vi.2008 (M Horn) [Barcoded]; **USA: West Virginia:** ♂ Hampshire Co., 29-30.v.2004 (SW Droege).

Type depository: Lectotype, Germany, by designation of Tkalcu. Depository unknown. [Not examined]

***Hoplitis fulgida* (Cresson, 1864)**

Osmia fulgida Cresson, 1864b, Proc. Ent. Soc. Phil., 3: 34.

Osmia viridis Cresson, 1864b, Proc. Ent. Soc. Phil., 3: 35.

Osmia platyura Cockerell, 1911b, Ann. Mag. Nat. Hist., 8: 765.

Chlorosmia lawae Michener, 1936c, Amer. Mus. Novitates, 875: 29.

Hoplitis (Monumetha) fulgida fulgida Hurd & Michener, 1955, Bull. Calif. Ins. Sur., 3: 81.

Hoplitis (Monumetha) fulgida platyura Hurd & Michener, 1955, Bull. Calif. Ins. Sur., 3: 81.

Hoplitis (Alcidamea) fulgida Sedivy et al., 2013, Zool. J. Linn. Soc., 167(1): 28-42.

Biology: *Hoplitis fulgida* is polylectic and has been recorded foraging on many plant families including Asteraceae, Boraginaceae, Fabaceae and Hydrophyllaceae (Michener 1947; Wilson et al. 2010; Asher & Pickering 2016). In Canada it has been collected from early May (08, Osoyoos, BC) to August (18, Ram Creek, FSR, BC).

Diagnosis: The female of *H. fulgida* can be recognized by the combination of integument brilliantly metallic bluish-green to purple, compound eye not parallel sided, dorsal end tapered, distinctly narrower than ventral end and mesoscutum not especially wide, not at least one and a half times wider than long. The male of *H. fulgida* can be recognized by the combination of integument brilliantly metallic green, ultimate flagellomere rounded at apex and T7 apical margin truncate.

***H. fulgida* redescription**

Figures: 3.6; 3.45; 3.46

Female (N=63): length 8.5mm (7 to 12mm); head width 2mm (2 to 3mm); ITW 1mm (1 to 2mm); forewing length 5.5mm (5 to 7mm).

Colouration: integument brilliant metallic, bluish green, except as follows: scape mostly dark brown, feebly metallic bluish green in some areas, flagellomeres dark brown; labrum brown to black; mandible dark brown to black, except in outer interspace where it is feebly metallic

bluish green; clypeus with apical margin dark brown to black between lateral angles of truncation; all legs with tarsi, basitarsi and tarsal claw brown to piceous; hind tibial spur dark brown; wings hyaline, dusky brown; sterna with apical impressed margin brown to black.

Pubescence: hairs mostly black; head and mesosoma moderately pubescent with long, erect hairs ($>2\text{MOD}$), except as follows: clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation ($\sim 1\text{MOD}$); pubescence of genal area somewhat shorter than in rest of head ($\sim 1\text{MOD}$), erect; pubescence of metasoma shorter, more evenly distributed ($<1.5\text{MOD}$); T6 with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margin ($\sim 1\text{MOD}$); sternal scopa black, oriented posteroventrally, arising from the disc ($\sim 3\text{MOD}$).

Surface sculpture: head, including mandible and antenna, and mesosoma with fine punctation, interspaces shining ($i \sim 3/4d$), except as follows: scape with punctation finer, less dense ($i \sim d$); mandible with finer punctation, somewhat denser ($i = 1/2d$), punctures finest in outer interspace, becoming larger toward rutellum, except along carinae where it is impunctate; clypeus with narrow impunctate apical margin, the impunctate margin wider between lateral angles of clypeal truncation than along lateral margins of truncation; frontal line narrowly impunctate in vertexal area just posterior to median ocellus, the impunctate region not large, not especially conspicuous; mesepisternum and mesoscutum with larger punctation than in genal area and vertexal area, respectively, similarly spaced ($i \sim 3/4d$), except for medially on mesoscutum where punctation density decreases ($i \sim d$); metepisternum with punctation inconspicuously finer than that of mesepisternum, similarly spaced ($i \sim 3/4d$); tegula nearly impunctate, sparsely and shallowly punctured anteriorly ($i > d$); axilla with finer, denser ($i < 1/2d$) punctation than in mesoscutum; mesoscutellum punctured as in mesoscutum, somewhat sparsely so along longitudinal midline; metanotum with denser ($i \sim 1/2d$) punctation than in mesoscutellum, punctures about as large, somewhat shallow, not well-defined; metapostnotum areolate ($i < 1/4d$), feebly scrobiculate at lateral extremes; propodeum with lateral surface finely and shallowly punctate ($i \sim 1/2d$), punctures of declivous dorsal surface not well defined, somewhat large, somewhat sparse ($i > 1/2d$), punctation of metasoma less dense ($i > d$) than that of head and mesosoma, punctures about as large; T1 anterior surface impunctate; T1 and T2 disc

with punctures especially fine, conspicuously sparse ($i > 2d$); T3 punctured as in T2 but with interspaces highly foveolate, somewhat reducing the metallic shine; T4 and T5 with punctuation obscure, punctures shallow, not well defined, larger than those of T3, interspaces as in T3 ($i \sim 1/2d$); T6 especially finely and densely punctured ($i = 1/2d$); apical impressed margin of T1 to T5 impunctate; S1 to S6 with moderate punctuation in disc ($i < d$), S1 to S5 with marginal zone impunctate, that of S6 punctured as in disc.

Structure: head length to bread subequal ($L:W=48:45$); scape elongate, nearly 4x longer than wide ($20:5$); pedicel exposed, as long as wide; flagellomeres mostly unmodified: F1 longer than wide ($9:5$), F2-F9 length to width nearly equal, F10 longer than wide ($12:8$), with the apex rounded; mandible quadridentate, teeth sharp, well defined, mandible widened at apex, the apex wider than the greatest width of the compound eye ($25:21$), distance between tooth of rutellum and first tooth of pollex nearly twice the distance between the first and second teeth of the pollex ($11:6$), the distance between the first and second teeth of the pollex and the second and third teeth of the pollex subequal ($6:7$); inner margins of compound eyes subparallel ($UOD:LOD=26:27$); hypostomal carina low, especially anteriorly and posteriorly; clypeus nearly flat, feebly convex at posterior margin, truncate, the lateral margins of truncation straight, lateral angles of truncation broadly rounded, the margin between angles of truncation nearly straight, feebly concave or emarginate, feebly reflexed dorsad; tentorial pits deep, well defined; supraclypeal and frontal areas conspicuously convex; supraantennal depression weak; $IAD=AOD$; $IOC < OOC$ ($18:23$); $IOC < OV$ ($18:28$); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL=40:37$); genal area wider than compound eye in lateral view ($19:14$); mesosoma length to width nearly equal ($L:W=25:23$); admedian line, anteriorly, and parapsidal lines deepened, distinct; mesoscutellum and metanotum gently sloping posteriorly to a nearly declivous propodeum, somewhat sloping; metasoma elongate ($L:W=91:42$); T1 anterior surface with longitudinal furrow deep, the surface rounded onto dorsal surface, the two surfaces not distinctly delineated by structure; gradular furrows of T2 and T3 deepened; T6 marginal zone reflexed dorsally, concave in profile.

Male (N=37): length (9 to 14mm); head width (2 to 3mm); ITW (1 to 2mm); forewing length (5.5 to 8mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres light brown to amber-coloured; hind tibial spur piceous; tegula amber-coloured posteromedially; wings lighter than in female; terga with apical impressed margin narrowly midnight blue then golden at apex.

Pubescence: hairs mostly white, sometimes feebly ochraceous or cinereous; head, mesosoma and metasoma sparsely pubescent with erect hairs ($<1\text{MOD}$), except as follows: setae arising from the apical margin of the clypeus between lateral angles of truncation a uniform thin fringe, the hairs oriented anteriorly, lightly ochraceous; clypeus, paraocular area, supraclypeal area and frontal area with dense, erect hairs ($\sim 2.5\text{MOD}$); marginal zone of S1 with denser pubescence ($\sim 1.5\text{MOD}$), that of S2 longer ($>2\text{MOD}$); apical margin of S3 and S4 with long, lightly ochraceous setae oriented posteromedially, the hairs longer toward lateral margins ($>2\text{MOD}$); S5 with apical fringe of short, ochraceous setae ($<1\text{MOD}$); S6 with a thin apical tuft at midline of median emargination, the hairs oriented posteriorly ($\sim 1\text{MOD}$).

Surface sculpture: punctation of head and mesosoma denser ($i < 1/2d$) than that of female, except as follows: hypostomal area with punctures somewhat shallow, less dense ($i < 2d$); clypeus with impunctate apical margin more conspicuous laterally than in female; vertexal area without impunctate region; punctures of mesepisternum less dense ($i < d$) than those of genal area, those of metepisternum as in rest of mesosoma ($i < 0.5d$); axilla finely and densely punctate ($i \sim 0.25d$); mesoscutellum with punctures larger than those of mesoscutum, about as dense ($i < 0.5d$); punctation of metanotum obscure, punctures large, not well defined ($i < 0.5d$); metapostnotum roughened anteriorly, smooth, impunctate posteriorly; propodeum with dorsolateral angle with large, obscure punctures ($i \sim 0.5d$); punctation of metasoma less dense ($i > 0.5d$) than that of head and mesosoma, the puncture size variable, except as follows: T1 anterior surface impunctate; marginal zone of T1 to T6 impunctate; S1 to S5 sparsely punctate in disc, the punctures

somewhat fine ($i > d$), denser and larger submarginally in lateral $\frac{1}{4}$ of width ($i \sim 1/2d$); S6 finely and sparsely punctate in disc ($i > 2d$), impunctate in marginal zone.

Structure: head wider than long (L:W= 44:39); scape elongate, over 2.5x longer than wide (30:12), pedicel wider than long (9:6); flagellomeres mostly unmodified, longer than wide, F11 longer than wide (12:7), with a rounded apex; mandible bidentate, not widened at apex, the apex not as wide as the greatest width of the compound eye (11:36); compound eyes convergent below (UOD:LOD= 26:23); clypeus with lateral margins of truncation broadly rounded, apical margin between lateral angles concave, the clypeus seemingly bilobed; IAD:AOD= 14:11; IOC subequal OOC (13:14); IOC < OV (13:18); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 30:23); compound eye wider than genal area in lateral view (37:24); mesosoma longer than wide (L:W= 47:44); metasoma elongate, over three times as long as wide (L:W= 31:10); T6 with apical margin rounded, lateral teeth pointed, widened at base, as long as their basal width; T7 truncate at apex, with truncation spade-like but with the apex rounded, disc depressed submarginally; S1 to S4 thickened submarginally; S1 and S2 with a median, apical tooth-like process arising subapically, oriented posteriorly, that of S1 short (L=B) with apex blunt and emarginate, that of S2 wider than long (L:W= 6:5), pointed; apical margin of S1 and S2 straight; S3 and S4 apical margins inconspicuously emarginate at midline; S5 apical margin broadly concave in middle $\frac{2}{3}$ of disc; S6 to S8 retracted.

Genitalia: as in Fig. 3.46f.

Distribution: *Hoplitis fulgida* is somewhat common along the Pacific coast. It has been collected from Yukon Territory and Alaska south to California and east as far as New Mexico, Colorado and Alberta. It is primarily a montane species with most records collected at higher altitudes along the Rocky Mountain Range (Fig. 3.6c). [CAN: AB; BC; YT; USA: AK; AZ; CA; CO; ID; MT; NM; NV; OR; UT; WA; WY.]

Specimens examined: CAN: British Columbia: Okanagan-Similkameen Reg. Dist.: ♀ Oliver, Ripley Lk., 11.vii.2008 (LR Best) [Barcoded]; 2 ♀ 1 ♂ Oliver, 26.vii.2008 (LR Best); 8 ♂ Oliver,

Ripley Lk., 31.v.2013 (G Rowe & L Graham); 3 ♂ Oliver, Ripley Lk., 15.vi.2013 (G Rowe & L Graham); ♀ Oliver, Ripley Lk., 17.vi.2013 (G Rowe & L Graham); ♀ Oliver, Ripley Lk., 01.vii.2013 (G Rowe & L Graham); ♀ Oliver, Ripley Lk., 26-27.vii.2010 (LR Best); ♀ Oliver, Ripley Lk., 31.vii-03.viii.2009 (LR Best) [Barcoded]; 3 ♀ Oliver, Ripley Lk., 12.vii.2008 (LR Best) [1 Barcoded]; ♀ Oliver, 26.vii.2008 (LR Best); ♂ Oliver, 21.vi.2008 (LR Best); 2 ♂ Oliver, 02-03.vi.2010 (LR Best); ♀ Oliver, 31.v.2008 (LR Best); ♂ Osoyoos, 08.v.2008 (LR Best) [Barcoded]; ♀ Osoyoos, 04.vii.2010 (LR Best); ♀ Osoyoos, 10.vii.2008 (LR Best) [Barcoded]; 2 ♀ Osoyoos, 04-05.vii.2010 (LR Best); 5 ♀ Willowbrook, Green Lk., 14.vi.2008 (LR Best) [4 Barcoded]; ♀ Okanagan Falls, 14.vi.2008 (LR Best); 2 ♂ 2 ♀ Mt. Kobau, 09-11.vi.2010 (LR Best); ♂ Mt. Kobau, 09-11.vi.2010 (LR Best) [Barcoded]; 2 ♂ 1 ♀ Chaplin Property, 16-22.vi.2010 (LR Best); ♂ Mt. Baldy, 22-25.vi.2010 (LR Best); *East Kootenay Reg. Dist.*: ♀ Ram Creek, FSR, 18.viii.2009 (LR Best) [Barcoded]; *North Okanagan Reg. Dist.*: ♂ Lumby, Quesnel Rd., 02.vi.2008 (LR Best) [Barcoded]; ♂ Lumby, Twin Crks., 23.vi.2008 (LR Best); ♂ Lumby, Twin Crks., 24.vi.2008 (LR Best); *Bulkley-Nechako Reg. Dist.*: 4 ♀ 2 ♂ Burns Lk., Francois Lk., 16.vi.2006 (LR Best) [2 ♀ 2 ♂ Barcoded]; *Kootenay Boundary Reg. Dist.*: 8 ♀ Camp McKinney, 01.viii.2009 (LR Best); 8 ♀ Camp McKinney, 02.viii.2009 (LR Best); **CAN: Yukon:** ♂ ♀ Carcross Dunes, 10.vii.2006 (L Packer) [Barcoded]; **USA: Oregon:** 9 ♀ *Crook Co.*, Hwy 26, 28.vi.2007 (J Gibbs & C Sheffield); **USA: California:** ♂ *Tuolumne Co.*, 26.v.2004 (JT Briggs) [Barcoded]; ♀ *Tuolumne Co.*, 03.vi.2006 (E Stephens) [Barcoded]; **USA: Colorado:** ♂ Ward Co., Boulder, 19.v.2007 (J Gibbs & C Sheffield); **USA: Idaho:** ♂ *Blaine Co.*, Hwy 75, 25.vi.2007 (J Gibbs & C Sheffield) [Barcoded]; ♀ ♂ *Blaine Co.*, Ketchum, 24.vi.2007 (J Gibbs & C Sheffield); ♂ *Elmore Co.*, Hwy 20, 27.v.2007 (J Gibbs & C Sheffield); ♀ *Butte Co.*, Craters of the Moon Nat. Mon., 27.v.2007 (J Gibbs & C Sheffield); ♀ *Camas Co.*, Hwy 20, 27.v.2007 (J Gibbs & C Sheffield); ♀ *Custer Co.*, Hwy 75, 25.vi.2007 (J Gibbs & C Sheffield); **USA: Montana:** ♀ *Gallatin Co.*, Hwy 287, 23.vi.2007 (J Gibbs & C Sheffield); **USA: Utah:** 4 ♂ *San Juan Co.*, La Sal Mts., 29.vi.1999 (L Packer); **USA: Washington:** ♀ *Grant Co.*, 30.v.2007 (J Gibbs & C Sheffield).

Type: Female, from Colorado, in the Academy of Natural Sciences of Philadelphia. [Examined]
***Hoplitis grinnelli* (Cockerell, 1910)**

Alcidamea grinnelli Cockerell, 1911c, Ann. Mag. Nat. Hist., 5: 22.

Hoplitis (Alcidamea) grinnelli septentrionalis Michener, 1947, Bull. Am. Mus. Nat. Hist., 89(4): 291.

Biology: *Hoplitis grinnelli* is polylectic and has been recorded foraging on many plant families including, but not limited to, Asteracea, Boraginacea, Fabaceae and Hydrophyllaceae (Asher & Pickering 2016). In Canada it is relatively uncommon and has been collected from late May (24, Penticton, BC) to late June (24-26, Mt. Kobau, BC).

Diagnosis: The female of *H. grinnelli* can be recognized by the combination of scape elongate, more than three times longer than wide, base of labrum without yellowish membranes, mandible tridentate, distance between lateral ocelli short, hardly greater than width of median ocellus, compound eye at least as wide as genal area, metasomal scopa light, T1 and T2 punctures at least as large as those of vertexal area, not especially fine, punctation not especially sparse in middle fifth of marginal width, not especially shiny and T1 not distinctly impunctate along longitudinal midline, T2 to T4 with gradular furrows not especially deep, that of T4 hardly deep, T6 with punctures not deeper and denser than those of T5, punctures similar to those of T5, and S6 unmodified. The male of *H. grinnelli* can be recognized by the combination of scape more than two and a half times longer than wide, flagellomeres two to five unmodified, bidentate mandible, base of labrum without membranes, clypeus without silvery tomentum, T7 apical margin produced to a median spine, apical margin of S2 not produced to a median spine, S2 with a high, median protuberance in disc, protuberance sub-basal, posterior surface nearly at centre of segment.

