Argyrotaenia mariana, ON: Leeds Co.: Charleston Lake Provincial Park, ©JJD

"[The Tortricidae] is probably the most difficult, in a systematic point of view, and the least interesting family in the order of Lepidoptera" – Dr. Brackenridge Clemens

"Remember how in that communion only, beholding beauty with the eye of the mind, he will be enabled to bring forth, not images of beauty, but realities (for he has hold not of an image but of a reality)" – Plato

University of Alberta

Aspects of archipine evolution (Lepidoptera: Tortricidae)

by

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For my parents Edward and Sandra,
for tolerating and supporting my passion for natural history;
and to the many naturalists who helped fuel this addiction,
especially Chris Michener, Ron Tozer, and Dan Strickland,
thank you.

Abstract

The economically important tribe Archipini (Lepidoptera: Tortricidae) has posed many taxonomic challenges, ranging from species and generic boundaries to their overall phylogeny. In Chapter 2, the species *Clepsis anderslaneyii* Dombroskie & Brown 2009, is described based upon material from southeastern Arizona, helping to complete our knowledge of the Nearctic archipine fauna. In Chapter 3, I apply an iterative approach utilizing morphological, molecular, and geographical evidence to test the species boundaries of the *Pandemis limitata* (Robinson) group. None of these character suites alone fully supported the species boundaries; however, in combination they successfully differentiated most specimens and for that reason I maintain the three separate species. Generic boundaries and putative synapomorphies of the genus *Pandemis* are examined using COI and ITS2 DNA. Definitive conclusions were precluded by weak phylogenetic support and losses of major structures in some taxa. In Chapter 4, a molecular phylogeny of the Archipini is presented, based on phylogenetic analysis of 28S and COI DNA for 134 species in 33 genera. It shows an Australasian origin for the tribe, with subsequent radiations into the rest of the Old World, and later the New World. Through tests for correlated evolution and total correlation, I examine factors that may facilitate the loss of secondary sexual characters (SSCs). SSCs are more frequently lost when host plant range is narrowed and when taxa radiated into the New World, but novel SSCs do not significantly replace existing SSCs. In Chapter 5, the need for accurate higher-level identifications is addressed in a user-friendly, interactive, matrix-based key to the Lepidoptera of Canada. It covers 222 taxon groups, using 73 characters with 266 states including many characters, like measurements and ratios, that are difficult to quantify using a dichotomous key. It works best with the traditionally challenging microlepidoptera and now provides a new gateway to their identification. Overall, this thesis proposes taxonomic changes for many pest and related species, and furthers a deeper understanding of their evolution.

Acknowledgements

I am fortunate to be surrounded by a vibrant and friendly entomological community, and especially the Alberta Lepidopterists' Guild. There are too many people to mention here who provided stimulating discussion and encouragement throughout my time at the University of Alberta.

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

28S: 28S ribosomal RNA

BMNH: The Natural History Museum, London, United Kingdom

bp: base pairs

CF: costal fold

CNC: Canadian National Collection, Ottawa, Ontario

COI: cytochrome *c* oxidase I

EME: Essig Museum of Entomology, Berkeley, California, U.S.A.

ITS2: internal transcribed spacer 2

PCR: polymerase chain reaction

SSC: secondary sexual character

USNM: National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A.

Chapter 1

General Introduction

Archipini

Tortricidae comprise a family of over 9000 species (Brown 2005) in the speciose order Lepidoptera, which includes moths and butterflies. Over 1700 of these tortricids are in the tribe Archipini of the subfamily Tortricinae (Chapter 4), and this tribe forms the taxonomic focus for the majority of this thesis. The Archipini are an economically important group with pest species found worldwide (Horak & Brown 1991), including the most important forest pests in North America, the Spruce Budworm complex (Rose & Lindquist 1994). Many archipines are polyphagous, and as a result some are pests across a variety of crops and trees. Because of their broad host range, there is great potential for anthropogenically assisted establishment in new areas, and in fact nearly 20% of all Lepidoptera pests regulated by the Canadian Food Inspection Agency are in the Archipini (Canadian Food Inspection Agency 2011). This is especially evident in the Nearctic region where 13 species have been introduced accidentally, in some cases causing major economic losses (Barr, *et al.* 2009). Some pest species of Archipini have recently been well studied taxonomically (e.g. Hoebeke, *et al.* 2008; Hulcr, *et al.* 2007; Langhoff, *et al.* 2009; Lumley & Sperling 2010; Timm, *et al.* 2010), but there has been little phylogenetic work on the whole tribe (Jinbo 2000). Some archipines have also been used to address broader ecological and evolutionary questions (Jones & Evenden 2008; Safonkin & Triseleva 2008; Sleep, *et al.* 2009).

Species delimitation

To understand the large diversity of tortricids, I need meaningful and consistent names. A species name is a label for a testable hypothesis of species boundaries, and can depend upon which of the many, fundamentally different, species concepts is used (Coyne & Orr 2004). Species boundaries are explored in both Chapters 2 and 3.

Chapter 2 is an example of a case where differences between species are great enough that a species can be unambiguously described as being separated from its congeners. In this chapter, I use alpha taxonomic methods to describe a rarely encountered, new species of Archipini, *Clepsis anderslaneyii* Dombroskie and Brown 2009 from the Madrean of southeastern Arizona. It is distinct morphologically from all other described *Clepsis* species in both male and female genitalia.

While there is as as yet little debate about the validity of the above new species name, in many cases, a specific or generic epithet can spur heated debate that leads to confusion in the literature (O'Grady 2010). Therefore where some ambiguity exists, care should be taken to increase the probability of nomenclatural stability. I believe that the best way to deal with this challenge is to use a total evidence approach that involves multiple sources of characters, including molecular, morphological, and geographic data (Wiens 2007). In Chapter 3, I test species boundaries in the *Pandemis limitata* (Robinson) group using these three lines of evidence.

Phylogenetics

Once names are established for species, they need to be placed into an evolutionary context that will allow further study at greater depth (Wheeler 2009). A molecular phylogenetic analysis can be used to establish synapomorphies and strengthen generic boundaries in taxonomically difficult groups and is employed in Chapters 3 and 4. In Chapter 3, a molecular phylogeny using mitochondrial COI and nuclear ITS2 genes is used to elucidate synapomorphies and generic boundaries of the genus *Pandemis*. In Chapter 4 a phylogeny of the Archipini is proposed using DNA sequences for the 28S and COI genes and is used to examine generic limits for many genera and how they relate to each other on a worldwide level.

Also in Chapter 4, I use the Archipini phylogeny as a framework to examine the historical zoogeography and the evolution of secondary sexual characters (SSCs). These SSCs may act as mating stimuli, be important in female choice, or serve in male-male competition (Clutton-Brock 2007). However, in most moth species, females mate with the first conspecific male that they encounter; therefore, the last two scenarios are less probable in the Archipini (Young 1997). It is thus most likely that SSCs in the Archipini contribute to a prezygotic boundary between ecologically and genetically similar species (Panhuis, *et al.* 2001). If gene flow is somehow otherwise reduced between such species, I can posit that there will no longer be positive selection for SSCs as a prezygotic barrier. These structures are then more likely to be lost. Three potential mechanisms for this loss of SSCs are: 1) reduced ecological overlap with congeners due to reduced host plant breadth or specialization, 2) redundancy due to the evolution of more efficient novel SSCs, and 3) expansion into a habitat unoccupied by its congeners. I test these possibilities using tests of correlated evolution and overall correlation.

Identification

The studies outlined above, and indeed all studies based on organisms, are severely weakened unless identifications are accurate (Wheeler 2009). Yet the task of determining the family of a moth, let alone the identity of the species, is often out of reach for most non-expert lepidopterists. In Lepidoptera, the existing keys are either difficult to use or incomplete (e.g. Heppner 1996; Kristensen 1999); this is perhaps best exemplified by the Lepidoptera being the only major insect order lacking a key in Marshall (2006). This means that many identifications depend on expert taxonomists. There has, however, been a precipitous decline in the number of taxonomists, leading to an impediment in identifications and new descriptions (Pearson, *et al.* 2011). To help alleviate this barrier to identification, in Chapter 5, I developed a user-friendly, interactive, matrix-based key to the Lepidoptera of Canada. Although labour-intensive to create, a matrix-based key is probably the only effective way to make a user-friendly key to the Lepidoptera since most lepidopterists identify specimens primarily by gestalt (e.g. robust vs. delicate body, broad vs. slender wing, big vs. small). These non-discrete characters do not lend themselves well to a traditional dichotomous key since they often broadly overlap. On the other hand, the process-of-elimination method employed by matrix-based keys works well for these characters. This key promises to be an efficient starting point for difficult lepidopteran identifications.

Summary

Before we can ask meaningful biological questions, we need to have accurate and consistent names for the specific organisms under investigation. A phylogenetic framework can help solidify these names, and is essential in allowing me to investigate various evolutionary hypotheses about these organisms. In addition, we need comprehensive and user-friendly identification tools in order to accurately attach these names to the correct organisms. In this thesis, I approach these issues at multiple taxonomic levels. For example, at the ordinal level, I developed a matrix-based key to the subfamilies and tribes of Canadian Lepidoptera. At the tribal level, I developed a phylogenetic framework for the tribe Archipini, which redefined the limits of several genera. I was further able to use this phylogeny to examine the evolution of secondary sexual characters. Finally, at the species level, I assessed the species boundaries in the genus *Pandemis*, and described a new species in the genus *Clepsis*. Together these studies provide new insights and tools for the Lepidoptera and a phylogenetic foundation for further work on the Archipini.

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Chapter 2

A New Species of *Clepsis* Guenée, 1845 (Lepidoptera: Tortricidae) from the Sky Islands of Southeastern Arizona

*A version of this chapter is published.

Dombroskie J. J., and J. W. Brown. 2009. A New Species of *Clepsis* Guenée, 1845 (Lepidoptera: Tortricidae) from the Sky Islands of Southeastern Arizona. Proceedings of the Entomological Society of Washington 111:769-774.

Introduction

Clepsis Guenée, encompassing 144 described species, is present in every major zoogeographic region except the Australasian (*sensu* Heppner 1991). The genus is most diverse in the Holarctic and Neotropical regions (Brown 2005; Razowski & Wojtusiak 2006; Razowski 2006), with 14 species recognized from North America north of Mexico (Razowski 1979b; Powell 1983). The most recently described species from the Nearctic is *Clepsis penetralis* Razowski 1979 (type locality: Logan, Utah).

The mountain ranges of southeastern Arizona (i.e., Chiricahua, Huachuca, and Santa Rita mountains), known as the "sky islands," are of considerable interest to biologists and biogeographers. These montane ''islands'' are forested ranges separated by a lowland "sea" of desert and grassland. According to the Sky Island Alliance (2008), "they are among the most diverse ecosystems in the world because of their great topographic complexity and unique location at the meeting point of several major desert and forest biological provinces." "The region is a blend of tropical and temperate [biotic components], harboring well over half the bird species of North America, 29 bat species, over 3,000 species of plants, and 104 species of mammals..." Because the Lepidoptera fauna of these ranges is relatively well collected and studied (e.g., Bailowitz and Brock 1991; Walsh 2008), it is somewhat surprising to find a new tortricine occupying all three ranges. The purpose of this paper is to describe, diagnose, and illustrate the new species.

Materials and Methods

I examined 17 pinned adults and genitalia preparations for three specimens of each sex of the new species, and these were compared to adults and genitalia of all Nearctic *Clepsis*, relying primarily on the collection of the National Museum of Natural History, Washington, D.C. In addition, monographic treatments of the genus (Razowski 1979a; 1979b) and subsequently published descriptions of congeners were thoroughly reviewed (Razowski and Becker 2003; Razowski 2006; Razowski & Wojtusiak 2006). Depositories cited in the text are abbreviated as follows: BMNH, The Natural History Museum, London, United Kingdom; CNC, Canadian National Collection, Ottawa, Ontario; EME, Essig Museum of Entomology, Berkeley, California, U.S.A.; and USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A.

Dissection methods follow Brown and Powell (1991). Forewing length was measured on a straight line from the base of the costa to the apex including the fringe. Whole specimens and genitalia slides were examined using a Wild M3Z stereo dissecting scope under 6.5X and 40X power, respectively, with illumination from a Flexilux 90 HLU under the highest power. Details of the cornuti and signum were examined using a Zeiss compound microscope. Terminology follows Horak (1984) for features of the genitalia, R. Brown and Powell (1991) for elements of the forewing pattern, and Gilligan *et al.* (2008) for other morphological structures. Images of adults and genitalia were captured using a Visionary Digital© imaging system and enhanced using Adobe Illustrator© software.

Results and Discussion

Clepsis anderslaneyii Dombroskie and Brown, new species

(Figs. 2-1–2-3)

Diagnosis.—*Clepsis anderslaneyii* may be mistaken for weakly marked individuals of the variable *Argyrotaenia dorsalana* (Dyar) (Tortricinae: Archipini). It is separated from *A. dorsalana* by the presence of a male forewing costal fold and a reduction of the forewing median fascia (Fig. 2-1); the latter feature always extends to the dorsum in *A. dorsalana*. Male genitalia (Fig. 2-2) are consistent with the *Clepsis* ground plan (Razowski 1979a; 1979b), with a transtilla that is narrow or obsolete medially and conspicuously dentate and swollen subbasally. In the female genitalia (Fig. 2-3), the ductus bursae is shorter than that of any congener. The new species does not fit convincingly into any of the species groups of *Clepsis* recognized by Razowski (1979a; 1979b), but it falls closest to species of the *unicolorana* group based on the simple gnathos, greatly reduced socius, and small signum. Among Nearctic congeners, the male genitalia of *C. anderslaneyii* are most similar to those of *C. fucana* (Walsingham) (see Powell 1964: fig. 55). In *C. fucana* the uncus is broadest at the middle with a prominent medial groove, the tegumen is taller than wide, the transtilla is thicker basally with more prominent denticles, and the valva is more rounded apically. In *C. anderslaneyii* the uncus is broadest distally with the medial groove absent, the tegumen is wider than tall, the transtilla is thinner basally with less prominent denticles, and the valva is slightly pointed apically forming approximately a 60° angle.

Description.—Male. Head: Vestiture straw yellow to orange yellow throughout. Frons with smooth, appressed scaling; vertex with postocular scales long, occasionally tipped dark brown. Antenna unmodified, lacking basal notch, sensillae approximately as long as flagellomere width; dorsal scales alternating between narrow dark brown row and wider yellow row; occasionally with brown scaling on scape. Ocellus small, surrounded by thin black ring on cuticle, separated from compound eye by approximately width of ocellus. Labial palpus approximately 2.0X as long as horizontal height of compound eye, straw yellow, occasionally with brown scaling on lateral surface; second segment expanded distally by scales, ascending, roughly triangular; third segment small, porrect, extending beyond scales of second segment.