H. grinnelli **redescription**

Figures: 3.6; 3.47; 3.48

Female (N=16): length (6 to 8mm); head width (1.5 to 2.5mm); ITW (1 to 1.5mm); forewing length (4 to 5mm).

Colouration: integument black, except as follows: flagellomeres light brown to yellow; cap of rutellum of mandible piceous; tegula yellowed; tarsi and tarsal claw on all legs light brown to amber-coloured; hind tibial spur honey-coloured; wings hyaline, dusky, darkest along costal margin in marginal cell; sterna with apical impressed margin brown.

Pubescence: hairs mostly white, sometimes lightly ochraceous dorsad; head, mesosoma and metasoma generally sparsely pubescent with suberect hairs ($\sim 1\text{MOD}$), pubescence denser on the following: hypostomal area with pubescence conspicuously bowed, the apices oriented toward the midline anteriorly ($>2\text{MOD}$); clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation ($<0.5\text{MOD}$); pubescence of apical $1/3$ of clypeus usually at least somewhat ochraceous ($\sim 1\text{MOD}$); paraocular area with dense, subappressed pubescence ($\sim 1\text{MOD}$); frontal area with long, suberect pubescence ($>1.5\text{MOD}$); mesosoma with pubescence conspicuously denser, usually ochraceous on the following: pronotal collar and pronotal lobe, mesepisternum, axilla, metanotum and dorsolateral angle of propodeum suberect ($>2\text{MOD}$); mesoscutum with dense, erect pubescence along posterior margin, usually ochraceous ($>2\text{MOD}$); metapostnotum and lateral surface of propodeum glabrate; metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, interrupted in middle third of T1 to T3, and often less dense on T6, hairs mostly white ($\sim 1\text{MOD}$); sternal scopa light, straw-coloured, oriented posteroventrally, arising from the disc ($>4\text{MOD}$).

Surface sculpture: head, including mandible and antenna, moderately punctate ($i=1/3d$), interspaces shining, except as follows: scape with punctation somewhat finer, similarly spaced ($i=1/3d$); mandible with finer punctation, similarly spaced ($i=1/3d$), except along carinae where it is impunctate; hypostomal area shiny, punctation large and shallow, not well defined, somewhat less dense ($i>1/2d$) than in genal area; punctation of clypeus large at posterior margin, becoming finer toward an impunctate apical margin between lateral angles of clypeal truncation, punctation less dense medially ($i\sim d$), and narrowly impunctate in basal $1/3$ of longitudinal midline; supraclypeal area less densely punctate ($i<d$); mesosoma with punctures larger than those of head, similarly dense ($i=1/3d$), except as follows: mesoscutum somewhat sparsely punctured

medially ($i > 1/2d$); tegula finely and sparsely punctate ($i > 2d$); mesepisternum with punctation variably spaced ($i < d$); axilla with size of punctures variable, dense ($i < 1/3d$); mesoscutellum with pits large and sparse ($i < 3/4d$), except along posterior margin where punctures are finer, somewhat obscure ($i < 1/2d$), continuing in metanotum except in lateral third where it is mostly impunctate; metepisternum with punctures sparser ($i > 1/2d$) than those of mesepisternum; metapostnotum very finely punctate ($i = 1/2d$); metasoma somewhat finely punctate, variably spaced; propodeum with lateral surface finely punctate ($i = 1/2d$), dorsal surface with larger, sparser punctures ($i > 3/4d$), T1 anterior surface impunctate, disc somewhat finely punctate, the punctures about as large as those of vertexal area, somewhat less dense ($i < d$); T2 and T3 with punctation inconspicuously finer than that of T4, at least medially where punctation is least dense ($i < 2d$); T4 moderately dense ($i = 1/2d$), punctures hardly larger than those of T3; punctures of T5 inconspicuously finer than those of T4, denser ($i = 1/3d$); T6 as in T5 but with punctation in marginal zone obscured by roughened interspaces; sterna moderately punctate in disc ($i = 1/2d$), impunctate in marginal zone in S1 to S5, that of S6 punctured as in disc.

Structure: head wider than long ($L:W = 65:72$); scape elongate, over 3x longer than wide ($22:7$); pedicel exposed, longer than wide ($5:4$); flagellomeres mostly unmodified: F1 as long as wide, F2-F9 wider than long, F10 longer than wide ($10:8$), with the apex rounded; mandible tridentate, short and wide, distance between tooth of rutellum and first tooth of pollex less than the distance between the first and second teeth of the pollex ($5:8$); compound eyes convergent below ($UOD:LOD = 52:43$); hypostomal carina low; clypeus feebly convex, truncate, the lateral margins of truncation nearly straight, feebly concave to the well defined, rounded lateral angles of truncation, the margin between angles of truncation broadly concave such that clypeus appears broadly bilobed; supraantennal depression moderate; $IAD:AOD = 17:12$; $IOC < OOC$ ($12:14$); $IOC > OV$ ($12:10$); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 23:18$); genal area narrower than compound eye in lateral view ($18:20$); mesosoma length to width nearly equal ($L:W = 53:51$); mesoscutellum and metanotum gently sloping posteriorly to an entirely declivous propodeum; metasoma somewhat elongate ($L:W = 64:43$); T1 anterior surface with a short, narrow, longitudinal furrow, the surface rounded onto the dorsal surface, the two surfaces not distinctly delineated by structure; T6 marginal zone strongly reflexed dorsally, angulate in profile.

Male (N=13): length 5.5mm (5 to 8mm); head width 1.5mm (1.5 to 2mm); ITW 1mm (1 to 1.5mm); forewing length 4mm (4 to 5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: wings lighter, not especially darkened in marginal cell; terga with apical impressed margin brown to dark gold.

Pubescence: hairs mostly white to light ochraceous; head and mesosoma covered in moderately dense, suberect pubescence (~1MOD), pubescence denser on the following: hypostomal area with pubescence not conspicuously bowed and somewhat shorter (<1.5MOD); hairs arising from the apical margin of the clypeus between lateral angles of truncation a uniform thin fringe, the hairs oriented anteriorly, not usually darker than those of clypeus; T6 and T6 not apically fasciate; S3 and S4 with a median, apical tuft, that of S3 dense, the hairs bent dorsad halfway for their length (~2MOD), that of S4 less dense and less conspicuous than that of S3, the hairs straight, not conspicuously bent at their midlengths (~1.5MOD); S5 with an apical fringe for the width of the marginal zone (~1MOD), the hairs about as long and as dense as the median tuft of S4 (~1.5MOD), the hairs arising from the premarginal line.

Surface sculpture: hypostomal area impunctate; punctures of clypeus moderate, even or punctures only inconspicuously finer toward impunctate apical margin; punctures of supraclypeal area and of lower paraocular area as in base of clypeus ($i=1/3d$); mesosoma with punctures not larger than those of head; mesoscutum punctured as in vertexal area and with sparse medial zone smaller than that of female, less conspicuous ($i=d$); axilla, anteriorly, as in mesoscutum, posterolateral margin narrowly with punctation obscured by roughened interspaces, the punctures hardly finer than those of anterior; mesoscutellum less dense ($i>1/2d$) except along narrow posterior and lateral margins which are obscured; T6 with marginal zone impunctate; T7 punctation obscure ($i\sim 1/2d$); sterna moderately punctate ($i<d$), except as follows: S2 sparsely

punctate in protuberance of disc, and in submarginal swellings on S3 to S6; apical margins of S1 to S5 very narrowly impunctate, that of S6 very finely and densely punctured (i~1/3d).

Structure: head conspicuously wider than long (L:W= 41:52); scape somewhat elongate, 2.5x longer than wide (25:10), pedicel nearly entirely enclosed by scape; flagellomeres mostly unmodified, F1 longer than wide (L:W= 11:9), F2 to F10 at least as wide as long, F11 longer than wide (L:W= 12:7), the apex pointed and curved ventrally; mandible bidentate, not especially wide; compound eyes convergent below (UOD:LOD= 32:25); clypeus truncate, the lateral margins of truncation sinuate, leading to well defined, rounded, lobe-like lateral angles of truncation, the margin between angles undulate and posterior to the most apical part of the lateral angles of truncation; supraantennal depression strong; IAD:AOD= 14:10; IOC subequal OOC (19:20); IOC=OV; median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 40:26); genal area not as wide as compound eye in lateral view (18:22); mesosoma somewhat longer than wide (L:W= 79:68); metasoma somewhat elongate, over 1.5x as long as wide (L:W= 58:35); T6 with apical margin rounded, lateral teeth blunt, only as long as their basal width; T7 produced to a blunt, spine-like apex and with a narrow, sub-basal excavation at middle of disc, the excavation deep and distinct; S1 and S3 to S5 with disc feebly swollen submarginally, that of S5 least conspicuous; S1 apical margin broadly concave; S2 with a large, median protuberance in middle 1/3 of disc, the lateral margins of protuberance evenly tapered to a somewhat pointed, or conical, apex, the posterior surface steep, somewhat flatter in profile than the gradually tapering anterior surface; S2 apical margin produced to a narrow, median emargination; apical margin of S3 rounded, that of S4 and S5 narrowly emarginate medially, the emargination feebly concave, that of S5 wider than that of S4; margin of S6 rounded; S6 to S8 retracted.

Genitalia: as in Fig. 3.48h.

Distribution: *Hoplitis grinnelli* is distributed along the Pacific coast west of the Rocky Mountain Range from southern British Columbia south to southern California and Mexico (Fig. 3.6d). [CAN: BC; USA: AZ; CA; ID; NM; NV; OR; TX; UT; WA.]

Specimens examined: **CAN: British Columbia:** *Okanagan-Similkameen Reg. Dist.:* ♀ Mt. Kobau, Hwy 3, 9-11.vi.2010 (LR Best) [Barcoded]; ♀ Mt. Kobau, Hwy 3, 24-26.vi.2010 (LR Best) [Barcoded]; ♀ Osoyoos, Strawberry Crk. Rd., 19.vi.2010 (LR Best) [Barcoded]; ♀ Osoyoos, Mt. Kruger, 14.vi.2008 (LR Best) [Barcoded]; ♀ ♂ Penticton, Skaha Bluffs, 24.v.2013 (G Rowe & L Graham); ♀ Sparrow Grasslands, NCC, 23.vi.2013 (G Rowe & L Graham); *Comox Valley Reg. Dist.:* ♀ Vancouver Is., 2km S Courtenay Hwy 19A, 03.vi.2007 (J Gibbs & C Sheffield); *Thompson-Nicola Reg. Dist.:* ♀ 4 ♂ Nicola Valley, Clapperton, 30v.2010 (LR Best) [♀ 4 ♂ Barcoded]; ♂ Nicola Valley, Clapperton; 5.vi.2010 (LR Best) [Barcoded]; **USA: Oregon:** ♂ Harney Co., Malheur Wildlife Refuge, 20.v.2012; **USA: Montana:** ♂ Missoula Co., MPG Ranch, 11.vi.2013 (M Kuhlman & T Hayes) [Barcoded]; **USA: Washington:** ♀ Lewis Co., Packwood; 31.v.2007 (J Gibbs & C Sheffield) [Barcoded]; ♂ Garfield Co., USDA/WSU Res. Stn., 18.v.1983 (SL Clement); **USA: California:** ♀ San Bernardino Co., Baker, 29.iv.2013 (A Ruttan) [Barcoded]; ♀ Kern Co., Arvin, 19.iv.2012 (TL Griswold) [Barcoded]; ♂ Riverside Co., Palm Springs, 11-17.iv.2013 (FD Parker & TD McIntyre) [Barcoded]; *Mariposa Co.:* ♀ Elephant Rock, 03.v. 2004 (JT Briggs) [Barcoded]; ♂ Foresta Rd., 19.v.2006 (TL Griswold) [Barcoded]; **USA: Nevada:** *Clark Co.:* ♀ Wheeler Pk., 21.vi.2005 (S Higbee) [Barcoded]; ♀ Lovell Cyn., 20.v.2005 (E Ahlstrom) [Barcoded]; ♀ Black Mtn., 19.v.2005 (R Andrus) [Barcoded]; **USA: New Mexico:** ♀ ♂ Lowe Ranch, 20.iv.2011 (JD Herndon) [Barcoded].

Type: Holotype male, from Salmon Arm, British Columbia, in the Canadian National Collection. [Examined]

***Hoplitis hypocrita* (Cockerell, 1906)**

Osmia hypocrita Cockerell, 1906, Can. Entomol., 38: 160.

Hoplitis (Cyrtosmia) hypocrita Michener, 1947, Bull. Am. Mus. Nat. Hist., 89(4): 292.

Hoplitis (Alcidamea) hypocrita Sedivy et al., 2013, Zool. J. Linn. Soc., 167(1): 28-42.

Biology: *Hoplitis hypocrita* is polylectic and has been recorded foraging on many plant families including, but not limited to, Asteraceae, Fabaceae, Hydrophyllaceae and Scrophulariaceae (Asher & Pickering 2016). In Canada *H. hypocrita* has been collected from late May (24, Penticton, BC) to late June (19, Osoyoos, BC).

Diagnosis: The female of *H. hypocrita* can be recognized by the distinct, longitudinal ridge in the middle of the disc of S6. The male of *H. hypocrita* can be recognized by the combination of a tridentate mandible, T6 and T7 apical margin tridentate.

H. hypocrita **redescription**

Figures: 3.6; 3.49; 3.50

Female (N=8): length (11 to 13mm); head width (3.5 to 4mm); ITW (3mm); forewing length (8 to 9mm).

Colouration: integument black, except as follows: hind tibial spur black or piceous; basitarsi and tarsal claw on all legs testaceous; wings hyaline, dusky along perimeter, clear in submarginal and medial cells.

Pubescence: hairs black, white or lightly ochraceous; integument with short, erect, black inconspicuous pubescence (~1.5MOD), head, mesosoma and metasoma with long, moderately dense, suberect white or lightly ochraceous pubescence (<4MOD), pubescence denser on the following: clypeus with a small tuft of ochraceous setae on either side of the midline between lateral angles of clypeal truncation, the hairs erect, oriented anteromedially and arising from the apical margin beneath the truncation (<1MOD); anterior ½ of clypeus with short, black, suberect setae (~1MOD), basal 1/2 with suberect white hairs (~2MOD); paraocular and frontal area densely pubescent, the hairs white, suberect (~2MOD); pronotum mostly glabrate, pronotal collar with long, suberect, pubescence (>4MOD), the hairs mostly white; mesepisternum with long, suberect pubescence (>4MOD), the hairs mostly black or dark brown; mesoscutum, mesoscutellum, axilla, metanotum and dorsolateral angle of propodeum covered in long, dense, erect or suberect pubescence (>3MOD), the hairs white to lightly ochraceous; metapostnotum glabrate; T1 anterior surface nearly glabrate, dorsal surface densely pubescent in disc, the hairs long (>3MOD), suberect, white to lightly ochraceous; T6 with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margin (~1MOD); sternal scopa dark, dark brown to black, oriented posteroventrally, arising from the disc (>3MOD).

Surface sculpture: head, including mandible and antenna, finely and densely punctate ($i < 1/2d$), interspaces shining, except as follows: scape with finer punctation ($i \sim 1/3d$); mandible with punctation denser ($i = 1/3d$), except along carinae where it is impunctate; punctures of hypostomal area sparse, puncticulate, the punctures shallow, not well defined ($i > 1/2d$); clypeus and supraclypeal area densely punctate ($i < 1/3d$), impunctate along apical margin between lateral angles of clypeal truncation, and narrowly impunctate along longitudinal midline of both segments; lower paraocular area puncticulate ($i \sim 1/2d$), the punctures as large as those of clypeus, impunctate along supraantennal suture; frontal area dull, interspaces not shining, except medially, anterior to median ocellus; vertexal area narrowly impunctate along longitudinal midline; pronotum very finely punctate ($i < 1/2d$), pronotal collar and pronotal lobe puncticulate with punctures large, shallow and not well defined ($i > d$); mesoscutum anteriorly and mesepisternum puncticulate ($i = 1/2d$), dull, mesoscutum otherwise as in vertexal area ($i < 1/2d$), conspicuously punctate along notaulus and parapsidal line, and strigate-rugose, somewhat shiny along admedian line; tegula moderately punctured, punctures variably spaced ($i > 1/2d$) and variably sized; tegula moderately punctured, punctures variably spaced ($i > 1/2d$), and variably sized; axilla finely punctate ($i < 1/2d$), punctures somewhat obscured by roughened interspaces; mesoscutellum as in posterior portion of mesoscutum ($i < 1/2d$); metepisternum shining, punctures less dense ($i > 1/2d$) than those of mesepisternum, punctures variably sized; metanotum imbricate-punctate; metapostnotum very finely punctate ($i = 1/2d$); propodeum with lateral and dorsal surfaces very densely and very finely punctate ($i \sim 1/3d$), the dorsal surface puncticulate with larger pits shallow, less well defined ($i > 1/2d$); T1 anterior surface mostly impunctate, shining, with few large pits ($i > 2d$); T1 to T5 with punctation in longitudinal middle 1/3 less dense, becoming denser toward lateral margins ($i < 1/2d$); punctation in middle 1/3 of disc of T1 and T2 ($i \sim 1/2d$) denser than that of T3 ($i \sim d$), that of T3 denser than that of T4 and T5 ($i \sim 1.5d$); T1 to T5 with interspaces shining and with marginal zones impunctate, or very sparsely punctured; T6 finely and densely punctate ($i < 1/2d$) with interspaces roughened, dull, marginal zone punctured as in disc; S1 to S6 imbricate-punctate in disc, S1 to S5 with marginal zones impunctate, marginal zone of S6 impunctate along medial process and on median apical projection.

Structure: head hardly wider than long (L:W= 52:55); scape elongate, over 4x longer than wide (35:8); pedicel exposed, longer than wide (8:5), flagellomeres mostly unmodified: F1

twice as long as wide (10:5), F2-F9 about as long as wide, F10 longer than wide (L:W=10:6), with the apex rounded; mandible tridentate, wide, the tooth of the rutellum and the first tooth of the pollex sharp, the second tooth of the pollex inconspicuous, distance between tooth of rutellum and first tooth of pollex less than 1/2 the distance between the first and second teeth of the pollex (10:21), the margin between the first and second teeth of the pollex shallow, nearly straight or feebly undulating; compound eyes convergent below (UOD:LOD= 36:32); hypostomal carina moderately high, highest at anterior angle and becoming weaker toward posterior; clypeus flat, apical margin broadly concave between lateral angles of truncation, the angles broadly rounded, the margin thus appearing broadly bilobed; supraantennal depression weak; tentorial pits large, deep, well defined; IAD:AOD= 19:21; IOC<OOC (15:22); IOC subequal OV (15:16); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 29:18); genal area wider than compound eye in lateral view (24:20); mesosoma length subequal width (L:W= 63:58); lateral surface of pronotum greatly exposed, pronotal collar conspicuously convex; notaulices deep, well defined anteriorly; mesoscutellum gently sloping posteriorly to a nearly declivous metanotum and an entirely declivous propodeum; metasoma somewhat elongate (L:W= 44:29); T1 anterior surface with a short, narrow, longitudinal furrow, the surface rounded onto the dorsal surface, the two surfaces not distinctly delineated by structure; T2 and T3 with gradular furrows distinctly deepened; T6 marginal zone reflexed dorsally, concave in profile; S6 with a strong, median, longitudinal ridge produced in disc, ending somewhat abruptly at the premarginal line, the ridge produced to a small, blunt process at the apical margin, the process only about as long as wide, the lateral extremes of the apical margin produced to rounded, lobe-like processes, the lobes as long as their basal widths.

Male (N=10): length (10 to 12mm); head width (2.5 to 3mm); ITW (2mm); forewing length (7.5 to 8mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: integument black to piceous, except as follows: flagellomeres brown; tegula brown; hind tibial spur brown; basitarsi and tarsi of all legs brown; tarsal claw on all legs dark amber-coloured.

Pubescence: hairs mostly white to light ochraceous; head, mesosoma and metasoma covered in dense, suberect pubescence ($>3\text{MOD}$), pubescence denser on the following: setae arising from the apical margin of the clypeus between lateral angles of truncation a thin fringe, the setae oriented anteriorly, ochraceous ($<1\text{MOD}$), the setae at midline long, the fringe becoming shorter and thinner toward lateral angles of clypeal truncation; clypeus, supraclypeal area and frontal area with dense, suberect pubescence ($\sim 2\text{MOD}$); paraocular area with dense, subappressed pubescence ($\sim 1\text{MOD}$); vertexal area and genal area with pubescence less dense than rest of head ($\sim 2\text{MOD}$); metapostnotum glabrate; dorsolateral angle of propodeum with pubescence conspicuously darkened, almost black ($>3\text{MOD}$); T1 and T2 with somewhat dense pubescence in disc, the hairs long ($\sim 3\text{MOD}$), suberect, densest submarginally at lateral extremes, though not quite conspicuous hair bands; S4 with a median, apical tuft-like fringe in middle 1/3 of segment, the hairs dense, black at base becoming lighter, lightly ochraceous, at apex, arising from the premarginal line and oriented posteroventrally for first 1/2 of length, then bent dorsad, ($<2\text{MOD}$); S5 with an apical fringe for the width of the marginal zone ($\sim 1\text{MOD}$), the hairs arising from the premarginal line, oriented posteriorly and slightly toward midline, usually white to lightly ochraceous, sometimes darkened, brown.

Surface sculpture: clypeus finely and densely punctate ($i < 1/2d$), except impunctate along apical margin between lateral angles of clypeal truncation; lower paraocular area and supraclypeal area evenly punctured, punctures larger than those of clypeus ($i = 1/3d$); T6 as in T5; T1 to T6 with interspaces roughened, hardly shining; T7 with punctation obscure, puncture sizes variable ($i > 1/2d$), interspaces not shining; S1 to S5 imbricate-punctate in disc, marginal zones impunctate.

Structure: head conspicuously wider than long (L:W = 56:71); scape elongate, nearly 4x longer than wide (23:6), pedicel exposed, about as long as wide (L:W = 9:10); flagellomeres mostly unmodified, width even across flagellomeres, length increasing from basal segments to

apical segments, F1 to F8 longer than wide, F11 over 2x longer than wide (19:9), the apex pointed, curved ventrally; mandible tridentate, the tooth of the rutellum sharp, those of the pollex rounded, less well defined, distance between tooth of rutellum and first tooth of pollex equal to the distance between the first and second teeth of the pollex, the margin between the first and second teeth of the pollex shallow, concave; compound eyes convergent below (UOD:LOD= 45:37); hypostomal carina moderately high; clypeus feebly convex, truncate, lateral margins of truncation nearly straight, apical margin between lateral angles of truncation feebly concave, undulate; supraantennal depression strong; IAD:AOD= 32:20; IOC<OOC (26:33); IOC>OV (26:22); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 51:22); genal area wider than compound eye in lateral view (31:22); mesosoma hardly longer than wide (L:W= 56:48); metasoma elongate, over 1.5x as long as wide (L:W= 72:43); T6 with apical margin tridentate, median tooth smaller, as long as its basal width, pointed, lateral teeth wider than long (L:W= 6:11), rounded at apex, apical margin between teeth straight; T7 produced to a tridentate apical margin, the median tooth longer than the lateral teeth, but only as long as its basal width, and somewhat dorsal to lateral teeth, all apices rounded; sterna mostly unmodified, submarginal swellings in discs subtle, interrupted at longitudinal midline; S1 short, apical margin straight; S2 with disc somewhat produced, the apical margin rounded and somewhat produced narrowly at middle; S3 to S5 with apical margin straight; S6 apical margin rounded; S6 to S8 retracted.

Genitalia: as in Fig. 3.50f.

Distribution: *Hoplitis hypocrita* is primarily a western species. It has been collected as far east as Colorado and Wyoming along the eastern foothills of the Rocky Mountain Range, and west to the Pacific coast from southern British Columbia south to California and Arizona (Fig. 3.6e).

[CAN: BC; USA: AZ; CA; CO; ID; MT; NV; OR; UT; WA; WY.]

Specimens examined: CAN: British Columbia: Okanagan-Similkameen Reg. Dist.: 2 ♂ Penticton, Skaha Bluffs, 24.v.2013 (G Rowe & L Graham); ♀ Oliver, Mt. Kruger, 31.v.2008 (LR Best) [Barcoded]; ♀ Oliver, Mt. Kruger, 07.vi.2008 (LR Best) [Barcoded]; 2 ♂ Blacksage Rd., 12.vi.2010 (LR Best); ♀ Osoyoos, Strawberry Crk. Rd., 19.vi.2010 (LR Best); ♀ Base of Mt.

Kobau, 9-11.vi.2010 (LR Best); ♀ Richter Pass, Hwy 3, 14.vi.2010 (LR Best); **USA: Oregon:** 4 ♂ Wheeler Co., Hwy 26, 28.vi.2007 (J Gibbs & C Sheffield); **USA: Idaho:** ♀ Butte Co., Hwy 26, Craters of the Moon Nat. Mon., 27.v.2007 (J Gibbs & C Sheffield); **USA: California:** ♀ Napa Co., Nichilini Winery, 15.vii.1974 (RW Rust & SL Clement); ♂ Mt. Diablo, 24.iv.1937 (M Cazier); ♂ Coalinga, 15.v.1938 (unk. col.); **USA: Nevada:** ♀ Carson City, 25.vi.1929 (EP van Dnzoo).

Type: Female, from Boulder Colorado, UC Riverside (Timberlake collection). [Not examined]

***H. louisae* (Cockerell, 1934)**

Osmia louisae Cockerell, 1934b, Amer. Mus. Novitates, 697: 14.

Chlorosmia viridimicans Michener, 1936c, Amer. Mus. Novitates, 875: 29.

Hoplitis (Monumetha) louisae Hurd & Michener, 1955, Bull. Calif. Ins. Sur., 3: 81.

Hoplitis (Alcidamea) louisae Sedivy et al., 2013, Zool. J. Linn. Soc., 167(1): 28-42.

Biology: *Hoplitis louisae* is polylectic and has been recorded foraging on many plant families including Asteraceae, Boraginaceae, Fabaceae and Hydrophyllaceae (Ascher & Pickering 2016). There is one Canadian record for *H. louisae* from southern British Columbia. Records throughout its range were collected from early May to late July (Michener 1947; Ascher & Pickering 2016).

Diagnosis: The female of *H. louisae* can be recognized by the combination of integument brilliantly metallic bluish-green, compound eye nearly parallel sided, ventral and dorsal ends nearly of equal width and mesoscutum wide, more than one and a half times wider than long. The male of *H. louisae* can be recognized by the combination of integument brilliantly metallic bluish-green, ultimate flagellomere with apex pointed and T7 with apex produced to a median pointed spine..

***H. louisae* redescription**

Figures: 3.6; 3.51; 3.52

Female (N=4): length 12mm (10 to 12mm); head width 3mm (2.5 to 3.5mm); ITW 2.5mm (2 to 3mm); forewing length 9mm (7.5 to 9mm).

Colouration: integument brilliant metallic, bluish-green to purple, except as follows: scape mostly dark brown, feebly metallic bluish-green in some areas, flagellomeres brown to dark brown; labrum brown to black; mandible dark brown to black, except in outer interspace where it is feebly bluish-green, metallic; clypeus with apical margin dark brown to black between lateral angles of truncation; tegula dark brown posteriorly; tarsi, basitarsi and tarsal claw on all legs brown to piceous; hind tibial spur dark brown; wings hyaline throughout, dusky brown, darkest apically; sterna with apical impressed margin brown to black.

Pubescence: hairs mostly dark, cinereous to black; head and mesosoma moderately pubescent with long, erect hairs (~2MOD), longest in frontal area (~3MOD), except as follows: clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation (~1.5MOD); tegula and metapostnotum without conspicuous pubescence; mesoscutellum with long, erect pubescence at posterior margin (~4MOD); pubescence of metasoma somewhat shorter, the hairs somewhat thicker and darker than in head and mesosoma (<1.5MOD); T6 with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margin (~1MOD); sternal scopa black, oriented posteroventrally, arising from the disc (~4MOD).

Surface sculpture: head, including mandible and antenna, and mesosoma with fine punctation, interspaces shining ($i \sim 3/4d$), except as follows: scape with punctation finer, denser ($i \sim 1.3d$); mandible with finer punctation, somewhat denser ($i < 1/2d$), punctures finest in outer interspace, becoming larger toward rutellum, except along carinae where it is impunctate; hypostomal area less densely punctured ($i < d$); clypeus with narrow impunctate apical margin, wider between lateral angles of clypeal truncation than along lateral margins of truncation, punctures largest at posterior margin, dense ($i \sim 1/4d$), becoming finer toward apical margin ($i \sim 1/2d$); paraocular area with punctation as dense as posterior zone of clypeus ($i \sim 1/4d$), becoming less dense posteriorly into vertexal area ($i < d$); genal area and supraclypeal area and

frontal area very finely punctate, dense ($i \sim 1/4d$), the punctures somewhat obscure; punctures of mesoscutum as large as those of vertexal area, less dense ($i < d$); mesepisternum with larger punctation than that of genal area, less dense ($i < 1.5d$); metepisternum with punctation inconspicuously finer than that of mesepisternum, the punctures shallow, less well defined, about as dense ($i > d$); tegula nearly impunctate, sparsely and shallowly punctured ($i > d$), impunctate along lateral margins; axilla with finer, denser ($i < 1/2d$) punctation than in mesoscutum; punctation of mesoscutellum somewhat finer than that of mesoscutum, about as dense ($i < d$); punctures of metanotum not well defined, somewhat larger than those of mesoscutellum; metapostnotum areolate ($i < 1/4d$), feebly scrobiculate at lateral extremes; propodeum with lateral surface finely and shallowly punctate ($i \sim 1/2d$), punctures of declivous dorsal surface not well defined, somewhat large, somewhat sparse ($i > 1/2d$); punctation of metasoma less dense ($i > d$) than that of head and mesosoma, punctures about as large, somewhat shallow, less well-defined; T1 anterior surface impunctate; T1 and T2 disc conspicuously sparse ($i > 2d$); T3 and T4 somewhat denser ($i < 2d$) than T2, the punctures about as large; punctation of T5 obscure, the punctures shallow, not well defined, somewhat larger and dense ($i < d$) than T4; T6 especially finely and densely punctured ($i = 1/2d$); apical impressed margin of T1 to T5 impunctate; S1 to S6 with moderate punctation in disc, the punctures not especially well defined ($i < d$), S1 to S5 with marginal zone impunctate, that of S6 punctured as in disc.

Structure: head length to width subequal ($L:W = 43:41$); scape elongate, nearly 4x longer than wide ($22:6$); pedicel exposed, widened ($L:W = 6:9$); flagellomeres mostly unmodified: F1 longer than wide ($10:8$), F2 and F3 longer than wide, F4 as long as wide, F5 to F9 wider than long, F10 longer than wide ($14:10$), with the apex rounded; mandible quadridentate, teeth sharp, well defined, mandible widened at apex, the apex wider than the greatest width of the compound eye ($43:38$), distance between tooth of rutellum and first tooth of pollex about twice the distance between the first and second teeth of the pollex ($21:10$), the distance between the first and second teeth of the pollex greater than the distance between the second and third teeth of the pollex ($10:12$); inner margins of compound eyes subparallel ($UOD:LOD = 41:40$); hypostomal carina low; clypeus nearly flat, feebly convex at posterior margin, truncate, the lateral margins of truncation straight, lateral angles of truncation broadly rounded, the margin between angles of truncation nearly straight, feebly concave or emarginate, feebly reflexed dorsad; tentorial pits

deep, well defined; supraclypeal and frontal areas conspicuously convex; supraantennal depression weak; $IAD > AOD$ (22:19); $IOC < OOC$ (18:20); $IOC < OV$ (18:24); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 38:32$); genal area conspicuously wider than compound eye in lateral view (38:26); mesosoma length to width nearly equal ($L:W = 54:49$); admedian line, anteriorly, and parapsidal lines deepened, distinct; mesoscutellum and metanotum gently sloping posteriorly to a nearly declivous propodeum, somewhat sloping; metasoma elongate ($L:W = 85:48$); T1 anterior surface with longitudinal furrow deep, the surface rounded onto dorsal surface, the two surfaces not distinctly delineated by structure; gradular furrows of T2 and T3 deepened; T6 marginal zone reflexed dorsally, concave in profile.

Male (N=3): length (12mm); head width (2.5 to 3mm); ITW (2 to 2.5mm); forewing length (8mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: scape more conspicuously metallic bluish green, flagellomeres light brown to amber-coloured; tegula brown only narrowly at posterior margin; wings lighter than in female; terga with apical impressed margin midnight blue narrowly, then brown to gold at apex.

Pubescence: hairs mostly white, sometimes feebly ochraceous or cinereous; head, mesosoma and metasoma sparsely pubescent with erect hairs ($<1MOD$), except as follows: hypostomal area moderately pubescent, the hairs long, suberect ($>3MOD$); setae arising from the apical margin of the clypeus between lateral angles of truncation a uniform thin fringe, the hairs oriented anteriorly, lightly ochraceous (1MOD); clypeus with dense, suberect hairs ($<3MOD$), except along apical margin where it is glabrate; paraocular area with dense, subappressed pubescence ($\sim 1MOD$); frontal area with long, dense, suberect pubescence ($\sim 4MOD$); vertexal area and genal area moderately pubescent, the hairs long, suberect ($>3MOD$); pubescence of S1 moderately dense in disc, subappressed, black ($>2MOD$), light ochraceous in marginal zone, the hairs oriented posteriorly ($\sim 2MOD$); S2 to S4 glabrate in disc, marginal zone as in S1 but with

hair longer in S2 and S4 ($>2\text{MOD}$), longest in S3 ($>2.5\text{MOD}$); S5 glabrate in disc except for a tuft of long, black hairs oriented ventrally and arising at longitudinal midline of the premarginal line ($\sim 3\text{MOD}$), marginal zone with a short, ochraceous fringe oriented posteromedially out from the subapical margin for $1/3$ their length before a gradual bowing orients their apex dorsad ($\sim 1\text{MOD}$); S6 with a median tuft of long, black pubescence arising from the apical margin, oriented posteriorly.

Surface sculpture: scape moderately punctate ($i \sim 1/2d$); hypostomal area with punctures less dense ($i < 2.5d$); clypeus with impunctate apical margin more conspicuous laterally than in female; genal area punctured as in vertexal area; punctures of mesoscutum larger and denser ($i < 1/2d$) than those of vertexal area; mesepisternum punctured as in genal area; mesoscutellum punctured as in mesoscutum; marginal zone of T1 to T6 impunctate; T7 narrowly impunctate medially, rest of disc moderately punctate with fine punctures ($i < d$), marginal zone with punctures larger, about as dense as disc; S1 moderately punctate in disc ($i \sim 1/2d$), impunctate on apical process; S2 to S5 sparsely punctate in disc, the punctures somewhat fine ($i > d$), denser and larger submarginally in lateral $1/4$ of width ($i \sim 1/2d$); S6 finely punctate ($i < d$), except impunctate narrowly at apical margin.