Thorax: Dorsum of pro- and mesothorax straw yellow, sometimes with white scaling, especially posteriorly, lateral scales beneath wings white; posterior scaling of metathorax white. Fore- and midleg vestiture usually brown mixed with yellow, occasionally mostly brown or all yellow; hind legs straw yellow. Forewing (Fig. 2-1) length 8.5–9.0 mm (mean ¼ 8.6; n ¼ 8), costal fold narrow, length 0.3–0.43 forewing length, costal edge brown; dorsal surface straw yellow with variable, tiny, sparse, dark brown speckling; distinct brown blotch near middle of median fascia, often another brown blotch where subterminal fascia meets costa; scattered dots variable, nearly always present in middle of basal fascia, sometimes forming ill-defined, interrupted lines, especially beyond median fascia. Fringe concolourous with forewing. Ventral surface of forewing with dense grey-brown suffusion, darkest towards costal fold, sparsest in postmedian area and along outer half of costa; rarely almost unmarked. Hind wing white, rarely suffused with light brown on outer margins in heavily maculated specimens. Fringe white, sometimes pale yellow, in subtle contrast to remainder of hind wing, white ventrally, rarely with some grey-brown suffusion along costa, heaviest in basal half.

Abdomen: Vestiture concolorous with hind wing, rarely brownish ventrally. Genitalia (Fig. 2-2) with uncus broad, subrectangular, distal one-third slightly dilated; socius obsolete, gnathos arms slender, nearly uniform in width, joining in pointed terminal tip; tegumen broad, slightly wider than tall; transtilla slender mesally with distinct rounded bulge subbasally, dentate along dorsal margin of bulge, with small triangular invagination near valva base; valva rather stout, partially membranous, with apex pointed with long setae sparsely distributed along margins; sacculus broad with large medial bulge and distinct inward-pointing tooth at base; juxta shield-shaped, slightly cleft middorsally; phallus with stout phallobase, remainder slender; vesica with two deciduous cornuti (one visible to right of signum in Fig. 2-3), somewhat elongate spindle-shaped, narrowing distally to fine point with small lateral hook at base.

Female. Head and thorax: Similar to male except antenna with sensillae shorter than flagellomere width and somewhat appressed, with single erect sensillum at distal end of each flagellomere; antennal scales yellow, occasionally with some brown or yellow brown in narrow scale row. Compound eye slightly smaller than in male. Ocellus smaller than in male, surrounded by larger area of black pigmentation on cuticle, separated from compound eye by more than twice width of ocellus. Labial palpus rarely with a few lateral, half grey-brown scales. Legs yellow, occasionally with some brown scaling on the fore- and midleg. Forewing length 8.0–9.5 mm (mean = 8.8; n = 9); ventral surface straw yellow, unmarked. Frenulum with three bristles, occasionally four, rarely five; number of bristles often asymmetrical on same specimen.

Abdomen: Genitalia (Fig. 2-3) with papillae anales slightly narrowed anteriorly, curved medially, posterior portion with medial bulge; apophysis posterioris about 2/3 length of sternum VII; apophysis anterioris nearly as long as sternum VII; sterigma cup-shaped with sclerotized horns extending laterally; ductus bursae short, 0.15–0.20X length of corpus bursae, with paired slender sclerotized bars (=colliculum) near ostium extending ca. length of sterigma; ductus seminalis arising from near middle of ductus bursae; corpus bursae pear-shaped; single signum dagger- shaped with rounded tip and distinctly serrated margin (conspicuous only under high magnification).

Holotype.— ♂, USA: Arizona: Santa Cruz Co.: Santa Rita Mountains, Madera Canyon, 5800’ [1770 m], 22 July 1960, J. G. Franclemont, USNM slide 95,295 (USNM).

Paratypes (7 ♂♂, 8 ♀♀).—USA: Arizona: Cochise Co.: Chiricahua Mountains, Turkey Creek, 5600’ [1710 m], 1 ♂, 1 August 1986, R. H. Leuschner. Huachuca Mountains, Carr Canyon, 5600’ [1710 m], 1 ♀, 15 August 1999, D. C. Ferguson. Santa Cruz Co.: Santa Rita Mountains, Madera Canyon, 1 ♂, 3 ♀♀, 18 August 1946, 1 ♂, 2 ♀♀ (1 ♀ CNC, ♀ / EME, 1 ♂ BMNH), 21 August 1952, all S. S. Nicolay; 4880’ [1490 m], 1 ♀, 20 July 1959, 1 ♂, (BMNH), 28 July 1959, both R.W. Hodges; 50000 [1520 m], 1 ♂, 22 August 1976, R. H. Leuschner; 5600’ [1710 m], 1 ♂, 1 August 1959, R. W. Hodges; 5800’ [1770 m], 1 ♂ (CNC), 17 August 1960, 2 ♀♀ (1 ♀ EME), 20 August 1960, all J. G. Franclemont. Specimens deposited in USNM unless indicated otherwise.

Distribution and biology.—This species is recorded from the Chiricahua, Huachuca, and Santa Rita mountains of southeastern Arizona at elevations from 1490 to 1770 m. These “sky islands” are isolated northern outposts of the Madrean biogeographic province (*sensu* Brown 1982). Plant communities at these elevations range from open oak-pinyon-juniper woodlands to oak-pine woodlands. *Clepsis anderslaneyii* appears to be univoltine with capture dates from 20 July to 22 August; the majority of specimens were collected in August.

Etymology.—The specific epithet is a patronym to honor the marriage of Sara Anderson to Malcolm Slaney in 2007.

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Figure 2-1: *Clepsis anderslaneyii*, new species, holotype male.

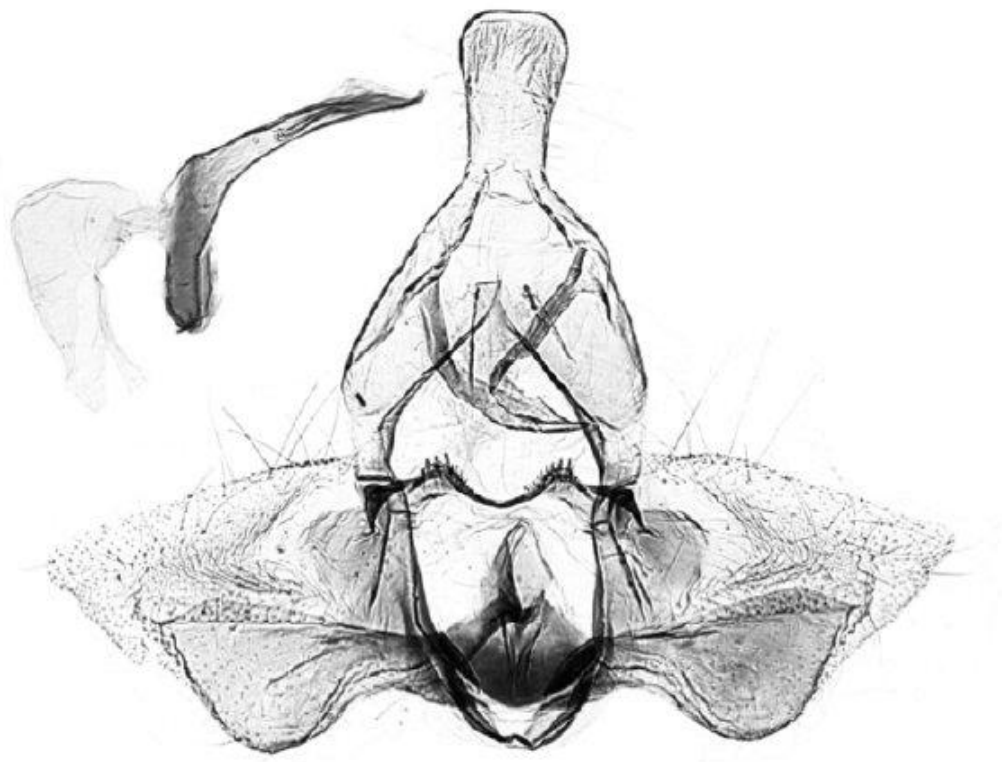

Figure 2-2: Male genitalia of paratype, valvae spread, aedeagus removed, USNM slide 126,495.

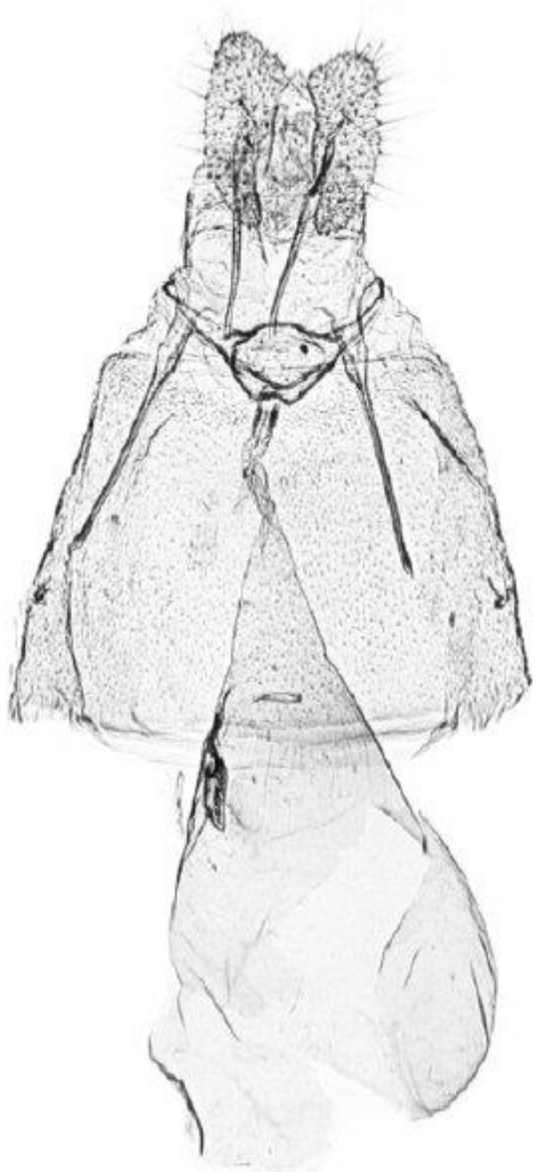

Figure 2-3: Female genitalia of paratype, USNM slide 95,296.

Chapter 3

Phylogeny of Nearctic *Pandemis* Hübner [1825] 1816 (Lepidoptera: Tortricidae), with focus on species boundaries in the *P. limitata* group

Introduction

The correct identification of an economically injurious organism is vital to our ability to manage it effectively. Identifications are fairly straightforward for many species, and only one or a few lines of evidence are needed to determine species boundaries; however, for more closely related species, specific identification can be difficult, and the species boundaries are often dependent upon which evidence is used (e.g. Roe & Sperling 2007; Schmidt & Sperling 2008; Lumley and Sperling 2010; Schlick-Steiner, *et al.* 2010). For this reason a total evidence approach should be used for nomenclatural stability (Agapow, *et al.* 2004; Sites & Marshall 2004).

A broad variety of species concepts are currently used, and the total evidence approach is emphasized by the general-lineage species concept, which states that species are separately evolving metapopulation lineages (de Quieroz 2007). This species concept uses multiple lines of evidence as opposed to a more limited set (e.g. Reeves & Richards 2011). The uncertainty surrounding species boundaries within the *Pandemis limitata* (Robinson) species group is a prime example where an iterative approach of testing these boundaries with new data can be employed (Yeates, *et al.* 2010).

The genus *Pandemis* Hübner [1825] 1816 is placed within the tribe Archipini (Lepidoptera: Tortricidae: Tortricinae) and has 67 described species worldwide (Brown 2005). The genus is widespread in the Holarctic, Oriental, and Afrotropical regions, with the greatest diversity in Madagascar and eastern Asia (Liu & Li 2002; Diakonoff 1973; 1963). Four native species are currently recognized in the Nearctic region, including *P. lamprosana* (Robinson), *P. limitata*, *P. canadana* Kearfott, and *P. pyrusana* Kearfott. Two species have been introduced to British Columbia from the Palaearctic: *P. cerasana*, and *P. heparana* ([Denis & Schiffermüller]) (Mutuura 1980).

The Nearctic *Pandemis* species are pests of apple (*Malus* spp.). The larva lives inside a rolled leaf and occasionally feeds on the fruit (Curkovic, *et al.* 2006; DeLury, *et al.* 2006; Madsen & Madsen 1980; Chapman & Lienk 1971). The six Nearctic species of *Pandemis* are polyphagous on deciduous trees and shrubs (Mutuura 1980; Prentice 1965), and *P. cerasana* (Hübner 1786) also will feed occasionally on conifers (Razowski 2002).

Nearctic *Pandemis* species have a typical archipine forewing pattern of yellow to brown ground colour with a brown patch on the costa just short of the apex and two broad dark brown bands, located in the basal area and the middle of the costa to the anal angle (Fig. 3-1). Males have a notch at the base of the antenna that may be used in a pre-mating ritual, since males and females in *P. pyrusana* meet head-to-head before mating (Curkovic, *et al.* 2006). In both sexes of *Pandemis* (except *P. lamprosana*), the second and third abdominal sternites host a thinly sclerotized area with modified dark scales (Razowski 1978). Also prominent are long scales on the elongated subgenital sternite of males that are referred to as coremata by Freeman (1958). The larvae are similar to other Archipini but can be distinguished as a group by the characters listed in MacKay (1962).

The original descriptions for all native Nearctic species used no genitalic dissections and relied on few specimens, so the extent of variation within these species was not appreciated. Robinson (1869) described both *P. lamprosana* and *P. limitata* based on an unspecified number of specimens from two collections and separated the former species from the latter by its fainter subapical costal spot on the forewing that extends further from the costa. Kearfott (1905) described *P. canadana* based on nine specimens and used characters like the shape of the forewing markings to differentiate it from *P. limitata*. However, these forewing characters are variable in both *P. limitata* and *P. canadana* and are not reliable for their differentiation (Freeman 1958). Kearfott (1905) also stated that *P. canadana* is subtly different in colour and he originally identified his types as dark forms of *P. limitata*. This paper was followed by the description of *P. pyrusana* (Kearfott 1907) based on just three reared specimens from California with strongly marked forewings and no elaboration on how they were different from other *Pandemis* species.

Both of the introduced species, *P. cerasana* and *P. heparana*, are easily separated from the four native Nearctic ones by forewing and hindwing pattern. In addition, their distinctly different male genitalia have an uncus shape that is relatively long and slender for *P. cerasana* and large and broad for *P. heparana* compared to the native species (Table 3-1). Although variable, our native species are currently separated from each other by wing colour, but there is some debate about whether these differences are sufficient to distinguish three of the species (Chapman & Lienk 1971; Powell 1964; Freeman 1958). There is no doubt that *P. lamprosana* is a separate species since it has distinct male genitalia and lacks the modified black scales on the second abdominal segment that are present in all other Nearctic *Pandemis* species (Table 3-1). However, genitalia appear to be identical among *P. limitata, P. canadana,* and *P. pyrusana* and there is overlapping variation in forewing pattern. The characters regularly used to differentiate these three species include the colour of the hindwing (grey and white, all grey, and all white, respectively) and the ground colour of the forewing (medium to dark brown for *P. canadana* and straw to medium brown for the other two). The paucity of phenotypic variation has led some authors to suggest that these taxa may be mere forms of one common widespread species (Chapman & Lienk 1971; Powell 1964; Freeman 1958). There may be some geographic segregation, with *P. pyrusana* restricted mainly to west of the Rocky Mountains while the other two species are found mainly east of the Rockies. *Pandemis limitata* and *P. pyrusana* are described as having identical pheromones, further supporting their conspecificity (Roelofs, *et al.* 1976; 1977). The larvae of all three species and *P. lamprosana* are also variable in head and prothoracic shield (the dorsal plate behind the head) pattern and cannot be distinguished (Chapman & Lienk 1971; MacKay 1962).

The purpose of this study is to iteratively test species boundaries (Yeates, *et al.* 2010) using the general-lineage species concept (de Quieroz 2007) within the *P. limitata* group using 1547 bp of COI and 697 bp of ITS2 sequences, geographical distributions, and quantification of wing colour. To allow improved polarization of characters and determine putative synapomorphies, I also build a preliminary molecular phylogeny for the available Nearctic and western Palearctic species of *Pandemis* and one closely related species in *Archepandemis*.

Materials & Methods

Fresh specimens of eight of the nine currently recognized Nearctic and western Palaearctic *Pandemis* species (except *P. chondrillana* (Herrich-Schäffer)) were obtained along with *Archepandemis coniferana* Mutuura 1978. *Archepandemis* was selected as an ingroup taxon as it was found to fit within the genus *Pandemis* in a broader study of the Archipini by Dombroskie & Sperling (Chapter 4). *Clepsis* and *Argyrotaenia* were also found to be sister genera in the broader study, and thus were chosen as outgroups here. Specimens sequenced are listed in Table 3-2.

I removed two legs from most specimens soon after the moths were killed and the legs were stored in 95% ethanol at -20°C. In a few specimens I removed legs either from specimens collected directly into ethanol or live frozen. DNA was extracted using QIAamp Mini Kits (Qiagen, Canada) and eluted in three steps into a 150 µl volume to increase the DNA concentration. PCR reactions for COI followed Lumley & Sperling (2010), except that 4 µl of DNA template were used. The PCR reactions for ITS2 were similar but used 3 µl of $MgCl_2$ and cycle sequencing follwed that of Wiegmann, *et al.* (2000). Primers used for COI were Jerry (CAACATTTATTTTGATTTTTTGG), Pat2 (TCCATTACATATAATCTGCCATATTAG), K525 (ACTGTAAATATATGATGAGCTCA), and K698 (TACAATTTATCGCCTAAACTTCAGCC) (Simon, *et al.* 1994; Sperling, *et al.* 1994), and for ITS2, ITS2F (TGTGAACTGCAGGACACATGAA), and ITS2R (ATGCTTAAATTTAGGGGGTAGTC) (White, *et al.* 1990). PCR purification was performed either with a QIAquick PCR purification kit (Qiagen) or ExoSAP-IT (USB Corporation, Cleveland, OH), and sequencing was done with BigDye Terminator version 3.1 cycle sequencing (Applied Biosystems, Foster City, CA). Sequences were purified using ethanol precipitation and sequencing reactions were run on an ABI Prism 3730 DNA analyser.

Chromatograms were examined with SeqMan Pro version 7.2.0 (DNASTAR) and sequences were aligned by eye in Mesquite version 2.73 (Maddison & Maddison 2010). PAUP* 4.0 (Swofford 2003) was used for parsimony analyses and default settings were used. Likelihood analyses were done using Garli (Zwickl 2006) using default settings and the GTR + I + G model of evolution as determined by Modeltest (Posada & Crandall 1998) and jModelTest 3.7 (Posada 2009). MrBayes v3.1.2 (Ronquist & Huelsenbeck 2003) was used for Bayesian analyses, with default settings and two sets of at least 10 million generations, except for combined COI and ITS2 analyses which ran for 3.5 million generations. Indels were treated as 5th characters in PAUP*, missing data in Garli, and as a separate dual-state data partition in Mr. Bayes. First and second codon positions in COI were weighted as equal, as well as 2, 3, and 4 times the weight of third codon positions. All three analyses were conducted for COI, ITS2, and combined COI + ITS2 datasets.

Photos of specimens for wing colour quantification were taken for all *P. canadana, P. limitata,* and *P. pyrusana* specimens used in the molecular analyses, except for specimen JD3292 because it was unspread. Methods were similar to those in Lumley & Sperling (2010) except for the following. Photos were taken with a Canon G11 digital camera using manual settings in macro mode. White balance on the camera was adjusted by placing a white card at the level of the specimens. Lighting was provided by a Cole Parmer 41723 Series high intensity illuminator at ¾ of full power, with the lights at both sides of the specimens at 45 degree angles and 5 cm away. Specimens were placed 5 cm from the camera lens and photographed using the highest quality JPEG format. Quantification of greyness was done using ImageJ (Abramoff, *et al.* 2004) using the histogram function where 0=black and 255=white. Polygons were drawn within any dark or light boundaries of the paler subbasal area and darker median band, while hindwing boundaries were determined by drawing a line from the base of the wing to the medial bulge in the outer margin to divide the basal from the apical areas (Fig. 3-1). I excluded the pale costal margin in the apical area of the hindwing (usually concealed by the forewing) from the apical hindwing polygon. I recorded the mean greyness value for each polygon for all specimens and all were compared pairwise against each other. I chose the dark median and inner adjacent paler subbasal bands of the forewing and the basal and apical portions of the hindwing because they varied the most between specimens.

For distribution records, I examined *Pandemis* specimens in the Canadian National Collection, Ottawa (n=232), Los Angeles County Museum (n=102), Royal Saskatchewan Museum, Regina (n=46); and Smithsonian Museum of Natural History, Washington (n=550). Due to several dubious records in Prentice

(1965) (G. Pohl, *pers. com.*), it was not used as a source of specimen records for the range maps. Specimen identities were based upon visual examination of the hindwing (all white = *P. pyrusana*, all grey = *P. canadana*, half grey half white = *P. limitata*).

Results

Phylogeny of Pandemis

Based on parsimony, maximum likelihood, and Bayesian analyses, the trees for COI and ITS2 gave conflicting phylogenies (Figs. 3-2 & 3-3 show two of the more resolved trees), and none of the analyses completely agreed with each other. While aligning sequences, it became evident that the indels in the ITS2 gene might contribute important information since each species usually had some unique indels. It was not possible to code indels in Garli, and that analysis produced a polytomous tree with almost no resolution. Adjusting the character weights of the first two codons in COI yielded trees that were highly polytomous, so all subsequent analyses were done with characters weighted equally. The tree obtained from Bayesian analysis of ITS2 (Appendix 3-1) was also an outlier in one major respect; the *P. lamprosana* + *P. limitata* group clade was inverted compared to the other analyses, with *P. lamprosana* as a terminal taxon rendering the *P. limitata* group paraphyletic. Other than this result, the remainder of the tree was similar to the other analyses.

Pandemis, inclusive of *Archepandemis,* was consistently monophyletic with posterior probabilities and bootstrap values of 90 to 100 (Fig. 3-4). *Pandemis heparana, A. coniferana, P. cinnamomeana,* and *P. corylana* were a monophyletic group with weak to strong support with COI, but this was not supported with either ITS2 or combined analyses. Three of the nine analyses place *A. coniferana* basal to the rest of *Pandemis* (Figs. 3-3, 3-5, Appendix 3-3). I choose to maintain it within *Pandemis*, which is supported by my analyses of COI and 28S+COI in Chapter 4. The combined *P. lamprosana* and *P. limitata* group clade usually were monophyletic with good bootstrap support, and *P. lamprosana* was usually the most basal species (Fig. 3-4). The *Pandemis limitata* group nearly always came out as a well-supported monophyletic group, with the notable exception of the Bayesian analysis of ITS2 as mentioned above.

DNA phylogeny of the P. limitata *group*

All species outside of the *P. limitata* group were recovered as monophyletic, although *P. corylana* had weak support from likelihood and parsimony COI analyses, possibly due to incomplete sequence for two of the specimens (Fig. 3-4). Within the *P. limitata* group, the two genes produced conflicting phylogenies. For COI (Fig. 3-2), most *P. canadana* and all *P. limitata* formed an intermixed clade. A single *P. canadana* specimen from the Porcupine Hills, Alberta, was either basal in the group or within the *P. canadana* and *P. limitata* clade (inclusive of one specimen of *P. pyrusana* from Waterton Lakes, Alberta). The remainder of *P. pyrusana* was either a monophyletic group with weak support values, or a paraphyletic grade with no bootstrap support. For ITS2 (Fig. 3-3), *P. canadana* was a monophyletic group with weak support. Both *P. pyrusana* and *P. limitata* were separate paraphyletic grades with the exception of a single *P. limitata* from Porcupine Hills, Alberta that grouped with *P. pyrusana*. Combining both COI and ITS2 resulted in a polytomy from parsimony analysis (Appendix 3-3), but both likelihood and Bayesian analyses (Appendix 3-4, Fig. 3-5) show a more structured tree with better support values. The latter two trees show *P. canadana* as a moderately well supported monophyletic clade, with *P. limitata* and *P. pyrusana* as successively more basal paraphyletic grades.

Wing colour quantification of the P. limitata *group*

Any of the graphs where histogram values of the greyness from the median band were used were less informative, due to the variability in darkness of that band within species. When plotted in three dimensions, the histogram values for the colour of the base and apical areas of the hindwing and subbasal forewing, provided the best segregation of all three members of the *P. limitata* group

(Appendix 3-6; Table 3-3; Fig. 3-6). The only exceptions are one specimen that is intermediate in appearance between *P. canadana* and *P. limitata* from Edmonton and three specimens from the Porcupine Hills that look intermediate between *P. pyrusana* and the other two species (three of which are shown in Fig. 3-8).

Geographical distribution of the P. limitata *group*

Plotting the geographic locations showed coarse-scaled distributions for the four native Nearctic species (Fig. 3-7). There is a region immediately west of the Appalachians with no *Pandemis* specimens in the examined collections, possibly due to lack of collecting in those states. *Pandemis limitata* has the broadest distribution as it is found across southern Canada from British Columbia to Nova Scotia with broad expansions southward on the eastern slopes of the Rockies to Arizona, through the midwest to Texas, and the Appalachians to Georgia, with one specimen from Durango, Mexico. *Pandemis canadana* is distributed in more northerly regions from British Columbia to Nova Scotia, and southwards along the eastern slope of the Rockies to Arizona. *Pandemis pyrusana* is found through much of the Cordilleran region from southern British Columbia and southwestern Alberta to Colorado and California. Both *P. canadana* and *P. limitata* are broadly sympatric across the southern boreal forest; however, they have different centres of relative abundance. *Pandemis canadana* was much more abundant in the northern prairies and maritimes, while *P. limitata* was much more abundant in Ontario and the northeastern United States. The three species in the *P. limitata* group intermingled in a zone from southwestern Alberta to southern interior British Columbia and Colorado.

Discussion

Pandemis limitata group species boundaries

Species boundaries within the *P. limitata* group are challenging to determine. Mitochondrial DNA shows no discernable differences between *P. canadana* and *P. limitata* (Fig. 3-2). Since these species are sympatric and closely related, it is reasonable that there has been widespread mitochondrial introgression (e.g. Schmidt & Sperling 2008; Lumley & Sperling 2011; Schoville, *et al.* 2011). *Pandemis pyrusana* appears to be a basal grade relative to both species and shows much more geographic structuring, especially as the specimens from California consistently form a well supported clade. This increased population structure may be a result of the complex topography of its geographic range since *P. pyrusana* is a Cordilleran species with many distributional barriers. Nuclear DNA tells a different story (Fig. 3-3). ITS2 shows *P. canadana* as a monophyletic entity and both *P. pyrusana* and *P. limitata* as paraphyletic.

The discordance in gene trees suggests the possibility of either introgression or incomplete lineage sorting (Maddison & Knowles 2006) and emphasizes the importance of using multiple loci when inferring species trees. This molecular evidence would be evidence against separate species under some more traditional species concepts. For example, potential for interbreeding violates the the biological species concept, while paraphyly is inconsistent with the phylogenetic species concept (Coyne & Orr 2004). In contrast, most modern concepts like the general-lineage species concept consider interbreeding and non-monophyly as a typical component of very recent speciation (de Quieroz 2007).

Further complexity is provided by a few specimens that could potentially be hybrids (Fig. 3-8). One putative specimen of *P. canadana* (JD3511) had mitochondrial DNA that placed it as either basal to or within *P. pyrusana*. This specimen was much paler overall (hindwing basal area greyness = 186) than most *P. canadana* examined ($\bar{x}$ hindwing basal area greyness = 153, σ = 17) but was still too dark for *P. pyrusana* ($\bar{x}$ hindwing basal area greyness = 209, σ = 10) (Table 3-3). Also, one of the putative *P. limitata* (JD3510) had nuclear DNA that placed it within a clade of *P. pyrusana*. The specimen had intermediate characters between typical *P. pyrusana* and *P. limitata* in that the hindwing had a partial faint infuscation of grey scaling consistent in pattern, but was much paler (hindwing basal area greyness = 189) than typical *P. limitata* ($\bar{x}$ hindwing basal area greyness = 162, σ = 16), and at a quick glance the specimen looks like *P. pyrusana*.

Both of these putative hybrids were collected in the Porcupine Hills of south western Alberta, in the Northern-Rocky Mountain suture-zone (Remington 1968; though see Swenson 2010), which is less than 100 km north of the nearest known *P. pyrusana* population. This part of south western Alberta is one of the areas where all three species currently occur in close proximity (Fig. 3-7). In addition to these two obvious examples of morphological intermediacy, there were two specimens (JD1386 & JD1392) that had apical hindwing greyness (188 & 194) that was closer to *P. limitata* ($\bar{x}$ hindwing apical area greyness = 187, σ = 16) than to *P. canadana* ($\bar{x}$ hindwing apical area greyness = 160, σ = 20); however, their forewing subbasal greyness (110 & 108) was closer to *P. canadana* ($\bar{x}$ forewing subbasal area greyness = 111, σ = 13) than to *P. limitata* ($\bar{x}$ forewing subbasal area greyness = 136, σ = 16). Both specimens have ITS2 sequences that nest them within *P. canadana* and their COI sequences place them in *P. canadana/P. limitata*. Since COI sequence shows no difference between the two taxa, it is difficult to verify whether these are indeed hybrids or just pale individuals of *P. canadana*.