Structure: head wider than long ($L:W = 45:52$); scape somewhat thickened, about $1.5\times$ longer than wide ($33:21$), nearly entirely enclosing pedicel, flagellomeres ventrally depressed, F1 to F4 longer than wide, F5 to F9 wider than long, F10 as long as wide, F11 longer than wide ($22:9$), the apex pointed, curved ventrally; mandible bidentate, not widened at apex, the apex as wide as $1/4$ the greatest width of the compound eye ($11:44$); compound eyes convergent below ($UOD:LOD = 73:68$); clypeus with lateral margins of truncation broadly rounded, apical margin between lateral angles concave, feebly undulate, not reflexed dorsad; $IAD:AOD = 16:14$; $IOC > OOC$ ($22:19$); $IOC > OV$ ($22:19$); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area ($FAL:VAL = 36:24$); compound eye wider than genal area in lateral view ($15:11$); mesosoma longer than wide ($L:W = 58:53$); metasoma elongate ($L:W = 68:48$); T6 with apical margin rounded, lateral teeth pointed, widened at base, as long as their basal width; T7 truncate at apex, with truncation produced to a pointed median process; S1 to S4 thickened submarginally; S1 and S2 with a median, apical tooth-like

process arising subapically, oriented posteriorly, that of S1 short (L=B) with apex blunt, that of S2 somewhat long, parallel sided, the apex pointed and somewhat curved dorsad (L:W=6:4); apical margin of S1 and S2 nearly straight, or feebly rounded; apical margin of S3 and S4 feebly concave; apical margin of S5 straight; apical margin of S6 emarginate in middle 1/4; S6 to S8 retracted.

Genitalia: as in Fig. 3.52f.

Distribution: *Hoplitis lousiae* is scarce in most collections. It has been collected at high elevations along the Rocky Mountain Range from southern British Columbia south to California, and east as far as eastern Wyoming and Montana south to Utah (Fig. 3.6f). [CAN: BC; USA: CA; ID; MT; OR; UT; WA; WY.]

Specimens examined: USA: Idaho: ♂ *Blaine Co.*, 27.v.2007 (J Gibbs & C Sheffield) [Barcoded]; ♀ *Blaine Co.*, 25.vi.2007 (J Gibbs & C Sheffield) [Barcoded]; 2 ♂ *Butte Co.*, 26.v.2007 (J Gibbs & C Sheffield) [2 ♂ Barcoded]; USA: Montana: ♀ *Gallatin Co.*, Hwy 287, 23.vi.2007 (J Gibbs & C Sheffield) [Barcoded]; USA: Utah: ♀ *Cache Co.*, 24.vii.2008 (TL Griswold) [Barcoded].

Type: Female, from Craters of the Moon, Idaho, in the American Museum of Natural History. [Examined]

***H. pilosifrons* (Cresson, 1864)**

Alcidamea pilosifrons Cresson, 1864a, Proc. Ent. Soc. Phil., 2: 386.

Hoplitis graceae Cockerell, 1923, Ann. Mag. Nat. Hist., 9(11): 263.

Alcidamea mucronata Cockerell, 1934c, Bull. Brooklyn Ent. Soc., 29: 18.

Hoplitis pilosifrons Michener, 1955, Kans. Ent. Soc. Jour., 28(3): 81.

Biology: *Hoplitis pilosifrons* is polylectic and has been recorded foraging on many plant families including Asteraceae, Boraginaceae, Campanulaceae and Fabaceae (Asher & Pickering 2016). In Canada it is relatively common and has been collected from late May (25, Grassy Lake, AB) to mid August (12, Grasslands National Park, AB).

Diagnosis: The female of *H. pilosifrons* can be recognized by the combination of scape elongate, more than three times longer than wide, base of labrum without yellowish membranes, mandible tridentate, distance between lateral ocelli long, at least one and a half times the width of median ocellus, genal area distinctly wider than compound eye, metasomal scopa light, T1 and T2 punctures at least as large as those of vertexal area, not especially fine, punctation not especially sparse in middle fifth of marginal width, not especially shiny and T1 not distinctly impunctate along longitudinal midline, T2 to T4 with gradular furrows not especially deep, that of T4 hardly deep, T6 with punctures deeper and denser than those of T5, and S6 unmodified. The male of *H. pilosifrons* can be recognized by the combination of flagellomeres two to five unmodified, bidentate mandible, base of labrum without membranes, clypeus without silvery tomentum, T7 apical margin produced to a median spine, apical margin of S2 not produced to a median spine, S2 with a low mound in disc, mound rounded at apex, nearly transverse.

H. pilosifrons redescription

Figures: 3.6; 3.53; 3.54

Female (N=11): length (8 to 9mm); head width (2 to 3mm); ITW (1.25 to 2mm); forewing length (5 to 6mm).

Colouration: integument black, except as follows: basal flagellomeres (F4 to F10) brownish-orange to yellowed; cap of rutellum of mandible piceous; tegula piceous; tarsi of all legs and hind tibial spur dark brown to black; tarsal claw of all legs dark amber-coloured; wings hyaline, lightly dusky along perimeter, clear in submarginal and medial cells; sterna with apical impressed margin dark brown.

Pubescence: hairs mostly white; head, mesosoma and metasoma generally sparsely pubescent with suberect hairs ($<2.5\text{MOD}$), pubescence denser on the following: mandible with outer interspace conspicuously pubescent, hairs suberect ($<1\text{MOD}$); clypeus fringed with ochraceous setae between lateral angles of truncation, the hairs erect, oriented anteromedially and arising from the apical margin beneath the truncation ($<0.5\text{MOD}$); paraocular and frontal area moderately pubescent, the hairs suberect, somewhat long ($<2\text{MOD}$); mesosoma with pubescence conspicuously denser, sometimes lightly ochraceous on the following: pronotum mostly glabrate, except in pronotal lobe which is as in mesoscutum ($<2.5\text{MOD}$); mesepisternum, laterally, posterior margin of mesoscutellum, metanotum and dorsolateral angle of propodeum moderately densely pubescent, hairs somewhat long, suberect ($<2\text{MOD}$); metapostnotum glabrate; metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, interrupted for middle third ($\sim 1\text{MOD}$); sternal scopa light, straw-coloured, oriented posteroventrally, arising from the disc ($>4\text{MOD}$).

Surface sculpture: head, including mandible and antenna, mesosoma and metasoma densely punctate ($i=1/4d$), interspaces shining, except as follows: mandible with finer punctation, somewhat less dense ($i=1/4d$), except along carinae where it is impunctate; punctures of hypostomal area shallow, not well defined, less dense ($i\sim 1/2d$) than in genal area; punctation of clypeus large at posterior margin ($i=1/4d$), becoming finer and less dense ($i\sim 1/3d$) toward an impunctate apical margin between lateral angles of clypeal truncation, clypeus narrowly impunctate along basal $1/3$ of longitudinal midline; lower paraocular area large as in basal zone of clypeus ($i=1/3d$), finer otherwise ($i=1/2d$); supraclypeal area somewhat variably punctured ($i<3/4d$), punctures least dense medially; pronotum very finely punctate ($i<1/4d$), pronotal collar and pronotal lobe punctulate with punctures large, shallow and not well defined ($i>1/2d$); mesoscutum and mesepisternum with punctures somewhat larger than those of vertexal area and genal area, respectively, similarly-spaced in mesepisternum ($i=1/4d$), less densely so in mesoscutum ($i\sim 1/2d$); tegula finely and sparsely punctate ($i>d$), punctation densest anteriorly; metepisternum less densely punctate ($i<d$) than in mesepisternum, mostly shining; axilla very densely punctate ($i<1/4d$), the punctures only somewhat finer than those of mesoscutum; mesoscutellum sparsely punctate anteriorly ($i=d$), denser toward posterior margin ($i\sim 1/4d$); metanotum imbricate-punctate; metapostnotum very finely punctate ($i=1/2d$); propodeum with

lateral and dorsal surfaces very finely and densely punctate ($i \sim 1/3d$), the dorsal surface punctulate with larger pits shallow, less well defined ($i > 1/2d$); T1 anterior surface mostly impunctate, shining, with few large pits ($i > 2d$), disc with denser ($i < 2d$) punctation than that of T2 to T4 ($i > 2d$); T5 punctation denser ($i < d$) than that of T4, less dense than that of T6 ($i < 1/4d$), the punctures of T6 conspicuously larger than those of T5 and T6 without narrow impunctate apical margin of T1 to T5; sterna moderately punctate in disc, punctures well defined ($i = 1/3d$); impunctate in marginal zone of S1 to S5, marginal zone of S6 punctured as in disc.

Structure: head wider than long (L:W= 64:54); scape elongate, over 3x longer than wide (26:8); pedicel exposed, as long as wide, flagellomeres mostly unmodified: F1 longer than wide (6:5), F2-F9 wider than long, somewhat ventrally flattened, F10 wider than long (L:W=7:9), with the apex rounded, curved ventrally; mandible tridentate, the teeth not especially sharp, distance between tooth of rutellum and first tooth of pollex less than the distance between the first and second teeth of the pollex (7:11), the margin between the first and second teeth of the pollex shallow, broadly concave; compound eyes convergent below (UOD:LOD= 64:54); hypostomal carina moderately high; clypeus convex medially, flat along lateral and apical margins, broadly truncate, the lateral margins of truncation straight, and lateral angles of truncation well defined, rounded, the margin between angles of truncation concave; supraantennal depression moderate; AD:AOD= 21:15; IOC<OOC (16:21); IOC=OV; median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 31:20); genal area wider than compound eye in lateral view (28:21); mesosoma length subequal width (L:W= 37:38); mesoscutellum and metanotum gently sloping posteriorly to an entirely declivous propodeum; metasoma somewhat elongate (L:W= 57:35); T1 anterior surface with a short, narrow, longitudinal furrow, the surface rounded onto the dorsal surface, the two surfaces not distinctly delineated by structure; T6 marginal zone strongly reflexed dorsally, angulate in profile.

Male (N=10): length 8mm (7.5 to 9mm); head width 2.5mm (2.25 to 2.5mm); ITW 1.5mm (1.5 to 2mm); forewing length 6mm (5.5 to 6mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres yellowed, sometimes light brownish-ochraceous; tegula brown; hind tibial spur honey-coloured; tarsi of all legs brown; tarsal claw of all legs honey-coloured; wings clearer than in female; terga with apical impressed margin brown to dark gold.

Pubescence: hairs mostly white to light ochraceous; head and mesosoma covered in moderately dense, suberect pubescence ($\sim 1\text{MOD}$), pubescence denser on the following: hypostomal area margined laterally and posteriorly by dense, somewhat short pubescence ($<1\text{MOD}$), hairs erect; hairs arising from the apical margin of the clypeus between lateral angles of truncation a uniform thin fringe, the hairs oriented anteriorly, not usually darker than those of clypeus; clypeus and frontal area with dense, suberect pubescence ($\sim 2\text{MOD}$); paraocular area with dense, subappressed pubescence ($\sim 1\text{MOD}$); pronotal collar mostly glabrate; S3 and S4 with a median, apical tuft-like fringe for middle 1/3 of segment, the hairs dense, oriented posteriorly and slightly toward midline, arising from the premarginal line ($\sim 1.5\text{MOD}$), disc with subappressed, short pubescence along longitudinal midline ($<1\text{MOD}$); S5 with an apical fringe for the width of the marginal zone ($\sim 1\text{MOD}$), the hairs arising from the premarginal line, oriented posteriorly and slightly toward midline ($\sim 1\text{MOD}$).

Surface sculpture: punctures of hypostomal area well defined, sparse and fine ($i > 3d$); punctures of clypeus fine, even ($i = 1/2d$) to an impunctate apical margin that continues along lateral margins of clypeal truncation; punctures of supraclypeal area and of lower paraocular area about as fine as those of clypeus, denser in lower paraocular area ($i \sim 1/2d$) and densest medially in supraclypeal area where punctation is finest ($i < 1/4d$); T1 to T5 similarly punctured ($i < d$); T6 with punctation larger and denser ($i \sim 1/4d$) than in T5; T7 larger still, punctures less well defined ($i \sim 1/2d$); disc sparsely punctured in protuberance of S2 ($i > d$), punctures large, otherwise moderately punctate in disc ($i \sim 1/2d$), those of marginal zone finer, less dense ($i = 1/2d$); S3 to S5 with submarginal swellings of disc with larger punctation, about as dense as rest of disc ($i \sim 1/3d$), marginal zone with finer punctation, similarly-spaced ($i \sim 1/3d$); apical margin of S1 to S5 impunctate, more narrowly so on S3 to S5.

Structure: head wider than long (L:W= 67:72); scape somewhat elongate, roughly 2x longer than wide (35:15), pedicel nearly entirely enclosed by scape; flagellomeres mostly unmodified, wide and long to basal segments and becoming narrower and shorter toward apical segments such that F1 is both the widest and the longest flagellomere, F1 hardly longer than wide (L:W= 12:11), except for F11, which is longer than wide (14:8), tapered from its base to a pointed, ventrally curved apex; mandible bidentate, not especially wide, the teeth sharp and the margin between them deep; compound eyes convergent below (UOD:LOD= 46:37); clypeal truncation as in female, except the margin between lateral angles of truncation only feebly concave; supraantennal depression strong; IAD:AOD= 12:8; IOC hardly greater than OOC (21:20); IOC>OV (21:14); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 30:19); genal area not as wide as compound eye in lateral view (25:32); mesosoma hardly longer than wide (L:W= 82:78); metasoma elongate, over 2x as long as wide (L:W= 69:32); T6 with apical margin rounded, feebly reflexed dorsad, lateral teeth as long as their basal width; T7 produced to a spine-like process, the apex somewhat rounded and with a narrow, sub-basal excavation at middle of disc, the excavation deep and distinct; S1 to S5 apical margins emarginate, broadly so on S1 and S5, narrowly at midline on S2 to S3; S1 and S3 to S5 with disc feebly swollen submarginally, except longitudinally along midline; S2 with a low, nearly transverse (>1/2 the width of the sternum) mound in disc, the apex broad, anteriorly rounded and posteriorly angulate in ventral view, anterior surface steeper from apex, somewhat flatter than the posterior surface in profile; margin of S6 rounded; S6 to S8 retracted.

Genitalia: as in Fig. 3.54f.

Distribution: *Hoplitis pilosifrons* has a disjunct distribution. Aside from its presence in California southwest of the Great Basin, *Hoplitis pilosifrons* is primarily an eastern species. It has been collected from southern Alberta south along the foothills of the Rocky Mountain range to Texas, and east to southern Quebec, Massachusetts and Florida (Fig. 3.6g). [CAN: AB; MB; ON; SK; QC; USA: AR; CA; CO; CT; DE; GA; IL; IN; KY; LA; MA; MD; MN; MO; MS; NB; NC; ND; NH; NJ; NM; NY; OH; PE; SC; SD; TN; TX; VA; WI; WV; WY.]

Specimens examined: **CAN: Alberta:** ♂ Grassy Lk., 25.v.1988 (L Packer); ♂ Division No. 2, Stafford Lk. Park, 12.vi.2007 (J Gibbs & C Sheffield); ♀ Division No. 2, Lethbridge, 20.vi.2007 (J Gibbs & C Sheffield); 2 ♀ Cypress Co., Cypress Hills P.P., 27-28.vii.2013 (G Rowe & L Graham); **CAN: Saskatchewan:** ♀ Grasslands N.P., 08.vii.2010 (N de Silva); **CAN: Ontario:** 2 ♀ Lanark Co., Burnt Lands Alvar Burn, 09.vi.2008 (PM Catling); ♂ York, Joker's Hill, 02.vi.2002 (V Kushmir) [Barcoded]; ♀ York, Terra Cotta Con. Area, 25.vi.2002 (V Kushmir); 3 ♂ York, Terra Cotta Con. Area, 03.vii.2002 (J Grixti); **USA: Maryland:** ♂ Prince George's Co., 30.v.2003 (S Droege); ♀ ♂ Prince George's Co., 05.vi.03 (S Droege); **USA: Illinois:** ♀ Macoupin Co., Carlinville, 25.vi.2006 (J Gibbs & C Sheffield) [Barcoded]; **USA: South Carolina:** 2 ♀ York Co., Rock Hill, Black Jack Preserve, 25-27.v.2001 (A Zayed).

Type: Male, from Connecticut, in the Academy of Natural Sciences of Philadelphia. [Examined]

***Hoplitis producta* (Cresson, 1864)**

Alcidamea producta Cresson, 1864a, Proc. Ent. Soc. Phila., 2: 386.

Autochelostoma canadensis Sladen, 1916, Can. Entomol., 48: 270.

Alcidamea helenae Cockerell, 1934a, Amer. Mus. Novitates, 732: 6.

Osmia gracilis Michener, 1936d, Pan-Pac. Ent., 11: 183.

Hoplitis (Alcidamea) producta gracilis Michener, 1947, Bull. Am. Mus. Nat. Hist., 89(4): 291.

Hoplitis (Alcidamea) producta bernardina Michener, 1947, Bull. Am. Mus. Nat. Hist., 89(4): 291.

Hoplitis (Alcidamea) producta interior Michener, 1947, Bull. Am. Mus. Nat. Hist., 89(4): 291.

Hoplitis (Alcidamea) producta panamintana Michener, 1947, Bull. Am. Mus. Nat. Hist., 89(4): 291.

Hoplitis (Alcidamea) producta subgracilis Michener, 1947, Bull. Am. Mus. Nat. Hist., 89(4): 291.

Biology: *Hoplitis producta* is polylectic and has been recorded foraging on many plant families including Asteraceae, Boraginaceae, Fabaceae and Rosaceae (Asher & Pickering 2016). In Canada it is relatively commonly collected from mid May (16, Red River, MB) to mid August (18, Ram Creek, BC). *H. producta* is a highly variable species with six described subspecies

geographically divided across North America (see Michener 1947). In Canada, three subspecies are common—*H. producta producta* east of the Rocky Mountain range, *H. producta interior* narrowly along the Rocky Mountain Range, and *H. producta subgracilis* west of the Rocky Mountain Range. DNA barcoding did not support the delineation of the subspecies based on traditional taxonomy (see Chapter 2). The three subspecies occurring in Canada differ by subtle characters, and their ranges intergrade (see Michener 1947). The redescription below and the key to species will include the differences that may be seen between the subspecies collected in Canada.

Diagnosis: The female of *H. producta* can be recognized by the combination of scape hardly more than three times longer than wide, if at all, base of labrum without yellowish membranes, mandible tridentate distance between lateral ocelli short, hardly greater than width of median ocellus, compound eye at least as wide as genal area, metasomal scopa light, T1 and T2 punctation very fine, finer than that of vertexal area, sparse in middle fifth of marginal width, especially shiny, T1 distinctly impunctate along longitudinal midline, T2 to T4 with gradular furrows not especially deep, that of T4 hardly deep, T6 with punctures not deeper and denser than those of T5, punctures similar to those of T5, S6 unmodified. The male of *H. producta* can be recognized by the combination of scape less than two and a half times longer than wide, flagellomeres two to five unmodified, bidentate mandible, base of labrum without membranes, clypeus without silvery tomentum, T7 apical margin produced to a median spine, apical margin of S2 not produced to a median spine, S2 with a high, median protuberance in disc, protuberance centred, posterior surface anterior to centre of segment.

H. producta **redescription**

Figures: 3.6; 3.55; 3.56

Female (N=29): length (4.5 to 9mm); head width (1.5 to 2.5mm); ITW (1 to 2mm); forewing length (4 to 6.5mm).

Colouration: integument black, except as follows: basal flagellomeres (F4 to F10) light brown to yellow; cap of rutellum of mandible piceous; tegula brown to dark amber-coloured, lightest anteriorly and laterally; all legs dark brown to piceous; tarsal claw of all legs amber-coloured; hind tibial spur light brown to straw-coloured; wings hyaline, dusky, except clear in submarginal and medial cells; sterna with apical impressed margin brown.

Pubescence: hairs mostly white to light ochraceous; head and mesosoma and metasoma generally sparsely pubescent ($<1.5\text{MOD}$), hairs suberect, pubescence denser on the following: hypostomal area with pubescence conspicuously bowed, the apices oriented toward the midline anteriorly ($>2\text{MOD}$); clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation ($<1\text{MOD}$); pubescence of apical $1/3$ of clypeus usually at least somewhat ochraceous ($\sim 1\text{MOD}$); paraocular area with dense, subappressed pubescence ($<2\text{MOD}$); frontal area with long, suberect pubescence ($\sim 2.5\text{MOD}$), the hairs lightly ochraceous; pronotal collar, pronotal lobe and mesepisternum with dense, suberect pubescence ($\sim 2\text{MOD}$); axilla, posterior margin of mesoscutellum and metanotum with long, erect pubescence, usually ochraceous ($\sim 2.5\text{MOD}$); propodeum with dorsolateral angle and dorsal surface densely pubescent, the hairs suberect ($<2\text{MOD}$); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T4 and T6, interrupted in middle third of T1 to T3 ($\sim 1\text{MOD}$); sternal scopa light, straw-coloured, oriented posteroventrally, arising from the disc ($>4\text{MOD}$).

Surface sculpture: head, including mandible and antenna, and mesosoma moderately and densely punctate ($i=1/3d$), interspaces shining, except as follows: scape with punctation somewhat finer and less dense ($i\sim 1/2d$); mandible with finer punctation, somewhat less dense ($i<1/2d$), except along carinae where it is impunctate; hypostomal area shiny, punctation large and shallow, not well defined, conspicuously less dense ($i>d$); punctation of clypeus larger and less dense at posterior margin ($i=1/2d$), becoming finer and denser ($i\sim 1/3d$) toward an impunctate apical margin between lateral angles of clypeal truncation, narrowly impunctate in basal $1/3$ of longitudinal midline; supraclypeal area and lower frontal area with finer, denser punctation ($i\sim 1/3d$), punctures finest between antennal sockets at a line drawn tangential to the posterior

margin of the antennal sockets, supraclypeal area impunctate briefly at anterior margin along longitudinal midline; paraocular area with punctation less dense ($i \sim 1/2d$) than surroundings; pronotum strigate, except in pronotal lobe and pronotal collar where it is sparsely and variably punctulate, the punctures shallow and not well defined ($i > 1/2d$); mesoscutum with punctures as large as those of vertexal area, punctation less dense ($i > 1/2d$) than in vertexal area, punctation sparsest medially ($i \sim d$); mesepisternum with punctures larger and less dense ($i \sim 1/2d$) than that of genal area; tegula finely and sparsely punctate ($i > d$), densest anteriorly; axilla finely and densely punctate ($i = 1/3d$); mesoscutellum as in mesoscutum, except along posterior margin where punctures become finer and denser ($i = 1/3d$); metanotum imbricate-punctate, impunctate at lateral extremes; metepisternum with punctures sparser ($i \sim d$), the punctation variable, fine to large; metapostnotum imbricate; propodeum with lateral surface somewhat finely punctate, the punctures not evenly spaced ($i < d$), dorsal surface with larger, sparser punctures ($i \sim 1/2d$), the punctures shallow, not well defined; T1 anterior surface mostly impunctate with a few large, shallow punctures ($i > d$); disc of T1 to T4 with punctation very fine and sparse ($i > 2d$), the punctures shallow, not as well defined as those of vertexal area, the surfaces conspicuously shining; punctures of T5 denser ($i < d$) than those of T4; T6 punctation finer and denser ($i = 1/3d$) than that of T5, the marginal zone with punctures somewhat obscured by roughened interspaces; sterna densely punctate in disc ($i = 1/3d$), impunctate in marginal zone in S1 to S5, that of S6 with punctures finer than those of disc, similarly dense ($i = 1/3d$).

Structure: head length to width nearly equal ($L:W=34:33$); scape elongate, nearly 4x longer than wide ($23:6$); pedicel exposed, as long as wide; flagellomeres mostly unmodified, width gradually increasing from basal to apical segments: F1 to F9 wider than long, F10 longer than wide ($L:W=14:12$), with the apex rounded; mandible tridentate, teeth sharp, distance between tooth of rutellum and first tooth of pollex less than the distance between the first and second teeth of the pollex ($11:16$), margin between teeth of pollex concave; compound eyes convergent below ($UOD:LOD=32:28$); hypostomal carina moderately high; clypeus feebly convex, truncate, the lateral margins of truncation nearly straight, or feebly convex, lateral angles of truncation either broadly rounded, not well defined, with the margin between them narrowly concave at middle, the concavity less shallow, or, lateral angles of truncation somewhat well defined, still rounded, the margin between them broadly concave, the concavity shallow;

supraantennal depression weak; IAD:AOD= 29:21; IOC<OOC (21:26); IOC hardly greater than OV (21:20); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 43:26); genal area narrower than compound eye in lateral view (25:21); mesosoma longer than wide (L:W= 42:35); mesoscutellum and metanotum gently sloping posteriorly to an entirely declivous propodeum; metasoma somewhat elongate (L:W= 64:43); T1 anterior surface with a short, narrow, longitudinal furrow, the surface rounded onto the dorsal surface, the two surfaces not distinctly delineated by structure; T6 marginal zone strongly reflexed dorsally, angulate in profile.

Male (N=41): length 7mm (5 to 8.5mm); head width 1.5mm (1.5 to 2.25mm); ITW 1mm (1 to 2mm); forewing length 5mm (3.5 to 6mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: wings lighter than in female; terga with apical impressed margin brown to dark gold.

Pubescence: pubescence somewhat denser than that of female; hypostomal area with pubescence not conspicuously bowed; clypeus with dense, suberect pubescence continuing in supraclypeal and frontal area (~2MOD), hairs mostly white; hairs arising from the apical margin of the clypeus between lateral angles of truncation a uniform thin fringe, the hairs oriented anteriorly, not usually darker than those of clypeus (~1MOD); T1 to T5 apically fasciate, the bands as in female; S3 and S4 with a median, apical tuft, the tuft dense, hairs oriented posteriorly (~2MOD); S5 with a short, apical fringe for the width of the marginal zone (~1MOD), the hairs not dense, arising from the premarginal line.

Surface sculpture: scape finely punctate, somewhat less dense than in head ($i=d$); head somewhat less densely punctate ($i=1/2d$) than in female; hypostomal area impunctate; punctures of clypeus fine, even ($i=1/2d$), except along impunctate apical margin, the impunctate margin as wide along lateral margins of clypeal truncation as between lateral angles of truncation; punctures of lower supraclypeal area and of lower paraocular area as in base of

clypeus ($i=1/2d$); mesoscutellum less densely punctate ($i<d$) than mesoscutum ($i<1/2d$); T1 to T6 similarly punctured, the punctures moderately well defined, not especially dense ($i<d$), apical margins impunctate; T7 with punctation somewhat obscure ($i\sim 1/2d$), apical margin punctured as in disc; sterna sparsely punctate ($i>d$), somewhat finely punctured in disc, except in protuberance of S2 and submarginal swellings of S3 to S5 where there are few punctures or is impunctate; apical margins of S1 to S5 narrowly impunctate, that of S6 very finely and densely punctured ($i\sim 1/3d$).

Structure: head wider than long (L:W= 65:72); scape somewhat elongate, less than 2.5x longer than wide (L:W= 28:12), pedicel entirely enclosed by scape; flagellomeres mostly unmodified, F1 length and width equal, F2 to F10 wider than long, F11 longer than wide (L:W= 10:6), the apex pointed and curved ventrally; hypostomal carina lower than in female; mandible bidentate, narrow, the teeth distinct but not sharp, apices somewhat rounded; compound eyes convergent below (UOD:LOD= 35:26); clypeus feebly convex, truncate, the lateral margins of truncation straight, lateral angles of truncation distinct, well defined, somewhat sharp ($\sim 110^\circ$), the margin between angles broadly concave, the concavity shallow; supraantennal depression strong; IAD:AOD= 15:9; IOC subequal OOC (13:14); IOC=OV; median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 21:18); genal area not as wide as compound eye in lateral view (16:23), sometimes width of genal area subequal width of compound eye; mesosoma longer than wide (L:W= 61:56); metasoma somewhat elongate (L:W= 81:53); T6 with apical margin rounded, lateral teeth blunt, the apices rounded, only as long as their basal width; T7 produced to a spine-like process, the apex somewhat rounded and with a narrow, sub-basal excavation at middle of disc, the excavation deep and distinct; S1 and S3 to S4 with disc feebly swollen submarginally, interrupted narrowly at longitudinal midline; S1 somewhat short, depressed in marginal zone, apical margin straight; S2 with a large, median protuberance in middle 1/3 of disc, the lateral margins of protuberance evenly tapered to a somewhat pointed, or conical, apex, the anterior margin of the apex convex in ventral view, the posterior margin flat, or feebly concave, both the anterior and posterior surfaces of the protuberance steep in profile, that of the posterior surface inconspicuously steeper than the anterior surface; S2 apical margin produced to an inconspicuous, narrow, median emargination; apical margin of S3 to S5 medially emarginate,

narrowly so on S3, that of S4 wider than S3, that of S5 widest; apical margin of S6 rounded; S6 to S8 retracted.

Genitalia: as in Fig. 3.56f.

Distribution: *Hoplitis producta* is widespread throughout North America. In Canada it extends north to northern Alberta (La Crete), and from British Columbia in the west to Nova Scotia in the east. It spans the United States from coast to coast and south into the northern parts of Mexico (Fig. 3.6h). [CAN: AB; BC; MB; NB; NS; ON; PEI; QC; SK; USA: AL; AZ; CA; CO; CT; DC; DE; GA; ID; IL; IN; KS; KY; MA; ME; MD; MI; MN; MO; MT; NC; ND; NE; NH; NJ; NM; NV; NY; OH; OR; RI; SC; SD; TN; TX; UT; VA; VT; WA; WI; WV; WY; MEX: SO.]

Specimens examined: CAN: **British Columbia:** *Okanagan-Similkameen Reg. Dist.:* ♀ Willowbrook, Green Lk., 14.vi.2008 (LR Best) [Barcoded]; 2 ♀ Oliver, Ripley Lk., 12.vii.2008 (LR Best) [Barcoded]; ♀ Oliver, Ripley Lk., 13.vii.2008 (LR Best) [Barcoded]; ♀ Oliver, Taylor Lk., 3.viii.2009 (LR Best) [Barcoded]; ♂ Oliver, Ripley Lk., 10.vii.2010 (G Gielans); ♀ Oliver, Ripley Lk., 15.vi.2013 (G Rowe & L Graham); ♂ Oliver, Ripley Lk., 17.vi.2013 (G Rowe & L Graham); ♀ Sparrow Grasslands, NCC, 23.vi.2013 (G Rowe & L Graham); ♂ Keremeos, Grist Mill; 28.vi.2013 (G Rowe & L Graham); ♂ Penticton, Skaha Bluffs, 24.v.2013 (G Rowe & L Graham); *East Kootenay Reg. Dist.:* 5 ♀ Pine Butte Ranch, NCC, 9-10.vii.2013 (G Rowe & L Graham); ♀ Invermere, 05.vii.2013 (G Rowe & L Graham); 2 ♀ Ram Creek, FSR, 18.viii.2009 (LR Best) [Barcoded]; *West Kootenay Reg. Dist.:* ♂ Midway, Hwy 3, 08.vi.2007 (J Gibbs & C Sheffield); *Cariboo Reg. Dist.:* ♂ Alexandria, Moffat Lk., 28.vi.2006 (LR Best and S Martinson) [Barcoded]; CAN: **Alberta:** ♂ Edmonton, 1.vii.1923 (EH Strickland); CAN: **Saskatchewan:** ♀ 2 ♂ Larson Ranch, Hwy 21 nr. Maple Crk., 15-31.vii.2008 (col.unk.) [♀ 2 ♂ Barcoded]; ♀ Grasslands N.P., 09.vii.2010 (N de Silva); CAN: **Ontario:** 2 ♂ King City, Joker's Hill, 20.vi.2002 (J Grixti) [Barcoded]; ♂ RM Haldimand-Norfolk Co., Manestar Sav., 28.v.1998 (H Douglas); ♂ RM Haldimand-Norfolk Co., Nixon, 28.v.1998 (H Douglas); 2 ♂ RM Haldimand-Norfolk Co., Manestar Sav., 29.v.1998 (H Douglas); ♀ Lambton Co., Pinery Nipissing, 28.v.1998 (H Douglas); 2 ♀ York, Terra Cotta Cons. Area, 25.vi.2002 (V Kushnir); ♂ York, Terra Cotta Cons. Area, 03.vii.2002 (J Grixti); ♀ Baxter, 6 Mile Lk., 8.vii.1981 (L Packer); ♂

Perth, 7.vii.1950 (WP Stephen); ♂Chapleau, Racine Lk., 7.vii.1990 (M Usui); ♂Chapleau, 24.vi.1990 (M Usui); ♂Lanark Co., Burnt Lands Alvar burn, 09.vi.2008 (PM Catling); 2 ♀ 1 ♂ Caledon, Terra Cotta Cons. Area, 25.vi.2002 (J Grixti); 2 ♀ Amaranth, Orangeville, 24-26.vi.1989 (L Packer); **USA: Arizona:** ♂ White Mtns., 19.vi.1950 (RH Beamer); **USA: California:** *San Benito Co.:* ♀ Scout Pk., 04.v.2011 (JM Meiners & T Lamperty) [Barcoded]; ♀ ♂ McCabe Canyon Mouth, 08.vi.2011 (JM Meiners & T Lamperty) [Barcoded]; ♂ McCabe Canyon Mouth, 12.v.2011 (JM Meiners) [Barcoded]; *San Bernardino Co.:* ♀ ♂ Sheep Crk., 25-30.v.2005 (ME Irwin) [Barcoded]; *Mariposa Co.:* ♂ Foresta Rd., 19.v.2006 (E Stephens) [Barcoded]; ♂ Ostrander Rocks, 13.vii.2006 (TL Griswold) [Barcoded]; ♂ Merced Lk., Moraine Dome, 04.vi.2004 (HW Ikerd & C Ratti) [Barcoded]; *San Diego Co.:* ♀ Pine Valley, 30-31.v.2002 (FD Parker & ME Irwin) [Barcoded]; ♂ Pine Valley, 30-31.v.2002 (JM Meiners & T Lamperty) [Barcoded]; ♂ Tuolumne Co., Tioga Pass, 08.viii.1993 (L Packer & T Pare); **USA: Colorado:** ♀ Jackson Co., North Delaney Butte Lk., 26-28.vi.2013 (FD Parker & TD McIntyre) [Barcoded]; ♂ Garfield Co., Rifle, 21.vi.2008 (FD Parker) [Barcoded]; ♀ Moffat Co., Artesia, 23.vii.1950 (RH Beamer); **USA: Idaho:** ♀ ♂ Caribou Co., Chesterfield Reservoir, 6-8.vi.2013 (FD Parker & TD McIntyre) [Barcoded]; **USA: Kansas:** ♀ Douglas Co., Univ. Kans. Nat. Hist., 11.vi.1957 (col. unk.); **USA: Maryland:** ♀ Charles Co., 14.vii.2003 (M Ibrahim); ♂ Prince George's Co., 05.vi.2003 (SW Droege); **USA: Minnesota:** ♂ Minnetonka, U. of Minnesota, ?.v.2005 (L Packer) [Barcoded]; **USA: Montana:** ♀ Hamilton, 07.vii.1949 (RH Beamer); ♀ Hamilton, Lost Horse Cyn., 02.viii.1949 (JR White); **USA: Nevada:** ♂ Clark Co., Lovell Cyn., 20.v.2005 (E Ahlstrom) [Barcoded]; **USA: Oregon:** ♂ Wasco Co., Dufur, Butler Cyn., 22-29.vii.2010 (ME Irwin & FD Parker) [Barcoded]; **USA: Texas:** ♀ Sanderson, 13.iv.1949 (CD Michener & RH Beamer); **USA: Utah:** ♂ Allen Canyon, 03.vii.1950 (GF Knowlton); ♂ Park City, 11.vi.1952 (AE Wolfe); ♀ Kane Co., Kanab Crk., 23.vi.1999 (L Packer); ♀ ♂ Cache Co., Wellsville, 25.vi.1999 (L Packer); ♀ ♂ Selver Co., Fish Lk. Pelical Cyn., 26.vi.1999 (L Packer); 2 ♂ San Juan Co., La Sal Mountains, Warner Lk., 28.vi.1999 (L Packer); ♂ Washington Co., Wire Valley Kn., 24.iv.2007 (H Ikerd) [Barcoded]; ♀ Washington Co., Stave Spr., 15.v.2007 (H Ikerd) [Barcoded]; ♂ Garfield Co., Escalante River, Jet Death Hollow, 30.iv.2001 (O Messinger) [Barcoded]; ♂ Logan Cyn., Spring Hollow, 01.vi.2012 (SJ Burrows [Barcoded]; *Washington Co.:* ♀ Lemmon Spr., 01.vi.2006 (B Hays & F Nicklen) [Barcoded]; ♂ Lemmon Spr., 16.v.2007 (K Davidson) [Barcoded]; **USA: Virginia:** ♀ Albemarle Co., 06.vi.2003 (Mersereau); **USA:**

Washington: ♂ Pullman, 30.v.1970 (col. unk.); ♂ Klickitat Co., Goldendale, 22-28.vii.2010 (ME Irwin & FD Parker) [Barcoded]; **USA: West Virginia:** *Hampshire Co.*: ♂ 24.v.2002 (SW Droege); ♀ 25.v.2003 (SW Droege); ♂ Albemarle Co., 05.vi.2003 (C Boston).