Two hypotheses may explain the origins of the species in the *P. limitata* group. The paraphyly of *P. limitata* with respect to *P. canadana* suggests that the latter species could have originated recently within *P. limitata* and there has not been enough time for complete lineage sorting. Most specimens in these two species have nearly identical COI haplotypes, which suggests that there may have been a previous selective sweep (Coyne & Orr 2004). This is further supported by the increased geographic structuring within ITS2 clades relative to COI. The lack of consistent COI difference between these species could also be due to rapid mitochondrial introgression, even though hybridization between the two does not seem common, since such a process can occur in a relatively short period of time with relatively few interspecific matings (Goodman, *et al.* 1999; Mallet 2005).

None of the character types alone, whether DNA, morphology, or geography, provided sufficient character variation to delimit the species as they are currently defined (Table 3-4). However, the combination of apical and basal hindwing greyness and forewing subbasal greyness allowed successful separation, as should be expected since the taxa were partly defined on the basis of these characters in the first place. Except where all three species meet in southwestern Alberta, the species were usually distinguishable using a combination of COI and ITS2 sequences. Their geographic distributions generally were distinct as well; *P. pyrusana* was Cordilleran, and both *P. canadana* and *P. limitata* were mainly found east of the Rocky Mountains. The ranges of the last two species overlapped broadly; however, *P. canadana* was the most common species in the northern prairie provinces and Maritimes, while *P. limitata* was more common south of the boreal region.

Molecular phylogeny and synapomorphies of examined Pandemis *species*

The importance of ITS2 indels for providing phylogenetic signal became evident in the alignment stage, with each species, as defined by hindwing colour, typically having well-defined blocks of indels. When the sequences were analysed using Garli, which lacks the capacity to treat indels as anything other than missing data, the resulting tree showed very little resolution or support values among taxa.

It is difficult to determine which characters are synapomorphic at the base of the genus since at least some of the characters are absent in several species. Of the species in this study, *P. dumetana* lacks the antennal notch and since it is found as the most basal lineage in a few of the analyses, it suggests that absence of a notch may be the pleisiomorphic state for the genus. *Pandemis lamprosana* lacks the basal abdominal modified scales; however, in this case it is most likely due to a reversal since it is well supported as a more derived clade in most analyses. Since *A. coniferana* is also positioned well within *Pandemis* in most DNA-based phylogenies, it seems likely that it has secondarily lost the antennal notch, basal abdominal modified scales, and modified pregenital sternite. Mutuura (1978) considered *Archepandemis* close to *Pandemis* based on identical wing venation and similar male genitalia, but he kept it out of the genus because it lacks many of the defining characters of the genus. However, careful examination of the male antenna in *A. coniferana* shows that there is a subtle notch that may be a remnant of that ancestral character. All COI analyses (Fig. 3-2, Appendices 3-2, 3-5) tend to place *Archepandemis* in a clade with the Palearctic *P. heparana, P. cinnamomeana*, and *P. corylana*. This may seem surprising since the other three are primarily polyphagous on deciduous trees and shrubs instead of being restricted to conifers and have a more typical *Pandemis* wing pattern. *Archepandemis* has a very different forewing pattern, with a grey checkered pattern instead of the typical brownish banded pattern; however, the pattern is clearly convergent on many different conifer-feeding archipines like *Archips packardiana* (Fernald), *Choristoneura fumiferana* (Clemens), *Dichelia histrionana* (Frölich), and *Syndemis afflictana* (Walker). Furthermore, since a few of the Palaearctic species, like *P. cerasana* and *P. cinnamomeana*, occasionally feed on conifers as well (Razowski 2002), adapting to a coniferivorous diet seems plausible. Another expected result is that *P. lamprosana* comes out as a sister to the *P. limitata* group. Morphologically, this makes sense since the genitalia are somewhat similar, the wing patterning is similar (at least to typical *P. limitata*), and the larvae are indistinguishable (MacKay 1962).

Conclusions

The species in the *Pandemis limitata* group are separable using a combination of morphology, geography, and DNA, suggesting that they are indeed distinct biological entities that are in the early stages of speciation. Because of this I choose to maintain the *status quo* and maintain them as separate but closely related species. Recognition as separate species is also important for understanding the detection and potential for spread of any of these species if they are introduced outside of their native ranges and become newly established pests.

Due to poor resolution and limited taxonomic sampling at deeper levels within *Pandemis*, it is difficult to discern which of the *Pandemis* characters are synapomorphies for the whole genus. The genus *Archepandemis* should be included within *Pandemis* based on molecular analyses; as well as overall morphological similarity and faint remnants of a basal antennal notch.

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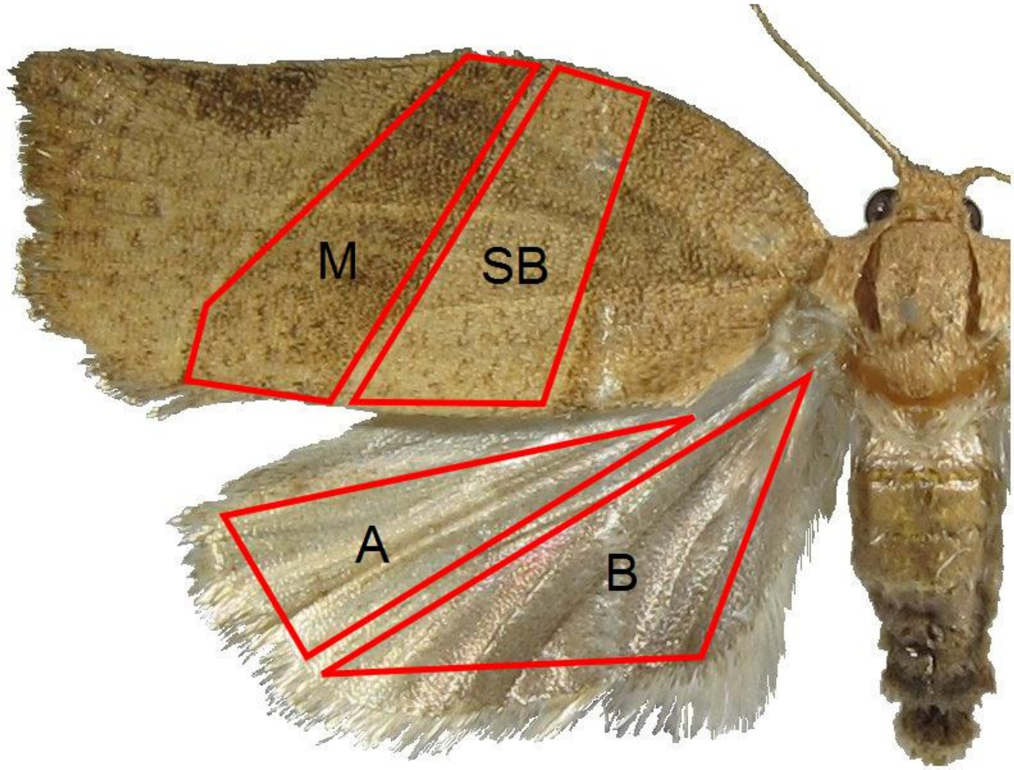


Figure 3-1: Location of greyness measurements. M = median, SB = subbasal, A = apex, B = base.

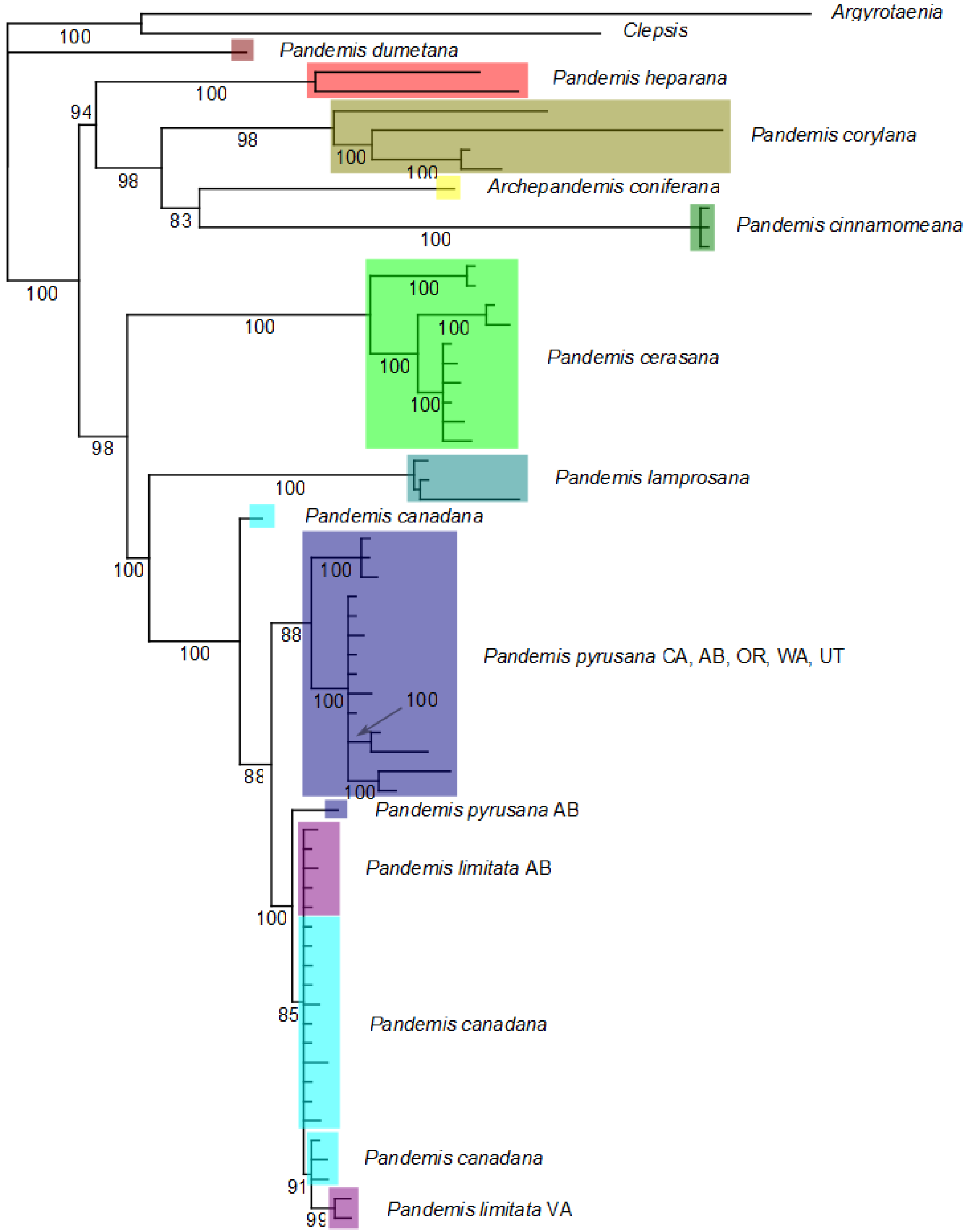


Figure 3-2: Bayesian analysis of COI with posterior probabilities.

Figure 3-3: Consensus tree of maximum parsimony analysis of ITS2 with bootstrap values.

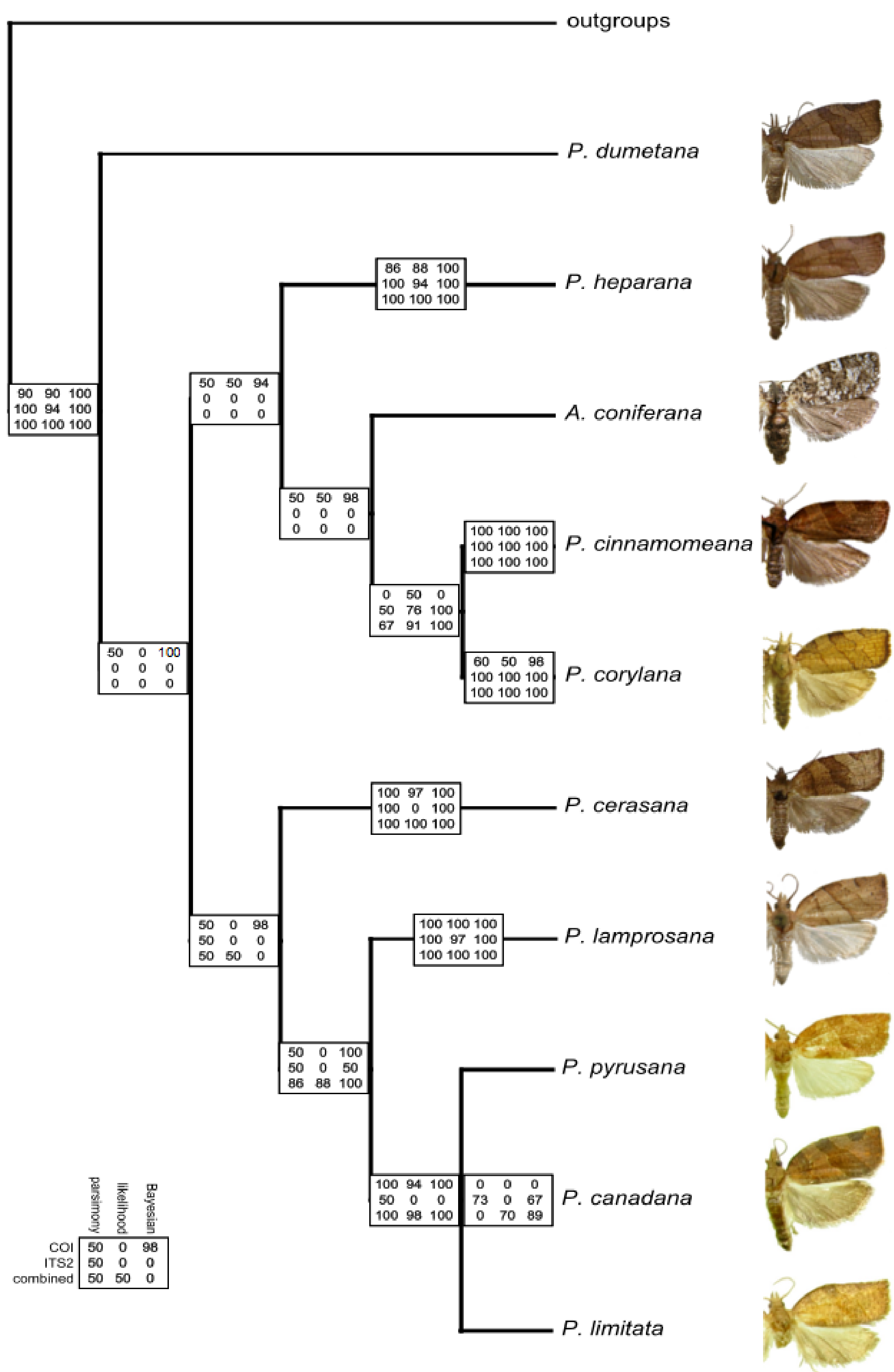


Figure 3-4: Summary of trees and support values for clades. Numbers are bootstrap values for parsimony and likelihood and posterior probabilities for Bayesian analyses. Species without values either had only a single specimen or were never fully monophyletic in the analyses.

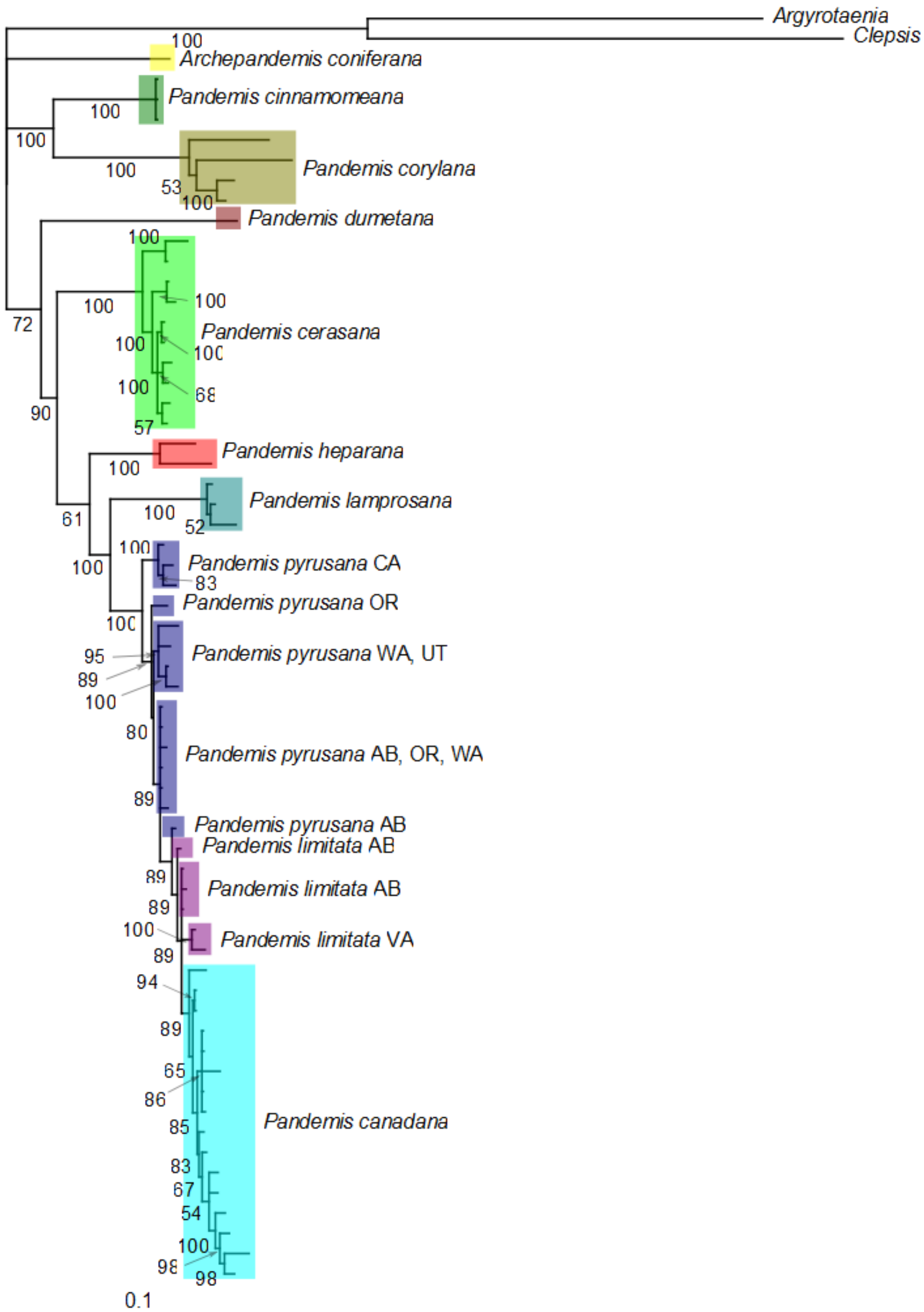


Figure 3-5: Bayesian analysis of combined COI and ITS2 with posterior probabilities.

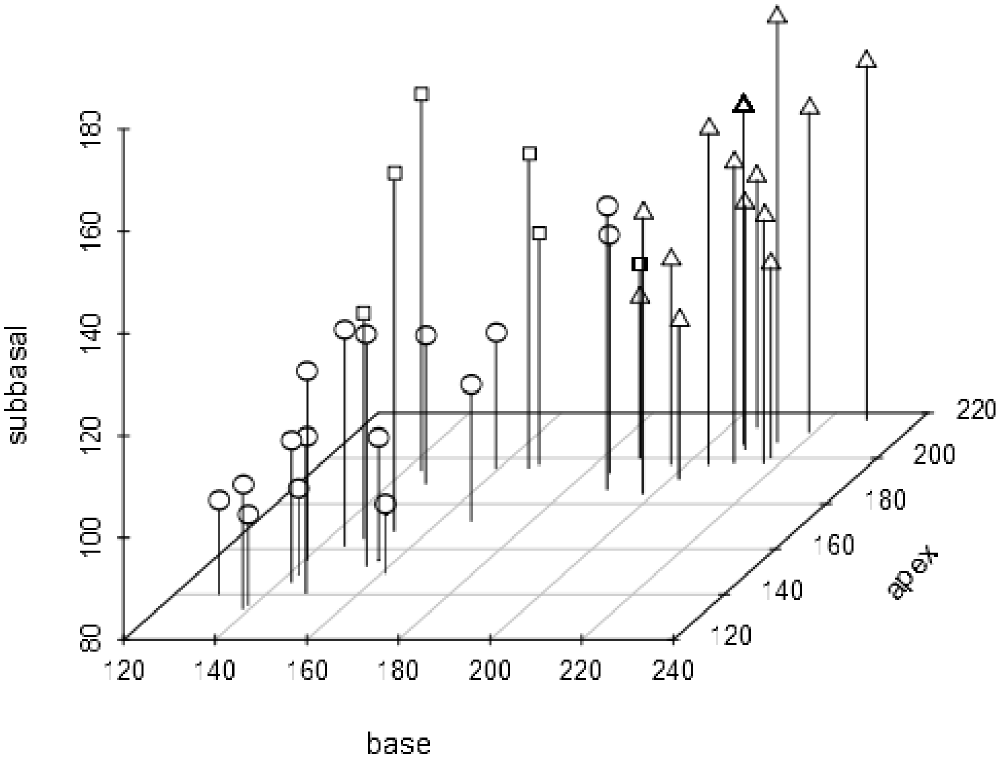


Figure 3-6: 3D plot of mean greyness of the basal and apical portions of the hindwing and the subbasal portion of the forewing. *Pandemis canadana*, *P. limitata*, and *P. pyrusana* are represented by circles, squares, and triangles respectively.

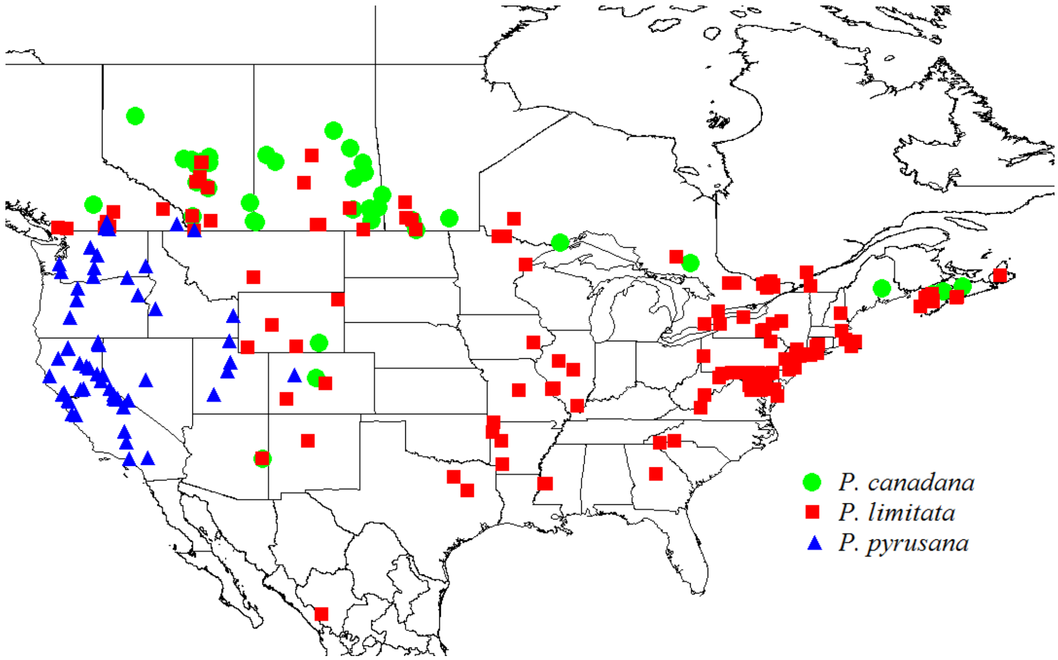


Figure 3-7: Geographic distribution of examined *Pandemis limitata* group specimens on a cylindrical map projection.

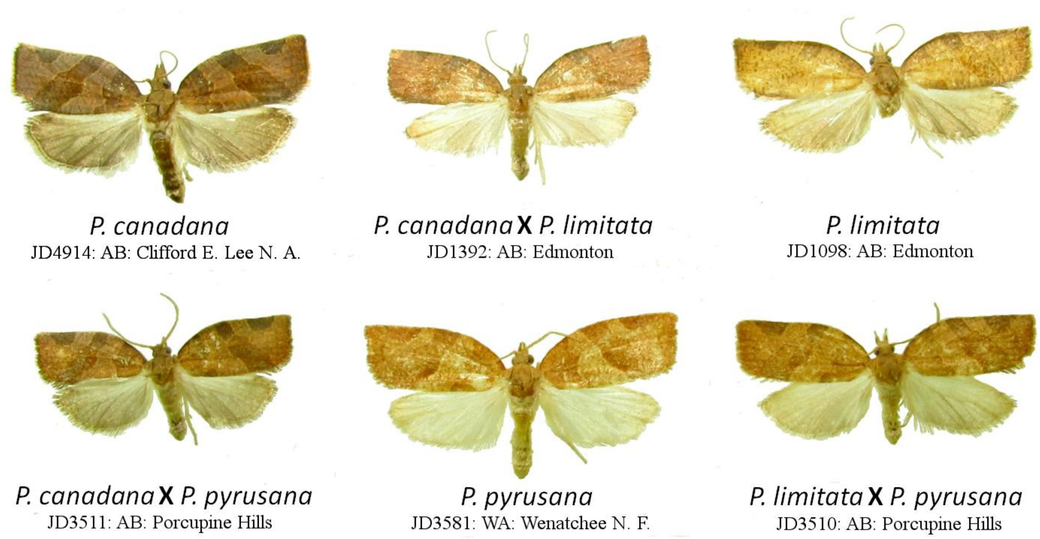


Figure 3-8: *Pandemis limitata* group specimens including putative hybrids.

Table 3-1: Morphological characters of Nearctic *Pandemis* spp. obtained from specimens examined in the personal collection of JD, CNC, and USNM. Genitalia measurements based on Razowski (2002), Powell (1964), and Freeman (1958).

	P. cerasana	***P. heparana***	***P. lamprosana***	***P. canadana***	***P. limitata***	***P. pyrusana***
forewing						
ground colour	straw to light brown	medium brown	straw to light brown	medium to dark brown	straw to medium brown	straw to medium brown
fasciae colour	light to medium brown	medium to dark brown	light to medium brown	chocolate brown	medium to chocolate brown	light to medium brown
border of fascia and ground	dark, usually distinct	pale or dark, usually subtle	pale, subtle	pale, usually distinct	pale, subtle to distinct	dark, subtle
shape of subapical spot	round to triangular, sometimes extended	variable, sometimes faint	triangular, rarely rounded, usually extended	round	round	round
overall pattern contrast	distinct	subtle to moderate	subtle to moderate	subtle to distinct	subtle to distinct	subtle to distinct
fine strigulations	medium to dark brown, variable	medium to dark brown, heavy	grey, variable	grey, variable	grey to brown, sparse	medium brown, variable
hindwing						
basal colour	light to medium greyish brown	light to medium greyish brown	white to faintly grey	dark grey	light to medium grey	white
apical colour	light to medium greyish brown	light to medium greyish brown	white, some brown strigulation at apex	dark grey, pale along costa	white to yellow with apical brown strigulation	white, often some yellow at apex
male abdomen						
dark modified scales near abdomen base	present	present	absent	present	present	present
uncus length*	2.25X	1.5X	1.75X	1.25X	1.25X	1.25X
socius length**	0.75X	0.5X	0.25X	0.75X	0.75X	0.75X

* Uncus length measured from apex to narrowest point, compared to width
** Socius length is relative to uncus length

Table 3-2: Specimens sequenced in this study.