Type: Male, from Virginia, in the Academy of Natural Sciences of Philadelphia. [Examined]

***Hoplitis robusta* (Nylander, 1848)**

Heriades robusta Nylander, 1848, Not. Sällsk. Fauna F1. Fenn. Forh., 1: 270.

Osmia rhinoceros Giraud, 1861, Verh. Zool. –Bot. Ges. Wien., 11: 464.

Heriades trinacria Morawitz, 1869, Hor. Soc. Ent. Ross., 6: 41.

Formicapis clypeata Sladen, 1916, Can. Entomol., 48: 271.

Hoplitis (Formicapis) clypeata Hurd & Michener, 1955, Bull. Calif. Ins. Surv., 3: 54.

Biology: *H. robusta* is polylectic and has been recorded visiting Fabaceae (Clement & Rust 1975), Asteraceae (Hurd & Michener 1955), Cistaceae (Müller & Mauss 2016), Caryophyllaceae and Ranunculaceae (Müller & Mauss 2016) but is thought to have a strong preference for Rosaceae (Müller & Mauss 2016). In Canada, *H. robusta* has been collected from mid-May (18, Milk River, AB) through late August (25, Yellowknife, NT).

Diagnosis: The female of *H. robusta* can be recognized by the mostly modified clypeus which bears a short, median, snout-like projection on the apical margin. The male of *H. robusta* can be recognized by the combination of clypeus with apical margin distinctly crenulate and T7 apical margin four-lobed.

***Hoplitis robusta* redescription**

Figures: 3.6; 3.57; 3.58

Female (N= 11): length (syntype: 7mm) (7 to 11mm); head width (syntype: 2mm) (1.5 to 3mm); ITW (syntype: 1.5mm) (1.5mm to 2mm); forewing length (syntype: 5mm) (5.5 to 7mm).

Colouration: integument black, except as follows: flagellomeres grayish-brown; tegula blackish-brown; wings hyaline, dusky; hind tibial spur amber-coloured; tarsi and tarsal claw of all legs brown.

Pubescence: hairs white to light ochraceous; integument covered in sparse, erect pubescence ($<1\text{MOD}$), denser on the following: paraocular area and frontal area with suberect pubescence ($>2\text{MOD}$); vertexal area, pronotum, mesoscutum, mesepisternum and dorsolateral angle of propodeum all with longer, denser pubescence ($>2\text{MOD}$); posterior margin of mesoscutellum with long, erect hairs ($\sim 3\text{MOD}$); sternal scopa suberect, straw-coloured ($\sim 4\text{MOD}$), oriented posteroventrally, arising from the disc; metasoma with hair bands arising from the apical impressed margins of T1 to T4 and T6 ($\sim 1\text{MOD}$), usually medially effaced on T1.

Surface sculpture: head finely punctate, though variably dense: acetabular interspace of mandible with interspaces convex, thickened ($i < d$), outer interspace with fine, even punctation ($i \sim d$), impunctate along carinae; clypeus moderately punctate ($i \sim d$) except narrowly impunctate along longitudinal midline; paraocular area finely and densely punctate ($i < 0.5d$); supraclypeal area finely punctate ($i < 0.5d$) with the interspaces roughened, dull; punctures of vertexal area and genal area somewhat variably spaced ($i < d$) and variably sized; hypostomal area impunctate; mesosoma punctured as in vertexal area, except for the following: punctures of mesoscutellum larger, denser ($i < 0.5d$); tegula finely and sparsely punctured ($i < 2d$), except centrally where it is impunctate; metanotum entirely roughened, though not entirely dull, shine most evident medially; metepisternum and dorsolateral angle of propodeum with larger, less dense punctation ($i > d$) with the interspaces roughened, dull; metapostnotum entirely roughened, basally with surface sculpture more even, posteriorly more variable; metasoma more finely punctate than head and mesosoma, though less densely so ($i > 2d$), interspaces shining, except for the following: T1 anterior surface evenly roughened as in basal zone of metapostnotum; T4 and T5 punctured as in T1 to T3 but with interspaces roughened; T6 with denser punctation ($i < d$) and with interspaces shining; sterna moderately punctate beneath scopa ($i < d$), impunctate in narrow marginal zone.

Structure: scape hardly more than 2x longer than wide ($L:W=18:8$); pedicel length to width subequal ($6:5$); head wider than long ($42:37$); hypostomal carina high; mandible widened

at apex, bidentate, but with margin of pollex usually undulate giving the semblance of a bidentate to 5-toothed mandible: distance from the tooth of the rutellum to tooth of the pollex 1.5x greater than the greatest width of the compound eye (18:12); tooth of rutellum sharp, well defined; clypeus short, broad, bearing a triangular snout-like projection medially on the apical margin, the clypeal margin somewhat emarginated on either side of the projection, emargination with a somewhat broad concavity; anterior tentorial pits deep, well defined; IAD:AOD= 19:28; tubercle in supraclypeal area at midpoint between antennal socket; supraantennal depression deep; compound eyes divergent below (UOD:LOD= 29:31); IOC roughly half OOC (11:23); IOC<OV (23:27); median ocellus anterior to midpoint between the posterior margin of the antennal socket and the posterior margin of the vertexal area (FAL:VAL= 32:35); genal area wider than compound eye in lateral view (16:10); mesosoma length to width subequal (L:W= 44:41); metapostnotum with basal zone sloping, otherwise declivous.

Male (N=3): length (syntype: 7mm) (6.5 to 8mm); head width (syntype: 2mm) (1.5 to 2mm); ITW (syntype: 1.75mm) (0.75 to 1.5mm); forewing length (syntype: 5mm) (5 to 6mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: terga with apical impressed margin black-brown.

Pubescence: clypeus densely pubescent with suberect hairs (>2MOD); terga apical fasciae very thin, often only evident at lateral margins, if at all; S3 with a small, tuft-like patch of pubescence narrowly at the midline, arising from the apical margin, oriented posteriorly, white to ochraceous (>2MOD); S5 with fringe of short, yellowed hairs oriented posteriorly and arising from the apical margin for its entire length (~1MOD).

Surface sculpture: head evenly, moderately punctate ($i=0.5d$), except for the following: apical margin of clypeus narrowly impunctate; genal area somewhat less densely punctured ($i\sim d$); hypostoma sparsely punctate ($i>2d$), with interspaces shining; mesoscutum and mesoscutellum punctured as in vertexal area ($i=0.5d$); mesepisternum with larger punctures than those of genal area, similarly spaced though with interspaces conspicuously dull; metepisternum with interspaces as in mesepisternum though with denser punctation ($i\sim 0.5d$); metanotum

punctured as in metepisternum; metasoma with shallower punctation than that of female, interspaces shining, patterned as in female; punctation of sterna obscure and with interspaces shining.

Structure: scape 2x longer than wide (22:11); head wider than long (35:33); hypostomal carina moderate; mandible bidentate, distance from the tooth of the rutellum to the first tooth of the pollex less than a fifth the greatest width of the compound eye (5:27); clypeus with apical margin straight, finely crenulate; tentorial pits not especially deepened, nor especially defined; IAD:AOD= 14:10; compound eyes convergent below (UOD:LOD= 22:19); IOC roughly two thirds OOC (12:17); IOC<OV (12:14); median ocellus behind midpoint between the posterior margin of the antennal socket and the posterior margin of the vertexal area (FAL:VAL= 26:19); genal area as wide as compound eye in lateral view; mesosoma length to width subequal (L:W= 34:36); T7 exposed, four-lobed, the lateral lobes wider than long (9:4), median lobes about as long as their basal widths (4:5); concavity between median teeth as broad as a semicircle; concavity between lateral and median teeth wider than a semicircle; sterna mostly unmodified; S6 with a long, narrow process oriented posteriorly and arising medioapically; S7 and S8 retracted.

Genitalia: as in Fig. 3.58e.

Distribution: In the Nearctic, *H. robusta* is primarily a montane species distributed throughout much of Canada and Alaska and south along the Rocky Mountain Range through California, Utah and Colorado (Fig. 3.6i). [CAN: AB; BC; MB; NT; ON; QC; SK; YT; USA: CA; CO; ID; MT; OR; UT; WA; WY.]

Specimens examined: CAN: **Alberta:** 2 ♀ Writing on Stone Pk., Milk River, 18.v.1988 (col. unk.); ♀ Heampstead camp gr., 7.vii.1996 (H Goulet); ♀ Rockyview Co., 2.viii.2009 (MME); ♀ Waterton Lk. N.P., 5-14.vii.1991 (H Goulet); ♀ Huallen, 26.vii.1940 (CL Neilson); CAN: **Northwest Territories:** ♀ Yellowknife, Back Bay, 25.viii.2004 (A Gunn); ♂ Yellowknife, Negus Pt., 30.vi.2005 (PCYU- ARC: 22); CAN: **Yukon Territory:** ♀ Dezadeash Lk., 2.viii.1988 (S and J Peck); 2 ♀ Whitehorse, YK River, 9-13.vii.2006 (L Packer); ♂ Carcross dunes nr. Lk. Bennett, 10.vii.2006 (L Packer); ♀ Yellowknife, Kam Lk., 21.vii.03 (A Gunn).

Type depository: Lectotype, female, from Helsingfors, Finland, in the Finnish Museum of Natural History, Helsinki. [Not examined]

***Hoplitis sambuci* Titus, 1904**

Hoplitis sambuci Titus, 1904, Proc. Ent. Soc. Washington, 6: 101.

Biology: *Hoplitis sambuci* is polylectic and has been recorded foraging on many plant families including Asteraceae, Boraginaceae, Fabaceae and Rosaceae (Asher & Pickering 2016). In Canada it has been collected from late May (26, South Okanagan NCC Lands, BC) to mid July (17, Summerland, BC).

Diagnosis: The female of *H. sambuci* can be recognized by the combination of scape more than three times longer than wide, base of labrum without membranes, mandible tridentate, hind tibial spurs dark, metasomal scopa light, T2 to T4 with gradular furrow distinctly deep, especially that of T4, S6 unmodified. The male of *H. sambuci* can be distinguished from other Canadian *Hoplitis* by the combination of base of flagellomeres two to five not modified, labrum without membranes, mandible bidentate, clypeus without silvery tomentum and apical margin not crenulate, S2 apical margin rounded, nearly straight at midline, T7 truncate, the truncation narrow, not more than one third the width between lateral teeth of T6.

***H. sambuci* redescription**

Figures: 3.6; 3.59; 3.60

Female (N=3): length 9.5mm (9 to 10mm); head width 3mm (3 to 3.5mm); ITW 2.5mm (2.5mm); forewing length 7.5mm (7 to 7.5mm).

Colouration: integument black, except as follows: flagellomeres, at least F4 to F10, grayish; tarsal claw of all legs brown to dark amber-coloured; hind tibial spur black; wings hyaline, dusky, darkest in marginal cell.

Pubescence: hairs mostly white, sometimes yellowed; head and metasoma generally sparsely pubescent ($<1.5\text{MOD}$), hairs suberect, pubescence denser on the following: hypostomal area with long pubescence conspicuously bowed, the apices oriented toward the midline anteriorly ($>3\text{MOD}$); apical margin of labrum fringed with short, ochraceous setae, the hairs erect ($\sim 1\text{MOD}$); clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation ($<1\text{MOD}$); clypeus somewhat densely pubescent, hairs dark, cinereous, suberect ($\sim 1.5\text{MOD}$), hairs more ochraceous at posterior margin of glabrate apical margin; paraocular area, supraclypeal area and frontal area with dense, cinereous to black, suberect pubescence ($>2\text{MOD}$); mesosoma moderately pubescent, hairs suberect, infuscated ($>2\text{MOD}$), except as follows: pronotal lobe margined posteriorly with appressed tomentum, the hairs white ($\sim 1\text{MOD}$); metepisternum less densely pubescent; posterior margin of mesoscutellum fringed with long, erect hairs ($<3\text{MOD}$); metapostnotum glabrate; metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T4, usually interrupted in middle third ($\sim 1\text{MOD}$); T6 apically fasciate, the hairs short, less dense than those of T4, not medially effaced; sternal scopa light, straw-coloured, oriented posteroventrally, arising from the disc ($>3\text{MOD}$).

Surface sculpture: head, including mandible and antenna, finely and densely punctate ($i=1/3d$), interspaces shining, except as follows: scape with punctation somewhat finer, moderately dense ($i\sim 1/2d$); mandible with finer punctation in outer interspace, somewhat less dense ($i=1/2d$), acetabular interspace with punctures larger, somewhat variable ($i\sim 1/3d$), carinae impunctate; hypostomal area shiny, punctation large and shallow, not well defined, conspicuously less dense ($i>1/2d$); punctation of clypeus large, as dense as rest of head ($i=1/3d$), punctures becoming finer toward impunctate apical margin between lateral angles of truncation, narrowly impunctate in basal $1/3$ of longitudinal midline; frontal area with finer, denser punctation ($i<1/3d$) between antennal sockets; pronotum puncticulate, not dense ($i>d$), the punctures large, shallow and not well defined, denser in pronotal lobe and pronotal collar ($i\sim 1/2d$) than laterally ($i>1/2d$); mesoscutum and mesepisternum with punctures larger and less dense ($i<1/2d$) than those of vertexal area and genal area, respectively; tegula finely and sparsely punctate ($i\sim 2d$), denser anteriorly ($i<d$); axilla densely punctate ($i<1/3d$), the punctures variably

sized, not larger than those of mesoscutellum, interspaces somewhat dull; mesoscutellum punctured as in mesoscutum ($i < 1/2d$), except narrowly impunctate along anterior $\frac{1}{2}$ of longitudinal midline; metanotum imbricate-punctate; metepisternum coriarius-punctate, punctures sparse ($i > d$), with much of the segment impunctate; metapostnotum very finely punctate ($i = 1/2d$); propodeum lateral surface with finer punctation than that of mesepisternum, similarly spaced ($i < 1/2d$) but punctures shallow, not entirely well defined, dorsal surface with punctures larger, similarly spaced ($i = 1/2d$) and only somewhat better defined, still shallow; T1 anterior surface impunctate or with a few large, shallow punctures ($i > d$); disc of T1 to T4 with fine, somewhat sparse punctation ($i \sim d$); punctation of disc of T5 larger ($i \sim 1/2d$); punctation of T6 dense ($i < 1/2d$), punctures in marginal zone somewhat obscure; apical margin of T1 to T5 impunctate; sterna mostly and densely punctate in disc ($i = 1/3d$), impunctate in marginal zone in S1 to S5, that of S6 with punctures somewhat finer than those of disc, similarly dense.

Structure: head hardly wider than long (L:W=55:58); scape elongate, over 3x longer than wide (26:7); pedicel exposed, longer than wide (L:W= 10:8), flagellomeres mostly unmodified, width gradually increasing from basal to apical segments: F1 longer than wide (L:W= 12:9), F2 to F9 wider than long, F10 longer than wide (L:W= 15:11), with the apex rounded; mandible tridentate, wide, teeth sharp, distance between tooth of rutellum and first tooth of pollex much less than the distance between the first and second teeth of the pollex (12:21), margin between teeth of pollex concave; compound eyes convergent below (UOD:LOD= 40:34); hypostomal carina high posteriorly, becoming weak at anterior; clypeus convex along longitudinal middle $\frac{1}{3}$, flat laterally and along apical margin, truncate, the lateral margins of truncation convex, rounded at lateral angles of truncation such that the latter are not well defined, apical margin between lateral angles of truncation broadly concave; supraantennal depression moderate; IAD subequal AOD (10:12); IOC<OOC (15:20); IOC<OV (15:18); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 26:22); genal area wider than compound eye in lateral view (23:17); mesosoma hardly longer than wide (L:W= 64:61); mesoscutellum and metanotum gently sloping posteriorly to an entirely declivous propodeum; metasoma somewhat elongate (L:W= 87:60); T1 anterior surface with a short, narrow, longitudinal furrow, the surface rounded onto the dorsal surface, the

two surfaces not distinctly delineated by structure; T2 to T4 with gradular furrows distinctly deepened; T6 marginal zone reflexed dorsally, gently concave in profile.

Male (N=9): length (8 to 10mm); head width (2.5 to 3mm); ITW (2 to 2.5mm); forewing length (6 to 7mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres, at least F2 to F11, lighter than in female, gray, brown or testaceous; cap of rutellum of mandible piceous; tegula dark brown to piceous; hind tibial spur lighter than in female, brown to piceous; wings lighter than in female, dusky usually only along costal margin in marginal cell, rarely dusky apically; terga with apical impressed margin dark amber to piceous.