Species	DNA No.	Location	latitude / longitude	Date	Collectors
Archepandemis coniferana	4571	CANADA: AB: EMEND	56.751 - 118.330	11 vii 2007	E. Kamunya
Argyrotaenia alisellana	2905	UNITED STATES: VA: Fairfax Co.: 1 km E Fairfax City	38.847 - 77.295	31 v 2006	J. W. Brown
Clepsis clemensiana	2913	CANADA: AB: Edmonton	53.525 - 113.492	23 vii 2006	J. J. Dombroskie, A. Rose
Pandemis canadana	4582	CANADA: AB: Clifford E. Lee Natural Area	53.413 - 113.789	05 vii 2008	J. J. Dombroskie, *et al.*
Pandemis canadana	4584	CANADA: AB: Cypress Hills Provincial Park	49.657 - 110.036	05 viii 2008	J. J. Dombroskie, *et al.*
Pandemis canadana	2932	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2911	CANADA: AB: Edmonton	53.545 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2921	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2930	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2964	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2965	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2966	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2967	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2968	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	2969	CANADA: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler
Pandemis canadana	4583	CANADA: AB: Lessard Lake	53.779 - 114.628	20 vii 2008	J. J. Dombroskie, *et al.*
Pandemis canadana	4570	CANADA: AB: Porcupine Hills	49.972 - 114.087	30 vii 2007	J. J. Dombroskie, *et al.*
Pandemis canadana	4574	CANADA: AB: Porcupine Hills	49.972 - 114.087	07 viii 2008	J. J. Dombroskie
Pandemis canadana	4568	CANADA: AB: Redwater	53.922 - 112.951	22 vii 2005	L. Lumley
Pandemis cerasana	4537	DENMARK: LFM: Mandemarke	54.967 12.491	09 vi 2007	O. Karsholt
Pandemis cerasana	4538	DENMARK: LFM: Mandemarke	54.967 12.491	09 vi 2007	O. Karsholt
Pandemis cerasana	4539	DENMARK: LFM: Mandemarke	54.967 12.491	09 vi 2007	O. Karsholt
Pandemis cerasana	4540	DENMARK: LFM: Mandemarke	54.967 12.491	09 vi 2007	O. Karsholt
Pandemis cerasana	4541	DENMARK: LFM: Mandemarke	54.967 12.491	09 vi 2007	O. Karsholt
Pandemis cerasana	4542	DENMARK: LFM: Mandemarke	54.967 12.491	09 vi 2007	O. Karsholt
Pandemis cerasana	4597	ITALIA: LOM: Samarate	45.621 8.798	05 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis cerasana	4586	ROMÂNIA: GJ: Cheile Sohodolului	45.139 23.139	01 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis cerasana	4588	ROMÂNIA: GJ: Cheile Sohodolului	45.139 23.139	01 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis cerasana	4589	ROMÂNIA: GJ: Cheile Sohodolului	45.139 23.139	01 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis cinnamomeana	4560	DENMARK: LFM: Mandemarke	54.967 12.491	07 - 13 vii 2007	O. Karsholt
Pandemis cinnamomeana	4561	DENMARK: LFM: Mandemarke	54.967 12.491	07 - 13 vii 2007	O. Karsholt

Pandemis cinnamomeana	4562	DENMARK: LFM: Mandemarke	54.967 12.491	07 - 13 vii 2007	O. Karsholt
Pandemis corylana	4593	ITALIA: LOM: Samarate	45.621 8.798	05 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis corylana	4594	ITALIA: LOM: Samarate	45.621 8.798	05 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis corylana	4596	ITALIA: LOM: Samarate	45.621 8.798	05 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis corylana	4598	ITALIA: LOM: Samarate	45.621 8.798	05 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis dumetana	4553	DENMARK: LFM: Mandemarke	54.967 12.491	07 - 13 vii 2007	O. Karsholt
Pandemis heparana	4592	ITALIA: LOM: Parco Ticino	45.583 8.703	06 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis heparana	4590	ROMÂNIA: GJ: Cheile Sohodolului	45.139 23.139	01 vi 2009	J. J. Dombroskie, D. Lawrie
Pandemis lamprosana	4566	UNITED STATES: AR: Crawford Co.: Ozark-St. Francis National Forest	35.702 -94.296	17 vi 2008	J. J. Dombroskie, D. Lawrie
Pandemis lamprosana	4573	UNITED STATES: MD: Patuxeut Wildlife Refuge	39.027 -76.798	xii 1997	J. A. Powell
Pandemis lamprosana	2923	UNITED STATES: VA: Fairfax Co.: 1 km E Fairfax City	38.847 -77.295	03 vi 2006	J. W. Brown
Pandemis limitata	2920	CANADA: AB: Edmonton	52.527 -113.535	11 vii 2006	F. A. H. Sperling
Pandemis limitata	2950	CANADA: AB: Edmonton	52.527 -113.535	11 vii 2006	F. A. H. Sperling
Pandemis limitata	2951	CANADA: AB: Edmonton	52.527 -113.535	11 vii 2006	F. A. H. Sperling
Pandemis limitata	4569	CANADA: AB: Porcupine Hills	49.972 -114.087	30 vii 2007	J. J. Dombroskie, *et al.*
Pandemis limitata	2939	UNITED STATES: VA: Fairfax Co.: 1 km E Fairfax City	38.847 -77.295	03 vi 2006	J. W. Brown
Pandemis limitata	2907	UNITED STATES: VA: Fairfax Co.: 1 km E Fairfax City	38.847 -77.295	31 v 2006	J. W. Brown
Pandemis pyrusana	2922	CANADA: AB: Waterton Lakes National Park	49.099 -113.905	15 viii 2006	J. J. Dombroskie, *et al.*
Pandemis pyrusana	2971	CANADA: AB: Waterton Lakes National Park	49.099 -113.905	15 viii 2006	J. J. Dombroskie, *et al.*
Pandemis pyrusana	2994	UNITED STATES: CA: Modoc Co.: Modoc National Forest	41.559 -120.299	22 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4551	UNITED STATES: CA: Modoc Co.: Modoc National Forest	41.519 -120.233	23 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4575	UNITED STATES: CA: Modoc Co.: Modoc National Forest	41.519 -120.233	23 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4576	UNITED STATES: OR: Douglas Co.: Umpqua National Forest	43.312 -122.112	25 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4577	UNITED STATES: OR: Jefferson Co.: Deschutes National Forest	44.489 -121.694	26 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	2995	UNITED STATES: OR: Wasco Co.: Mount Hood National Forest	45.232 -121.627	26 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4550	UNITED STATES: OR: Wasco Co.: Mount Hood National Forest	45.232 -121.627	26 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4578	UNITED STATES: OR: Wasco Co.: Mount Hood National Forest	45.232 -121.627	26 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4549	UNITED STATES: UT: Lander Co.: Toiyabe National Forest	39.225 -117.139	08 vii 2007	J. J. Dombroskie, *et al.*

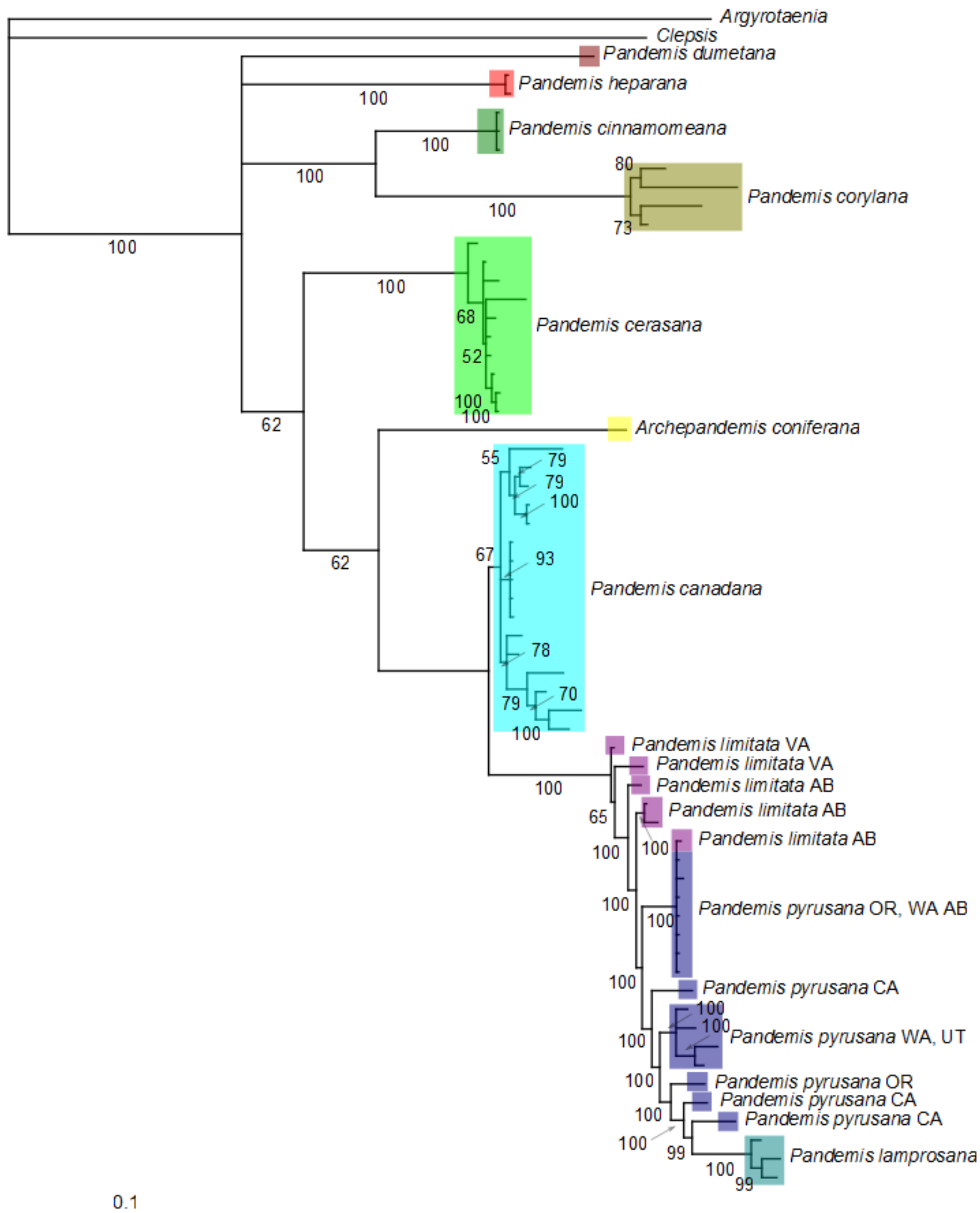
Pandemis pyrusana	4579	UNITED STATES: UT: Lander Co.: Toiyabe National Forest	39.225 -117.139	08 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	2996	UNITED STATES: WA: Chelan Co.: Wenatchee National Forest	47.963 -120.785	29 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4552	UNITED STATES: WA: Chelan Co.: Wenatchee National Forest	47.963 -120.785	29 vii 2007	J. J. Dombroskie, *et al.*
Pandemis pyrusana	4580	UNITED STATES: WA: Chelan Co.: Wenatchee National Forest	47.963 -120.785	29 vii 2007	J. J. Dombroskie, *et al.*

Table 3-3: Mean and standard deviation for histogram values of greyness for *Pandemis* spp.

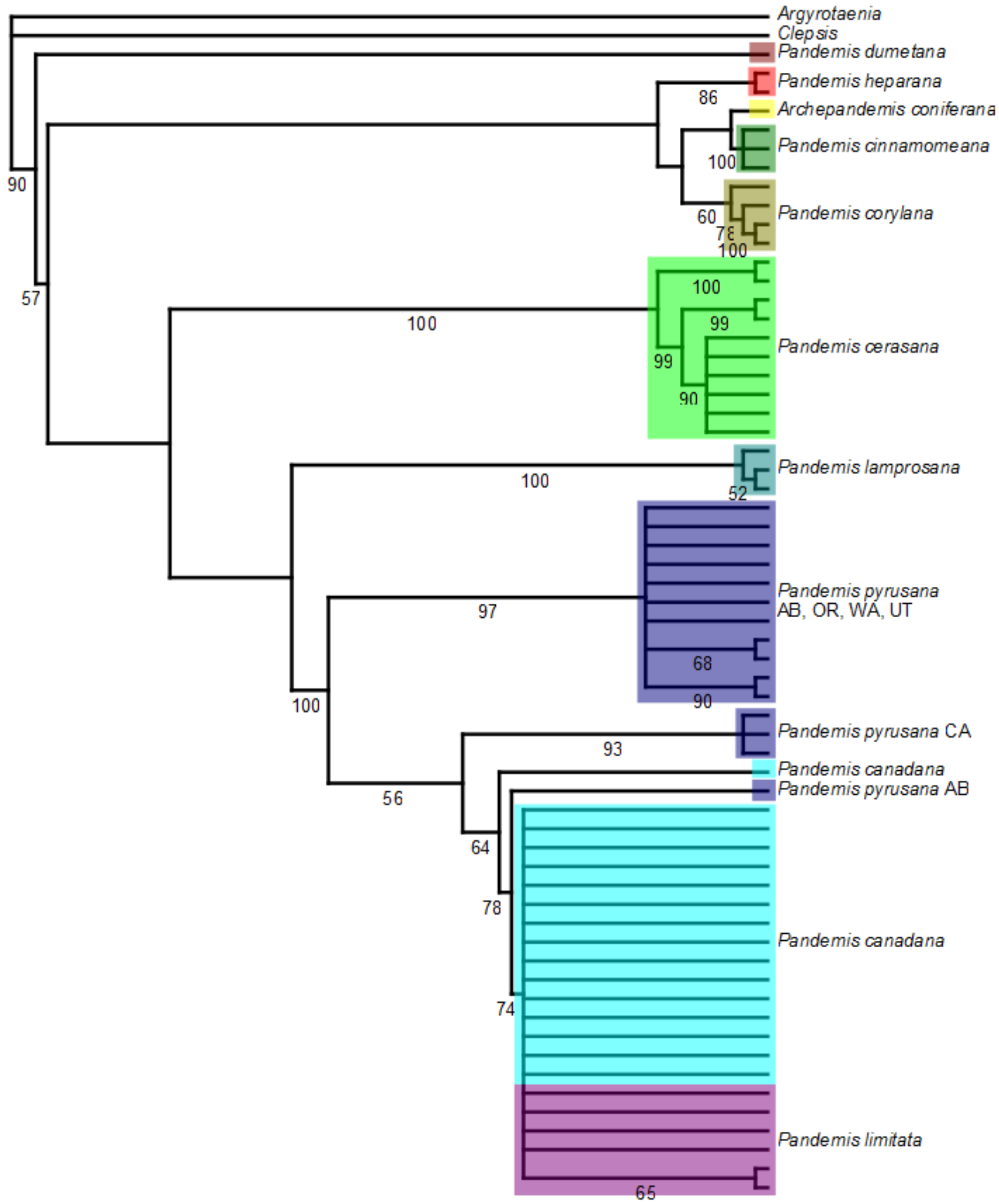
	polygon	$\bar{x}$	σ
P. canadana	Base	152.988	16.682
	Apex	159.925	20.111
	Median	84.506	10.617
	Subbasal	110.685	12.708
P. limitata	Base	161.580	16.254
	Apex	185.729	16.717
	Median	105.104	22.132
	Subbasal	135.931	15.513
P. pyrusana	Base	209.159	9.850
	Apex	200.374	9.738
	Median	113.450	14.606
	Subbasal	135.254	14.971

Table 3-4: Utility of individual characters for separating pairs of species in the *P. limitata* group.