Pubescence: pubescence somewhat denser than that of female, mostly ochraceous; hypostomal area with pubescence not conspicuously bowed ($\sim 2.5\text{MOD}$); clypeus less densely pubescent than in female, usually only dense laterally, suberect, somewhat ochraceous ($\sim 2\text{MOD}$); T5 apically fasciate, hair band less dense than that of T4, often uninterrupted medially; S2 with pubescence somewhat denser in disc, densest medially, hairs suberect ($\sim 2\text{MOD}$); S3 to S5 with apical fringe for width of marginal zone, hairs oriented posteriorly and arising from the premarginal line; S3 and S4 with hairs of fringe long ($>1.5\text{MOD}$), feebly bent ventrally halfway for their length in median emargination; S5 with fringe less dense than that of S4, hairs shorter, not bent ($\sim 1\text{MOD}$) .

Surface sculpture: mandible with punctation even, punctures fine and dense ($i < 1/2d$), except along carinae where it is impunctate; clypeus without impunctate basal midline, and punctures not conspicuously larger than rest of head, still larger basad, finer gradually toward wide, impunctate apical margin, where punctation is especially fine interspaces are somewhat dull; margin of tentorial pits distinctly impunctate; axilla densely punctate ($i = 1/3d$) as in female, but punctures equally sized and interspaces shining; metanotum with punctures less well defined,

imbricate-punctate, not especially shiny laterally; metapostnotum mostly impunctate, shiny, except narrowly areolate-rugose in lateral extremes of basal zone; T5 and T6 as in T1 to T4 of female; T7 with punctures somewhat obscure, almost imbricate-punctate.

Structure: head wider than long (L:W= 56:62); scape thickened, less than twice as long as wide (L:W= 27:14), pedicel entirely enclosed by scape, flagellomeres mostly unmodified, F4 L=B, F1 to F3 and F5 to F10 wider than long, F11 longer than wide (L:W= 7:6), the apex pointed and curved ventrally; mandible bidentate, the teeth not especially sharp, that of pollex broad at apex, the margin between them deep, an acute angle; compound eyes convergent below (UOD:LOD= 59:45); clypeus convex to apical margin, flat only at lateral margins, truncate, the lateral margins of truncation sinuate, lateral angles of truncation rounded, not well defined, the margin between angles straight with three small inconspicuous crenulations, one on either side of a median one, crenulations evenly spaced; IAD:AOD= 15:12; IOC<OOC (13:17); IOC>OV (13:12); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 21:16); genal area wider than compound eye in lateral view (25:18); mesosoma nearly as wide as long (L:W= 49:48); metasoma elongate (L:W= 76:44); gradular furrow of T5 distinctly deepened as in T2 to T4; T6 with apical margin rounded, lateral teeth longer than their basal width (9:7), the apices somewhat pointed; T7 fully exposed, produced to a subtruncate process, the process as broad as 1/3 the width of the apical margin of T6 between lateral teeth, the lateral margins of process broadly concave; S1 short, apical margin straight; S2 disc swollen, a low, rounded transverse hump, apical margin rounded with a narrow, shallow median emargination; S3 to S5 with disc feebly swollen submarginally, swelling interrupted narrowly at longitudinal midline, apical margins broadly concave in middle 1/3; S6 to S8 retracted.

Genitalia: as in Fig. 3.60f.

Distribution: *Hoplitis sambuci* ranges west of the Rocky Mountain Range to the Pacific coast. Its range extends north into southern British Columbia, and south through California (Fig. 3.6j). [CAN: BC; USA: CA; ID; NV; OR; WA.]

Specimens examined: **CAN: British Columbia:** *Okanagan-Similkameen Reg. Dist.:* ♀ Summerland, Garnet Lk., 17.vii.2008 (LR Best) [Barcoded]; ♂ Oliver, Ripley Lk., 15.vi.2013 (G Rowe & L Graham); ♂ Oliver, Ripley Lk., 12.vii.2008 (LR Best) [Barcoded]; ♂ Olivier, Ripley Lk., 14.vii.2008 (LR Best) [Barcoded]; ♂ Oliver, Sawmill Lk., 27.vi.2008 (LR Best) [Barcoded]; ♂ Blacksage Rd., 12.vi.2010 (LR Best); ♂ Okanagan Falls, Mahoney Lk., 08.vi.2008 (LR Best) [Barcoded]; ♂ Sagebrush, NCC, 26.v.2014 (J Heron); **USA: California:** ♀ ♂ Napa Co., Nichilini Winery, 15.vii.1974 (RW Rust & L Crement); ♀ Los Angeles Co., Tanbark Flat, 21.vi.1950 (JD Paschke); ♂ Montgomery Co., Santa Lucia Mts., 14.vi.1938 (CD Michener); ♂ Altadena, 02.v.1936 (CD Michener); ♀ Shasta Co., Hwy 299, 03.vii.2007 (J Gibbs & C Sheffield); **USA: Idaho:** ♂ Blaine Co., Ketchum, Sawtooth Botanic Grd., 24.vi.2007 (J Gibbs & C Sheffield).

Type: Female, from Pullman Washington, in the US National Museum. [Examined]

***Hoplitis spoliata* (Provancher, 1888)**

Osmia spoliata Provancher, 1888, Addit. Corr. Faune Ent. Canada Hym., p.327.

Andronicus cylindricus Cresson, 1864a, Ent. Soc. Phila. Proc., 2: 384.

Hoplitis monardae Cockerell, 1914, Ann. Mag. Nat. Hist., 14: 363.

Hoplitis hicksi Cockerell, 1932, Brooklyn Ent. Soc. Bull., 27: 203.

Hoplitis (Andronicus) cylindrica (Cresson, 1864a) Ent. Soc. Phila. Proc., 2: 384. (Homonym)

Hoplitis (Monumetha) spoliata Michener, 2000, *Bees of the World*, p. 455.

Hoplitis (Alcidamea) spoliata Sedivy et al., 2013, Zool. J. Linn. Soc., 167(1): 28-42.

Biology: *Hoplitis spoliata* is polylectic and has been recorded foraging on many plant families including Asteraceae, Boraginaceae, Fabaceae and Rosaceae (Asher & Pickering 2016). In Canada it is somewhat common and has been collected from late May (29, Manestar, ON) to early August (9, King's Co., NS).

Diagnosis: The female of *H. spoliata* can be recognized by the combination of scape at least three times longer than wide, base of labrum without membranes, mandible quadridentate and

sternal scopa straw-coloured to lightly ochraceous, S6 unmodified. The male of *H. spoliata* can be recognized by the combination of flagellomeres two to five widened, with ochraceous setae along ventral margin and S5 with two fringes, one transverse in disc, hairs infuscated, oriented ventrally, another along at least middle half of apical impressed margin, hairs suberect, oriented posteriorly.

H. spoliata redescription

Figures: 3.6; 3.61; 3.62

Female (N=31): length (10 to 13mm); head width (2.75 to 3.5mm); ITW (2 to 2.75mm); forewing length (7 to 9mm).

Colouration: integument black, except as follows: flagellomeres grayish; cap of rutellum of mandible piceous; tegula piceous; hind tibial spur piceous to black; tarsi and tarsal claw of all legs dark amber-coloured to piceous; wings hyaline, dusky, darkest in marginal cell and apically; terga with apical impressed margin piceous.

Pubescence: hairs mostly white, sometimes ochraceous; head, mesosoma and metasoma generally sparsely pubescent (<2MOD), hairs suberect, pubescence denser on the following: hypostomal area with long pubescence somewhat bowed, the apices oriented toward the midline anteriorly (<3MOD); clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation (<1MOD); clypeus, paraocular area and frontal area somewhat densely pubescent, hairs suberect, longer in frontal area (~3MOD) and paraocular area (>2MOD) than clypeus (~1.5MOD), pubescence of clypeus lightly ochraceous, darkest toward apical margin; mesosoma with pubescence densest in pronotal lobe and pronotal collar (<3MOD), mesepisternum (<3MOD), metanotum (<3MOD) and lateral surface of propodeum (<3MOD), hairs suberect, usually at least lightly ochraceous; mesoscutum, axilla and mesoscutellum mostly glabrate, except along posterior margin of mesoscutellum where hairs are long and erect, usually ochraceous (>3MOD); metapostnotum glabrate; metasoma with apical fascia arising from the

premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, usually interrupted in middle third of T1 to T3 ($\sim 1\text{MOD}$); sternal scopa light, straw-coloured to ochraceous, oriented posteroventrally, arising from the disc ($>4\text{MOD}$).

Surface sculpture: head, including mandible and antenna, moderately punctate ($i=1/2d$), interspaces shining, except as follows: scape with punctation somewhat finer, the punctures somewhat shallow, moderately dense ($i\sim 1/2d$); mandible with finer punctation in outer interspace and acetabular interspace ($i<1/2d$), carinae impunctate; hypostomal area punctation large and shallow, moderately dense ($i=1/2d$); punctation of clypeus becoming finer toward an impunctate apical margin between lateral angles of clypeal truncation, interspaces dull where punctation is finest ($i<1/2d$); supraclypeal and lower frontal area with finer, denser punctation ($i<1/4d$); margins of tentorial pits distinctly impunctate; pronotum puncticulate, not dense ($i>d$), the punctures large, shallow and not well defined, denser in pronotal lobe and pronotal collar ($i<d$) than laterally ($i\sim d$); punctures of mesoscutum less dense ($i>1/2d$) than those of vertexal area, interspaces alveolate; mesepisternum punctured as in genal area ($i=1/2d$), interspaces alveolate; metepisternum areolate-rugose with few shallow punctures, not dense ($i<d$) in dorsal 1/3, the punctures not well defined; mesoscutellum as in mesoscutum ($i>1/2d$) with interspaces shining, punctation densest at posterior and lateral margins ($i<1/2d$); axilla densely punctate ($i=1/3d$), the punctures finer than those of mesoscutum; metanotum imbricate-punctate; metapostnotum areolate except at lateral extremes of basal zone where it is scrobiculate; propodeum with lateral surface moderately punctate ($i=1/2d$), punctures shallow, not well defined, interspaces finely strigulate, dorsal surface areolate with few ($i>d$) shallow large punctures; T1 anterior surface areolate, disc with punctation fine, somewhat dense ($i>d$), interspaces somewhat roughened; disc of T2 to T4 with fine, somewhat dense punctation ($i<d$), hardly less dense than that of T1, interspaces shining; punctation of disc of T5 denser ($i<3/4d$), punctures as large as T4; punctation of T6 dense ($i<1/2d$), punctures in marginal zone somewhat obscure; apical margin of T1 to T5 impunctate; S1 to S5 punctures large and somewhat dense in disc ($i\sim 1/2d$), interspaces alveolate, impunctate along apical margin; S6 with punctures in disc less dense than in S5 ($i<d$), interspaces similarly alveolate, punctures in marginal zone somewhat obscure, imbricate-punctate, continuing along apical margin.

Structure: head hardly wider than long (L:W=39:44); scape elongate, over 3x longer than wide (20:6); pedicel exposed, longer than wide (L:W= 7:6), flagellomeres mostly unmodified, width gradually increasing from basal to apical segments: F1 longer than wide (L:W= 11:6), F2 as long as wide, F3 to F7 wider than long, F8 to F10 longer than wide (F10 L:W= 15:7), with the apex rounded; mandible quadridentate, widened at apex, the apex about 1.5x wider than narrowest point of mandible (32:21), teeth well defined, not especially sharp, distance between tooth of rutellum and first tooth of pollex twice the distance between the first and second teeth of the pollex (14:7), this owing in part to the elongated and incurved rutellum, and greater than the distance between the second and third teeth of the pollex (14:11); inner margins of compound eyes subparallel (UOD:LOD= 45:43); hypostomal carina high; clypeus feebly convex in longitudinal middle 1/3, flat laterally and along apical margin, truncate, the lateral margins of truncation nearly straight, feebly convex, rounded to lateral angles of truncation such that the latter are not well defined, apical margin between lateral angles of truncation broadly concave; supraantennal depression weak; IAD<AOD (10:13); IOC subequal OOC (11:12); IOC<OV (11:14); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 21:18); genal area distinctly wider than compound eye in lateral view (24:15); mesosoma longer than wide (L:W= 71:58); mesoscutellum and metanotum gently sloping posteriorly to an entirely declivous propodeum; metasoma elongate (L:W= 94:57); T1 anterior surface with a short, narrow, longitudinal furrow, the surface rounded onto the dorsal surface, the two surfaces not distinctly delineated by structure; T2 to T4 with gradular furrows distinctly deepened, deepest on T2 and T3; T6 marginal zone reflexed dorsally, gently concave in profile.

Male (N=21): length 11mm (9 to 12mm); head width 3mm (2.75 to 3.25mm); ITW 2mm (1.5 to 2mm); forewing length 8mm (7 to 8mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: flagellomeres lighter than in female, gray, yellowed or dark testaceous; terga with apical impressed margin brown to piceous.

Pubescence: hairs mostly ochraceous; antenna F2 to F5 with sparse, short, ochraceous, erect setae along anterior margin ($\sim 0.5\text{MOD}$); hypostomal area with pubescence not conspicuously bowed ($\sim 2\text{MOD}$); hairs arising from the apical margin of the clypeus between lateral angles of truncation a uniform thin fringe, the hairs oriented anteriorly, not usually darker than those of clypeus ($>1\text{MOD}$); pubescence of genal area denser than in female, hairs suberect ($>2\text{MOD}$); pubescence conspicuously denser on mesepisternum ($>3\text{MOD}$); mesoscutum, axilla, mesoscutellum and metanotum moderately pubescent, hairs suberect ($>3\text{MOD}$); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, the hairs sparse, often entirely effaced ($\sim 1\text{MOD}$); S1 to S4 with apical fringe in marginal zone, hairs oriented posteriorly and arising from the premarginal line, S1 to S3 with the fringe densest medially, hairs longest laterally, at least twice as long as hairs at midline ($\sim 1\text{MOD}$), that of S1 usually thin, that of S4 dense, the apices of the hairs even for width of segment ($<1.5\text{MOD}$); S5 with two fringes, one for width of disc, the hairs erect, brown ($>2\text{MOD}$), one for middle $1/2$ of width of marginal zone, the hairs suberect, oriented posteriorly, longest at midline ($>2\text{MOD}$), shorter at lateral margins ($<1\text{MOD}$); S6 with median tuft of short hairs ($\sim 1\text{MOD}$).

Surface sculpture: head, including mandible and antenna, with punctation generally finer than that of female ($i < 1/2d$), patterning similar, except as follows: clypeus with impunctate apical margin for entire width, not confined between lateral margins of truncation; interspaces of vertexal area alveolate; punctures of mesepisternum shallower than in female, less well defined; mesoscutum with interspaces shining; propodeum with lateral surface as in dorsal surface, which is as in female; metasomal terga with interspaces variably roughened, conspicuously so on T1, T6 and T7; T5 as in T5, which is as in female; T6 with punctures denser ($i \sim 1/2d$) than those of T5; T7 coriarius-punctate, with punctures very shallow, obscure, sparse ($i > d$), marginal zone with large punctures, somewhat imbricate-punctate, continuing along apical margin; S1 and S2 with disc punctulate, the punctures large, not dense ($i > d$), marginal zones with posterior angles densely punctate ($i = 1/3d$), punctures large, interspaces shining, impressed apical margins impunctate; S3 and S4 with disc as in S1 and S2 but with interspaces less conspicuously roughened, marginal zones as in S1 and S2; S5 and S6 moderately punctate in disc ($i = 1/2d$), punctures large, well defined, marginal zone of S5 as in S1 to S4, that of S6 strigate.

Structure: head wider than long (L:W= 36:44); scape thickened, only twice as long as wide (L:W= 28:14), pedicel partially enclosed by scape, flagellomeres modified, F2 to F5 distinctly widened, F1, F6 and F7 L=B, F8 to F11 longer than wide, the apex of F11 only feebly narrower than basal width of segment, rounded; mandible bidentate, the teeth sharp, that of pollex broad, spade-like, the margin between them deep, an acute angle; compound eyes convergent below (UOD:LOD= 26:23); clypeus feebly convex, broadly truncate, the lateral margins of truncation straight, lateral angles of truncation well defined, a somewhat sharp angle (~110°), the margin between angles nearly straight or very shallowly concave; IAD:AOD= 8:9; IOC<OOC (12:14); IOC subequal OV (12:13); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 21:16); genal area hardly wider than compound eye in lateral view (18:16); mesosoma longer than wide (L:W= 67:47); metasoma elongate (L:W= 94:40); gradular furrow of T4 not distinctly deepened as in T2 to T3; T6 with apical margin rounded, lateral teeth inconspicuous, shorter than their basal width (L:W= 4:7), the apices broadly rounded; T7 fully exposed, produced to a broad truncation, apical margin of truncation rounded between lateral angles of truncation, thickened, especially medially, marginal zone feebly reflex dorsally, somewhat concave in profile; S1 produced to a short, truncate process medially, the process oriented posteriorly, somewhat curved ventrally; S2 and S3 disc distinctly produced, feebly concave to narrow, submarginal swelling, submarginal swelling of S3 interrupted at longitudinal midline; marginal zone a posteriorly oriented surface in S2, sloping in S3, apical margin of S2 rounded, that of S3 narrowly emarginate medially; S4 mostly hidden by S3, submarginal swelling feeble to none, interrupted at longitudinal midline, apical margin distinctly emarginate medially; S5 disc mostly unmodified, apical margin straight; S6 to S8 retracted.

Genitalia: as in Fig. 3.62e.

Distribution: *Hoplitis spoliata* is absent west of the Rocky Mountain Range. It extends north through the northern parts of the Northwest Territories south to Texas and east through to the Canadian and American coasts from Nova Scotia to Georgia (Fig. 3.6k). [CAN: AB; BC; MB; NB; NS; NT; ON; PE; QC; SK; USA: CO; CT; DE; GA; ID; IL; KS; MA; MD; ME; MI; MN; MS; MT; NC; ND; NE; NH; NJ; NY; NV; OH; PE; SC; SD; TN; TS; TX; WA.]

Specimens examined: CAN: Alberta: ♀ Cypress Co., One Four, 4-6.viii.2013 (G Rowe & L Graham); ♀ Newell Co., Dinosaur P.P., 23.vii.2013 (G Rowe & L Graham); ♀ MD of Willow Crk., 30.vii.2009 (MME); **CAN: British Columbia:** *Okanagan-Similkameen Reg. Dist.:* Keremeos, Grist Mill: ♀ 28.vi.2013 (G Rowe & L Graham); ♂ 30.vi.2013 (G Rowe & L Graham); Oliver, Ripley Lk.: ♂ 17.vi.2013 (G Rowe & L Graham); ♂ 11.vii.2008 (LR Best) [Barcoded]; 2 ♂ 13.vii.2008 (LR Best) [2 ♂ Barcoded]; ♀ Summerland, Garnet Lk., 17.vii.2008 (LR Best) [Barcoded]; ♂ Oliver, Ripley Lk., 15.vi.2013 (G Rowe & L Graham); ♂ Oliver, Ripley Lk., 12.vii.2008 (LR Best) [Barcoded]; ♂ Olivier, Ripley Lk., 14.vii.2008 (LR Best) [Barcoded]; ♂ Oliver, Sawmill Lk., 27.vi.2008 (LR Best) [Barcoded]; ♂ Blacksage Rd., 12.vi.2010 (LR Best); ♂ Okanagan Falls, Mahoney Lk., 08.vi.2008 (LR Best) [Barcoded]; ♂ Sagebrush, NCC, 26.v.2014 (J Heron); *North Okanagan Reg. Dist.:* ♂ Cherryville, Monashee P.P., 19.vii.2008 (LR Best) [Barcoded]; ♀ Vernon, Kalamalka Lk., Turtle Pt., 28.vi.2008 (LR Best) [Barcoded]; 2 ♂ Cariboo Reg. Dist., Alexandria, Moffat Lk., 28.vi.2006 (LR Best & S Martinson) [2 ♂ Barcoded]; ♀ Central Kootenay Reg. Dist., Rosebery P.P., 05.viii.2009 (LR Best) [Barcoded]; *East Kootenay Reg. Dist.:* 3 ♀ Marion Benchlands, NCC, 07.vii.2013 (G Rowe and L Graham); 2 ♀ Marion Benchlands, NCC, 10.vii.2013 (G Rowe & L Graham); **CAN: Northwest Territories:** 2 ♂ Yellowknife, Negus Pt., 30.vi. 2005 (col. unk.); **CAN: Nova Scotia:** *Kings Co.:* ♂ East Torbrook, 12.vii.2001 (C Sheffield); ♀ Wst Blk. Rck., 29.vii.2002 (C Sheffield); ♀ Lockhartville, 09.viii.2001 (C Sheffield); **CAN: Ontario:** ♀ Caledon East, Woodlot Clearing, 07.vii.1989 (L Packer); ♀ Caledon East, Woodlot Clearing, 8-9.vii.1989 (L Packer); ♀ 3km N Almonte, 1-8.vii.1986 (Denis & Dumouchel); 3 ♂ 3km N Almonte, 17-24.vi.1986 (Denis & Dumouchel); ♂ RM Haldimand-Norfolk Co., Manestar Sav., 29.v.1998 (H Douglas); **CAN: Quebec:** *Luskville Falls:* 2 ♀ 17-24.vi.1980 (Denis & Dumouchel); 2 ♀ 17-25.vi.1986 (Denis & Dumouchel); ♀ 1-8.vii.1986 (Denis & Dumouchel); ♀ 22-29.vii.1986 (Denis & Dumouchel); *3km SW Manseau:* ♂ 05.vii.2013 (M Chagnon); ♀ 12.vii.2013 (M Chagnon); ♂ 17.vii.2013 (M Chagnon); ♀ 5km SE Villeroy, 17.vii.2013 (M Chagnon); **CAN: Saskatchewan:** ♀ 18km S Maple Crk., 10.vii.2005 (JR Vockeroth); ♀ Grasslands N.P., 08.vii.2010 (N de Silva); **USA: California:** ♀ ♂ Napa Co., Nichilini Winery, 15.vii.1974 (RW Rust & L Crement); ♀ Los Angeles Co., Tanbark Flat, 21.vi.1950 (JD Paschke); ♂ Montgomery Co., Santa Lucia Mts., 14.vi.1938 (CD Michener); ♂ Altadena, 02.v.1936 (CD Michener); **USA: Maryland:** ♀ Prince George's Co., 10-11.vi.2003 (R Jackowski); **USA: South Carolina:** ♀ Chesterfield Co., 18.v.2006 (SW Droege); ♀ Chesterfield

Co., 18-19.v.2006 (SW Droege); **USA: West Virginia:** ♂ Hampshire Co., 24.v.2002 (SW Droege); 3 ♂ Hampshire Co., 29-30.v.2004 (SW Droege).

Type: Male, from Connecticut, in the Academy of Natural Sciences of Philadelphia. [Examined]

***Hoplitis truncata* (Cresson, 1878)**

Alcidamea truncata Cresson, 1878, Trans. Amer. Ent. Soc., 7: 108.

Hoplitis mescalerium Cockerell, 1910, Entomol., 43: 90.

Hoplitis (Alcidamea) truncata mescalerium Cockerell, 1910, Entomol., 43: 90.

Biology: *Hoplitis truncata* is polylectic and has been recorded foraging on many plant families including Fabaceae and Rosaceae (Asher & Pickering 2016). In Canada it is relatively uncommon and has been collected throughout the month of July.

Diagnosis: The female of *H. truncata* can be recognized by the longitudinal carina along the midline of the clypeus and the thickened apical margin of the clypeus. The male of *H. truncata* can be recognized by the combination of flagellomeres two to five not widened, mandible bidentate, base of labrum without membranes, clypeus without silvery tomentum and apical margin thickened, not crenulate, S2 apical margin medially emarginate.

***H. truncata* redescription**

Figures: 3.6; 3.63; 3.64

Female (N=6): length (8 to 9.5mm); head width (2.5 to 3mm); ITW (2mm); forewing length (6 to 7mm).

Colouration: integument black, except as follows: flagellomeres brown to piceous; cap of rutellum of mandible piceous; tegula dark brown to piceous; tarsi of all legs piceous; tarsal claw

of all legs dark amber-coloured; hind tibial spur brown or amber-coloured; wings hyaline, dusky, darkest in marginal cell; sterna with apical impressed margin brown to dark amber-coloured.

Pubescence: hairs mostly white; head and mesosoma and metasoma generally sparsely pubescent ($<1.5\text{MOD}$), hairs suberect, pubescence denser on the following: hypostomal area with pubescence conspicuously bowed, the apices oriented toward the midline anteriorly ($>2\text{MOD}$); clypeus with a small tuft of ochraceous setae on either side of the midline of the clypeal truncation, erect, oriented anteromedially and arising from the apical margin beneath the truncation ($<1\text{MOD}$); pubescence of apical and lateral 1/3 of clypeus usually at least somewhat ochraceous ($\sim 1\text{MOD}$), hairs somewhat dense, suberect ($\sim 1\text{MOD}$), nearly glabrate midline continuing in supraclypeal and lower frontal area; paraocular area with dense, subappressed pubescence ($\sim 1\text{MOD}$); pronotal lobe margined posteriorly with appressed tomentum, the hairs white ($>1\text{MOD}$); pronotal lobe, pronotal collar, mesepisternum, axilla and dorsolateral angle of propodeum with long, suberect pubescence, denser than rest of mesosoma ($>2\text{MOD}$); metasoma with apical fascia arising from the premarginal line, at least as long as the narrow apical impressed margins of T1 to T6, usually interrupted in middle third ($\sim 1.5\text{MOD}$); sternal scopa light, white to straw-coloured, oriented posteroventrally, arising from the disc ($>3\text{MOD}$).

Surface sculpture: head, including mandible and antenna, moderately and densely punctate ($i=1/3d$), interspaces shining, except as follows: scape with punctuation somewhat finer, as dense as rest of head ($i=1/3d$); mandible with finer punctuation in outer interspace, somewhat less dense ($i=1/2d$), acetabular interspace imbricate-punctate, carinae impunctate; hypostomal area shiny, punctuation large and shallow, not well defined, conspicuously less dense ($i>3/4d$); punctuation of clypeus larger and denser in convex portion ($i=1/4d$), becoming finer and less dense where the segment flattens ($i\sim 1/3d$), apical margin between lateral angles of clypeal truncation impunctate, clypeus narrowly impunctate along longitudinal midline; margins of tentorial pits conspicuously impunctate, supraclypeal area usually impunctate at midline in apical $\frac{1}{2}$ of segment; paraocular area and frontal area with finer, denser punctuation ($i<1/3d$); vertexal area with punctuation less dense ($i>d$) than in rest of head, punctures similarly large; pronotum puncticulate, the punctures large, shallow and not well defined, denser in pronotal lobe and pronotal collar ($i<1/2d$) than laterally ($i>1/2d$); mesoscutum with punctures as large and as dense

as those of vertexal area ($i > d$); mesepisternum with punctures larger and denser ($i < 1/4d$) than that of genal area; tegula finely and sparsely punctate ($i > d$), densest anteriorly; axilla finely and densely punctate ($i = 1/4d$); mesoscutellum with large punctation in anterior $\frac{1}{2}$ and along longitudinal midline, the punctation less dense ($i > d$) than that of mesoscutum, punctures finer and denser toward posterior and lateral margins ($i < 1/2d$); metanotum densely punctate ($i < 1/3d$), the punctures large and well defined; metepisternum with punctures less dense ($i \sim 1/2d$) than those of mesepisternum, the interspaces not smooth, somewhat imbricate, but still shining; metapostnotum very finely punctate ($i \sim 1/3d$), except at lateral extremes where it is scrobiculate; propodeum with lateral surface with distinctly finer punctation than that of mesepisternum, punctation moderately dense ($i < d$), the punctures somewhat obscure, not well defined, dorsal surface punctulate, the punctures large, somewhat well defined, moderately dense ($i < d$); T1 anterior surface mostly impunctate with a few large, shallow punctures ($i > d$); disc of T1 to T3 with punctation less dense ($i < 1.5d$) than that of T4 ($i < d$); punctation of disc of T5 less dense ($i < 1/2d$) than that of T4; punctation of T6 densest ($i = 1/4d$); apical margin of T1 to T5 punctured nearly to margin, that of T6 impunctate; sterna densely punctate in disc ($i = 1/3d$), impunctate in marginal zone in S1 to S5, that of S6 with punctures somewhat finer than those of disc, similarly dense.

Structure: head somewhat wider than long ($L:W=71:63$); scape elongate, over 3x longer than wide ($30:8$); pedicel exposed, as long as wide; flagellomeres mostly unmodified, width gradually increasing from basal to apical segments: F1 longer than wide ($L:W=7:6$), F2 to F9 wider than long, F10 longer than wide ($L:W=10:8$), with the apex rounded; mandible tridentate, tooth of rutellum and first tooth of pollex sharp, second tooth of pollex somewhat rounded apically, still well defined, distance between tooth of rutellum and first tooth of pollex less than the distance between the first and second teeth of the pollex ($8:12$), margin between teeth of pollex concave, as deep as the margin between the tooth of the rutellum and the first tooth of the pollex; compound eyes convergent below ($UOD:LOD=45:39$); hypostomal carina moderate, weaker toward anterior; clypeus feebly convex in longitudinal middle $\frac{1}{3}$, broadly truncate, the lateral margins of truncation straight, lateral angles of truncation distinct, apical margin between lateral angles of truncation narrowly thickened, especially on either side of midline, the margin nearly straight, shallowly and narrowly concave at midline, the margin subtly reflexed dorsally;

clypeus bearing a conspicuous longitudinal carina along midline, the carina weakest at basal and apical margins; tentorial pits deep, distinct; supraantennal depression weak; IAD=AOD; IOC<OOC (16:22); IOC<OV (16:23); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 31:24); genal area hardly wider than compound eye in lateral view (18:17); mesosoma length to width subequal (L:W= 42:45); mesoscutellum and metanotum gently sloping posteriorly to an entirely declivous propodeum; metasoma somewhat elongate (L:W= 66:43); T1 anterior surface with a short, narrow, longitudinal furrow, the surface rounded onto the dorsal surface, the two surfaces not distinctly delineated by structure; T2 to T4 with gradular furrows distinctly deepened; T6 marginal zone reflexed dorsally, concave in profile.

Male (N=2): length 8mm (7 to 9mm); head width 2.5mm (2.5mm); ITW 2mm (2mm); forewing length 7mm (6.5 to 7.5mm).

Agrees with female, except for usual secondary sex characters and as follows:

Colouration: hind tibial spur lighter than in female, straw-coloured or honey-coloured; all legs wholly lightened, dark brown to piceous; wings lighter than in female; terga with apical impressed margin dark brown or dark gold.

Pubescence: pubescence somewhat denser than that of female, mostly ochraceous; hypostomal area with pubescence not conspicuously bowed (~2MOD); T6 and T7 not apically fasciate; S3 to S5 with apical fringe for width of marginal zone, hairs oriented posteriorly and arising from the premarginal line; S3 and S4 with hairs of fringe long (>2MOD), feebly bent ventrally halfway for their length at median emargination; S5 with fringe less dense than that of S4, hairs inconspicuously bowed ventrally (~1.5MOD) .

Surface sculpture: mandible with punctation even, punctures fine and dense ($i=1/3d$), except along carinae where it is impunctate; clypeus finely punctate ($i=1/2d$), except along impunctate apical margin between lateral angles of clypeal truncation; metanotum with

punctures less well defined, almost imbricate-punctate, punctation less dense ($i < 1/2d$) than in female; terga with interspaces conspicuously foveolate, punctures moderately large; T1 to T3 less dense ($i < 2d$) than T4 ($i < d$); T5 denser ($i < 1/2d$) than T4; T6 densest ($i < 1/3d$), apical margin conspicuously impunctate; T7 with punctures finer than those of T6, about as dense ($i = 1/3d$); S1 disc with large punctation, punctures not especially dense ($i > 1/2d$), interspaces smooth, shining, marginal zone impunctate; S2 to S4 sparsely punctate in submarginal swellings of discs ($i > d$), punctation large, interspaces shining, remainder of disc with punctation larger and denser ($i \sim 1/2d$) to an impunctate apical margin; S5 disc very sparsely punctate ($i > d$), punctation large, interspaces shining, narrow marginal zone moderately punctate, the punctation somewhat denser ($i < 1/2d$), apical margin impunctate.

Structure: head wider than long (L:W= 52:61); scape somewhat elongate, 2.5x longer than wide (L:W= 25:10), pedicel nearly entirely enclosed by scape; flagellomeres mostly unmodified, length and width gradually decreasing from basal segments to apical segments, F1 to F10 wider than long, F11 longer than wide (L:W= 10:6), the apex pointed and curved ventrally; mandible bidentate, the teeth distinct, somewhat sharp, the margin between them a sharp angle ($\sim 100^\circ$); compound eyes convergent below (UOD:LOD= 39:31); clypeus convex to apical margin, the margin not thickened, not reflexed, the margin between angles straight; IAD:AOD= 11:9; IOC subequal OOC (12:14); IOC subequal OV (12:13); median ocellus posterior to midpoint between posterior margin of antennal socket and posterior margin of vertexal area (FAL:VAL= 20:16); width of genal area subequal width of compound eye in lateral view (17:18); mesosoma nearly as wide as long (L:W= 43:41); metasoma somewhat elongate (L:W= 62:42); T6 with apical margin straight, lateral teeth blunt, the apices rounded, basal width greater than their length (L:W= 4:7); T7 fully exposed, produced to a broad truncation, the margin between lateral angles of truncation rounded, feebly reflexed dorsally in marginal zone; S1 short, disc feebly swollen submarginally, apical margin rounded; S2 to S4 with narrow, submarginal swellings in disc, interrupted at longitudinal midline of S3 and S4, apical margins distinctly emarginate at midline, emargination of S3 and S4 deeper and wider than that of S2; apical margin of S5 nearly straight, very broadly and shallowly concave; margin of S6 rounded, nearly straight narrowly at middle; S6 to S8 retracted.

Genitalia: as in Fig. 3.64e.

Distribution: *Hoplitis truncata* is primarily an eastern species and ranges through the United States from the eastern foothills of the Rocky Mountain Range to the east coast. Along the eastern foothills of the Rocky Mountain Range it has been collected in Wyoming and Colorado, and south to the foot of the Rocky Mountain Range through Utah Arizona and New Mexico. Confined to Ontario and Quebec. *H. truncata* is somewhat rare in Canada (Fig. 3.61). [**CAN:** ON; QC; **USA:** AL; AR; AZ; CO; CT; DE; FL; GA; IL; IN; KS; LA; MA; ME; MD; MI; MN; MS; NC; ND; NE; NH; NJ; NM; NY; OH; PE; SC; SD; TN; TX; UT; VA; WI; WV; WY.]

Specimens examined: **USA: Florida:** ♀ Gainesville, Agrio. Exp. Stn., (unk. date) (JRW); **USA: North Carolina:** ♀ Bryson City, 17.vi.1923 (JC Crawford); ♂ Raleigh, 11.v.1928 (TB Mitchell); ♂ Harnett Co., 10.v.1935 (TB Mitchell); **USA: New Mexico:** ♀ Santa Fe Co., Randall Davey Audubon, 02.vi.2012 (K Wetherill) [Barcoded]; **USA: South Carolina:** ♀ York Co., Rock Hill, 25-27.v.2001 (A Zayed) [Barcoded]; **USA: South Dakota:** 2 ♀ Penn Co., 9 miles N of Caster, Oreville Camp, 8-17.vii.1877 (S Peck); 3 ♀ Black Hills, nr. Rapid City, 8-11.vii.2012 (R Poulin); 2 ♀ Black Hills, nr. Rapid City, 10.vii.2012 (R Poulin).

Type: From Georgia, in the Academy of Natural Sciences of Philadelphia. [Examined]

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