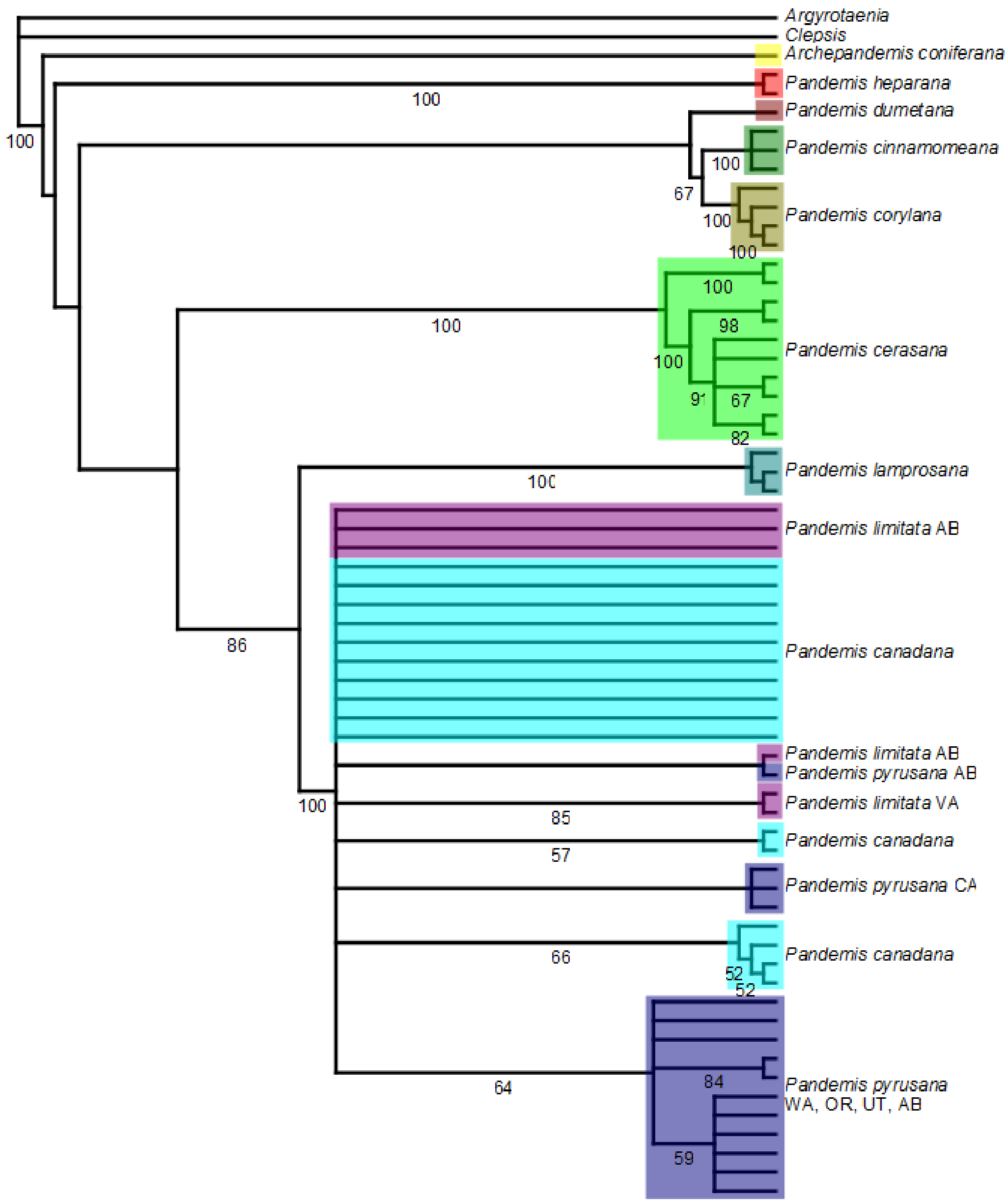
	greyness				geography	molecular		
Taxa Separated	HW base	HW apex	FW median	FW subbasal		COI	ITS	comb.
P. canadana & *P. limitata*	sometimes	sometimes	sometimes	sometimes	sometimes	no	yes	usually
P. canadana & *P. pyrusana*	yes	usually	usually	sometimes	usually	usually	yes	usually
P. limitata & *P. pyrusana*	yes	sometimes	sometimes	sometimes	usually	yes	usually	usually



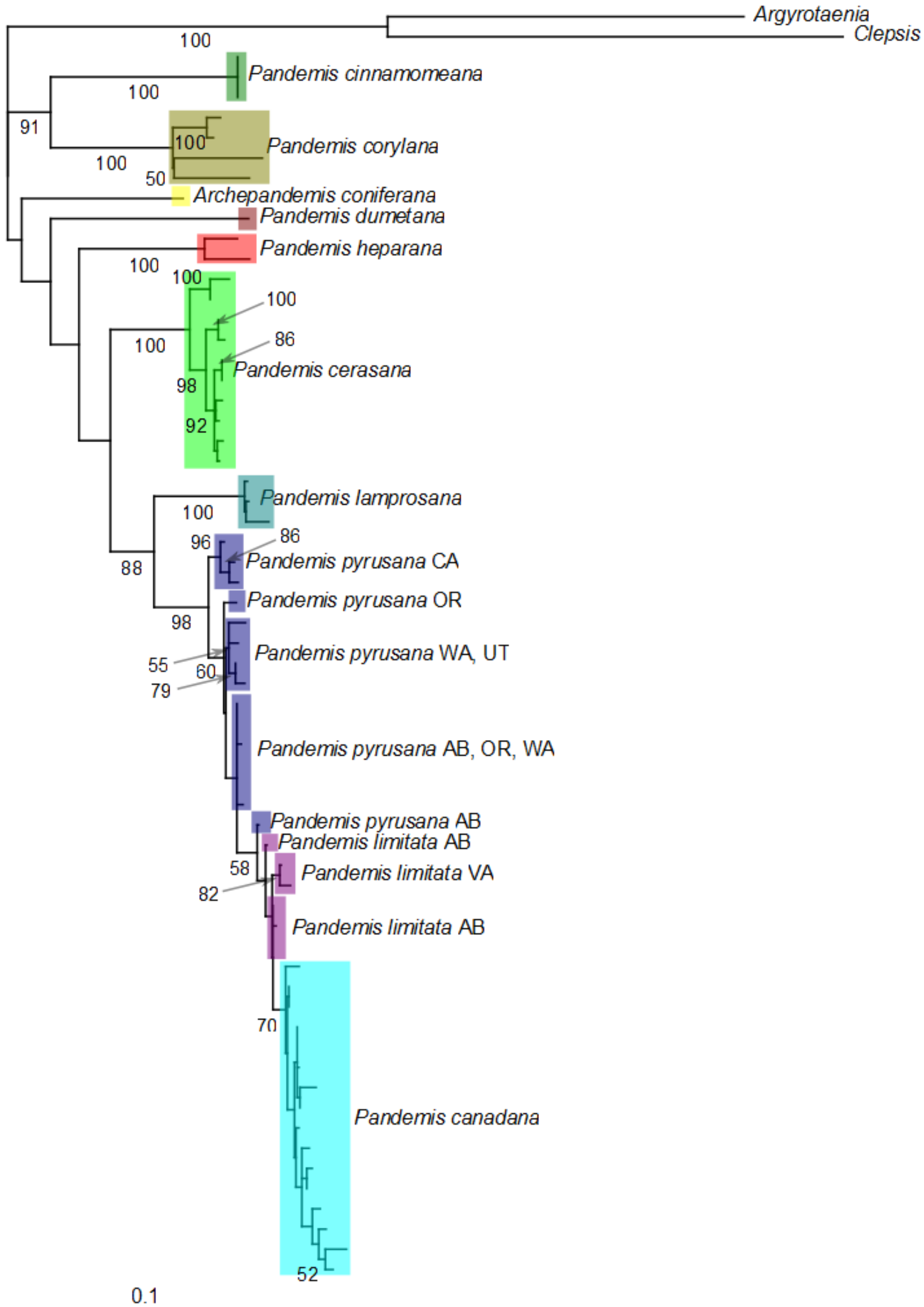
Appendix 3-1: Bayesian analysis of ITS2 with posterior probabilities.



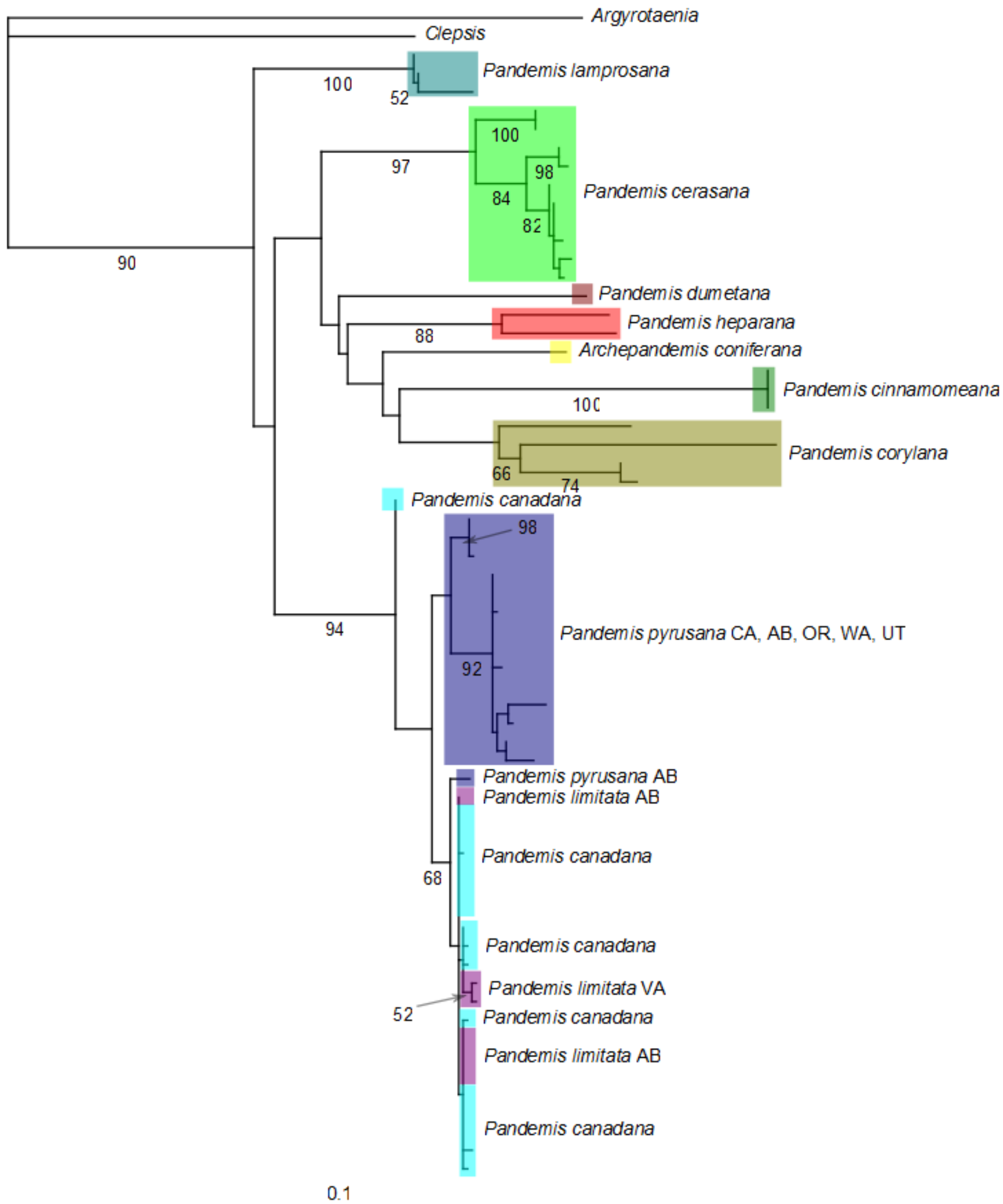
Appendix 3-2: Consensus tree of maximum parsimony analysis of COI with bootstrap values.



Appendix 3-3: Consensus tree of maximum parsimony analysis of combined COI and ITS2 with bootstrap values.



Appendix 3-4: Maximum likelihood analysis of combined COI and ITS2 with bootstrap values.



Appendix 3-5: Maximum likelihood analysis of COI with bootstrap values.

Appendix 3-6: Raw histogram values of greyness for *Pandemis* spp.

species	spec. no.	base	apex	median	subbasal
Pandemis canadana	JD1386	148.855	187.605	84.333	110.201
Pandemis canadana	JD1387	140.355	156.215	80.133	104.285
Pandemis canadana	JD1389	140.953	152.394	77.218	95.635
Pandemis canadana	JD1391	156.039	155.74	85.679	104.248
Pandemis canadana	JD1392	160.701	193.796	82.284	108.353
Pandemis canadana	JD1393	139.639	133.731	76.381	99.123
Pandemis canadana	JD1394	134.291	132.763	70.569	102.494
Pandemis canadana	JD1395	146.814	159.419	101.005	123.809
Pandemis canadana	JD1396	141.833	153.436	103.642	118.487
Pandemis canadana	JD1397	156.304	150.687	84.244	127.079
Pandemis canadana	JD2016	135.22	140.095	69.284	102.059
Pandemis canadana	JD3511	186.106	191.507	95.569	127.921
Pandemis canadana	JD4914	144.158	142.332	84.967	109.906
Pandemis canadana	JD5067	189.435	185.387	98.787	136.908
Pandemis canadana	JD5195	168.047	170.728	85.881	108.184
Pandemis canadana	JD5248	159.064	152.96	72.125	92.27
Pandemis limitata	JD0384	145.338	191.417	116.878	155.182
Pandemis limitata	JD0431	152.071	168.861	120.99	149.719
Pandemis limitata	JD1098	148.567	162.888	97.051	124.946
Pandemis limitata	JD1099	168.109	196.763	93.15	125.53
Pandemis limitata	JD1100	166.852	195.129	105.915	141.838
Pandemis limitata	JD3510	188.544	199.318	96.641	118.372
Pandemis pyrusana	JD1533	190.056	196.775	93.77	114.048
Pandemis pyrusana	JD1539	209.554	198.82	123.808	139.517
Pandemis pyrusana	JD2833	218.518	212.276	115.488	144.196
Pandemis pyrusana	JD2839	213.294	208.835	131.698	163.568
Pandemis pyrusana	JD3168	206.42	194.552	126.304	148.078
Pandemis pyrusana	JD3205	217.559	198.71	106.346	119.777
Pandemis pyrusana	JD3206	217.879	195.784	117.137	130.508
Pandemis pyrusana	JD3207	206.658	212.779	124.97	130.678
Pandemis pyrusana	JD3265	198.761	193.407	98.096	122.946
Pandemis pyrusana	JD3281	203.001	189.156	94.891	112.924
Pandemis pyrusana	JD3319	228.844	215.937	137.883	151.765
Pandemis pyrusana	JD3576	199.331	181.518	118.469	137.341
Pandemis pyrusana	JD3581	209.926	202.167	99.276	130.161
Pandemis pyrusana	JD3584	208.427	204.517	100.163	148.05

Chapter 4

Evolutionary and ecological correlates of novel secondary sexual structures in archipine tortricid moths.

Introduction

Coexistence among closely related and ecologically similar species requires mechanisms that reduce gene flow and maintain species boundaries. Secondary sexual characters (SSCs) are specific pre-mating stimuli that are not directly involved in copulation (Savalli 2001). In most animals they are most obviously developed in males (Savalli 2001). These characters can serve as a prezygotic barrier, allowing closely related and ecologically equivalent species to live in sympatry while maintaining their genomic integrity (Lande 1981). Such divergence of SSCs has been proposed as an important mechanism in speciation (Panhuis, *et al.* 2001; Phelan & Baker 1987; Carson & Bryant 1979). However SSCs can be energetically expensive (Møller & de Lope 1994), and it is reasonable to assume that they will tend to be lost when they are not needed as a pre-zygotic barrier between related species. If true, the loss of SSCs could be associated with at least three different scenarios: 1) reduced ecological overlap among sympatric species due to physical separation, (e.g. via a host plant shift or narrowing of host range as proposed by Phelan & Baker (1987)); 2) intraspecific SSC redundancy due to the evolution of novel structures that are either less expensive to develop or more efficient as a prezygotic boundary; or 3) expansion into a habitat unoccupied by other related species.

The tribe Archipini (Lepidoptera: Tortricidae) contains numerous major agricultural and forest pests and is an ideal group to examine these processes, since it contains a mix of oligophagous and polyphagous species, a high frequency of gains and losses of SSCs among its members, and a seemingly recent radiation into the New World, which is associated with relatively low generic diversity on these continents.

Like ornamentation in male mammals and elaborate courtship displays in birds, SSCs in archipine moths usually function in contest competition or as signals (Savalli 2001). Chemical communication by males using close range pheromones are the most widespread signals in Lepidoptera and many structural modifications are known to be associated with the dissemination of these pheromones (Scoble 1992, Hallberg & Poppy 2003). In Tortricidae, the most widespread of these structures is the costal fold (CF) (Figs. 4-1, 4-2), which is located near the base of the male dorsal forewing and conceals modified scent-disseminating scales (Brown & Miller 1983). In the few tortricid species that have been studied, there are one or two dense tufts of long scales, termed hair pencils, tucked underneath the fold and lying against an adjacent glanduliferous area of the wing. Microstructural features of these scales allow them to wick the gland product and subsequently disseminate it when the hair pencils are everted from the fold (Grant 1978). Structural variation within the CF can be found even within a genus. *Archips argyrospila* (Walker) and *A. mortuana* Kearfott have a CF that curls in on itself, while *A. rosana* (Linnaeus) has one set of hair pencils that originates adjacent to glandular tissue (Grant 1978). An even more impressive modification can be found in *Cryptoptila australana* (Lewin) in which the fold conceals a broad expansion from the subcostal vein that forms a double pocket (Horak 1984). The overall size of the CF varies widely within the Archipini, ranging from broad structures in *Adoxophyes negundana* (McDunnough), to slender folds in *Archips rileyana* (Grote), and vestigial non-functional remnants as in *Choristoneura rosaceana* (Harris) (Grant 1978) (Fig. 4-3).

Other potential gland-related SSCs are common among tortricids, although they tend to be more restricted in taxonomic breadth. These structures can be found in a variety of locations but most often occur on the antennae, thorax, hindlegs, forewing or hindwing surface, or various places on the pre-genitalic abdomen. The male genitalia themselves often have bizarre ornamentation or elaborate scaling that suggests a pheromone dispensing role. Such structures are much more difficult to examine; however, as most species have at least some scales or setae present on the genitalia and normal genitalic preparations typically inadvertedly remove most deciduous scales (JJD *pers. obs.*).

Understanding the functioning of pre-mating stimuli in pest species is useful for their efficient population control (Curkovic, *et al.* 2006). Although the exact function of SSCs in tortricids is poorly known due to limited histological study of only a few species of *Archips* (Grant 1978) and one of *Episimus* (Barth 1957), I can extrapolate their function from better studied and structurally similar SSCs in other moths where these structures deliver an indirect or direct mating stimulus through pheromone dissemination (Hallberg & Poppy 2003). For example, in *Epiphyas postvittana* (Walker), the male directs the costal folds towards the female's antennae as he rapidly fans his wings (Bartell 1977). Hair pencils likely serve a similar role in species such as *Grapholita molesta* (Busck), where the male produces the hair pencils as a pre-mating stimulus (Cardé, *et al.* 1975). It is also likely that the pheromones have varying functions, like enticing the female not to take flight or stimulating female abdominal extension (Scoble 1992).

The tribe Archipini includes many economically important species such as *Adoxophyes honmai* (Yasuda), *Ad. orana* (Fischer von Röslerstamm), *Archips argyrospila*, *Argyrotaenia franciscana* (Walsingham), *Choristoneura fumiferana* (Clemens) group, *C. rosaceana*, *Epichoristodes acerbella* (Walker), *Epiphyas postvittana*, *Homona coffearia* (Nietner), *H. magnanima* Diakonoff, and *Planotortrix* spp. (Timm, *et al.* 2010; Lee, *et al.* 2005; Liu & Li 2002; Razowski 2002a; Freeman 1958). The tribe is found worldwide, although it has relatively less diversity in the Neotropics (Horak 1999). There are 187 genera and 1709 species currently recognized (Baixeras, *et al.* 2010), although this number is undoubtedly low since many undescribed species are known in collections and there has been limited collecting in large parts of the tropics (Razowski 2004). In Canada and the United States, there are 18 genera and 123 species (Pohl 2006).

The tribe Archipini was initially described by Pierce & Metcalfe (1922) based only on the presence of an elongate signum with a bulbous capitulum in the female genitalia (Fig. 4-4). However, several of the taxa placed in the tribe by Pierce and Metcalfe (1922) lacked even this character and their description was based on the British fauna. Common (1956) subsequently had difficulty applying their arrangement to Australian species, which led him to broaden the group to include several more taxa lacking the signum and/or capitulum. Horak (1984, 1999) postulated that this concept of Archipini was polyphyletic and divided the tribe into three groups typified by *Archips, Clepsis,* and *Planotortrix*. Razowski (1987) briefly expanded the tribe to include the tribe Euliini but then removed it again, as well as placing the taxa that have a sclerotized costa of the valve of the male genitalia (Fig. 4-5) in the new tribe Ramapesiini (Razowski 1993). Jinbo (2000) has done the only phylogenetic analysis of the Archipini to date, based on morphology of the Japanese species, and found the Ramapesiini to be paraphyletic to a monophyletic Archipini *s. s.* In the present study I use Brown's (2005) concept of Archipini which includes the Ramapesiini. *"Dichelia" clarana* (Meyrick) is in quotation marks because it does not belong there and is placed in "new genus 1" as in Brown (2005). I also use *Choristoneura freemani* Razowski as a replacement name for the Nearctic species *Ch. occidentalis* Freeman, for the reasons given by Razowski (2008).

The aim of this study is to determine whether divergences of novel SSCs in Archipini are associated with other biological characteristics that implicate evolutionary tradeoffs. I examined specimens and literature sources for: 1) the presence of structures likely to function as SSCs, like the costal fold; 2) ecological overlap with other species, as indicated by similarity in larval host and geographic range; or 3) expansion and diversification into new geographic regions lacking their congeners. A phylogenetic framework was used to examine the relationships between novel SSCs and the CF, SSCs and host plant breadth, and SSCs and zoogeography. The phylogeny from Jinbo (2000) is not appropriate for this purpose since it examines only twenty genera and, due to relatively few parsimony informative characters, his bootstrap values are low. In this study I analyse 134 species in 33 genera representing all major zoogeographic regions except the Neotropics, using a phylogeny derived from up to 1542 bp of the mitochondrial COI gene and up to 902 bp of a nuclear gene, 28S. My sampling includes 67% of species and all genera known from the Nearctic except for *Durangarchips*. I then use my Archipini phylogeny to test whether: a) the presence of SSCs is linked to polyphagy (an indicator of greater opportunity for overlap of female calling locations (Young 1997)); b) existing SSCs are lost when novel SSCs evolve (as expected if there is redundancy between them); and c) SSCs are more likely to be lost after new areas like the Nearctic are colonized.

Materials and Methods

DNA was sequenced from 91 species including four outgroups, collection records are listed in Table 4-1. Ceracini, Cnephasiini, Sparganothini, and Tortricini were used as outgroup taxa, and *Epitymbia alaudana* Meyrick was treated as an ingroup. My sampling was guided by results from Zwick, *et al.* (unpublished presentation at 2007 Lepidopterists' Society Annual Meeting, MS, USA) who showed the first three tribes as close sister taxa and the Epitymbiini as subordinate within the Archipini. All sequences will be available on GenBank, while specimen vouchers are to be deposited in the Canadian National Collection and extracted DNA is stored in the Sperling Lab at the University of Alberta. Published COI sequences were also obtained from GenBank for 44 species and several unpublished sequences were generously shared by L. Lumley, A. Zwick, M. Horak, M. San Jose, and D. Rubinoff (Table 4-2).

For most specimens I removed two legs soon after the moths were killed and stored the legs in 95% ethanol at -20°C. For a few specimens legs were removed later, either from specimens collected directly into ethanol or live frozen. DNA was extracted using QIAamp Mini Kits (Qiagen, Canada) and eluted in three steps into a 150 µl volume. The whole COI gene was sequenced due to its ease of amplification, phylogenetic utility, and widespread use across Lepidoptera (Caterino, *et al.* 2000; Silva-Brandão, *et al.* 2005), allowing many published sequences to be used in this study (see refs. in Table 4-2). Attempts to also amplify EF-1α and CAD met with consistent difficulties in obtaining clean sequences. Consequently the D2 and D3 expansion regions of 28S were used instead, because of the greater ease of amplification of this gene region and its documented potential to show a stronger phylogenetic signal than COI for phylogenetically deeper nodes (Mardulyn & Whitfield 1999). PCR reactions for COI followed Lumley & Sperling (2010), except that 4 µl of DNA template were used. PCR reactions for 28S were similar but used 3 µl of $MgCl_2$ and cycle sequencing followed that of Wiegmann, *et al.* (2000). Primers used in my study are listed in Table 4-3. PCR purification was performed either with a QIAquick PCR purification kit (Qiagen) or ExoSAP-IT (USB Corporation, Cleveland, OH), and sequencing was done with BigDye Terminator version 3.1 cycle sequencing (Applied Biosystems, Foster City, CA). Sequences were purified using ethanol precipitation and sequencing reactions were run on an ABI Prism 3730 DNA analyser of the Molecular Biology Facility at the University of Alberta Department of Biological Sciences.

Chromatograms were examined with SeqMan Pro version 7.2.0 (DNASTAR) and since indels were minimal, sequences were easily aligned by eye in Mesquite version 2.73 (Maddison & Maddison 2010). Because each different phylogenetic algorithm has its own strengths and weaknesses (Avise 2004), I used multiple analyses employing maximum parsimony, maximum likelihood, and Bayesian methods. PAUP* 4.0 (Swofford 2003) was employed for maximum parsimony analyses using default settings. Likelihood analyses were carried out using Garli

(Zwickl 2006) with default settings and the GTR + I + G model of evolution as determined by Modeltest (Posada & Crandall 1998). MrBayes v3.1.2 (Ronquist & Huelsenbeck 2003) was used for Bayesian analyses, with default settings as determined by MrModeltest (Nylander 2004). Two sets of 14 million generations were sampled at a frequency of 1000, except for the 28S analyses which ran for 10 million generations. Indels were treated as 5th characters in PAUP*, and as missing data in Garli and Mr. Bayes. All three analyses were conducted for COI, 28S, and combined COI + 28S datasets. The resulting trees were summarized into one tree for further analyses based on support and concordance between trees, with morphology used as an additional ad hoc source of information to resolve poorly supported nodes.

The majority of non-molecular characters (Table 4-4) were recorded as binary variables to facilitate analyses. Zoogeography was determined by examining native ranges for individual species from literature (Appendix 4-1). Based on the previous hypothesis of Horak (1999), these data were divided into three unordered categories (0=New World, 1=Old World, and 2=Australasian) to examine the overall zoogeographic trends. To determine the correlation between radiation into new regions and SSCs, the data were further broken down into binary data of New World and Old World to facilitate analyses. The radiation from Australasia to the rest of the Old World was not examined due to poor generic coverage (19% of Australasian genera) compared to the Nearctic coverage (93% of genera).

Host plant breadth was determined from the tortricid host plant database of Brown, *et al.* (2008), and supplemented by Prentice (1965) and Dugdale (1990). Species were judged to be monophagous or oligophagous (0) if they have been recorded from two or fewer plant families as primary hosts, or polyphagous (1) if they were regularly recorded from three or more plant families.

Presence (1) or absence (0) of the costal fold and other SSCs was determined by examining between one and five male specimens and at least one female from the personal collection of JJD or the published literature (Brown, *et al.* 2003; Diakonoff 1941a; Dugdale 1990; Franclemont 1986; Green & Dugdale 1982; Hulcr, *et al.* 2007; Jinbo 2000; Lee, *et al.* 2005; Mutuura 1978; Newcomb & Gleeson 1998; Obraztsov 1961; Powell 1962; 1964; Razowski 1977; 1978; 1981; 1987; 2002a) (Table 4-4). All SSCs were considered to be novel structures except for the CF, which may be pleisiomorphic for the Tortricidae (Horak 1984). Specimens were placed on a microscope stage and examined under a Wild Heerbrugg dissecting microscope under 25X and 50X power to look for external SSCs. For abdominal characters, the abdomen was removed and dissections were carried out as in Brown & Powell (1992) with diluted chlorazol black as a dye. The entire pelt and genital capsule were then examined in glycerol under the same dissecting microscope using 50X power.

Whole specimens were photographed inside an Aristo DA-10 light box with a Canon G11 digital camera with an external Canon Speedlite 270EX attached by TTL cable. External characters were photographed with a Nikon Coolpix 8400 camera mounted onto an Olympus SZX16 dissecting microscope with illumination from an Olympus LG-PS2 light source. Images were stacked and assembled in CombineZP (Hadley 2010). Genitalic and abdominal characters were photographed using the previous system in a single shot and the specimens were mounted in glycerol on a slide under a coverslip.

The character correlation of 1) the costal fold versus combined novel SSCs (where presence of any novel SSCs is coded as present), 2) host breadth versus total SSCs, and 3) zoogeography versus SSCs, was tabulated comparing correlated changes within clades based on ancestral character state reconstructions. Ambiguous character state reconstructions were treated conservatively to have the least number of changes. Polytomious clades were treated as independent changes. For example, in comparing the loss of the CF versus the evolution of novel SSCs, clade 73 would support the null hypothesis that there is no correlation, while clade 76 would support the alternate hypothesis that novel SSCs evolve more frequently when the CF is lost as happens with the *Lozotaenia* lineage. Pagel's (1994) test of correlated discrete character evolution was not appropriate to use since the tree had several polytomies. Sample sizes were too small to run a χ^2 contingency analysis. To test for total correlation of the previous character pairs in terminal taxa, a two-by-two χ^2 test was conducted with the summary data. Zoogeographic origins were mapped onto the summary tree using ancestral character state reconstruction under a likelihood optimality criterion. Parsimony was the optimality criterion used for mapping the SSCs and host breadth characters.

Results

Maximum parsimony, maximum likelihood, and Bayesian methods were used on each of the three datasets (28S, COI, and combined 28S+COI), resulting in nine trees with similar tree topologies (Appendices 4-2–4-10). Sequence for 28S was unproblematical to align (alignment available on TreeBase) due to only 22 small indels. However, there were only 136 parsimony informative codons (667 invariant, 128 autapomorphic) and all three analyses that used only 28S sequence resulted in poorly resolved phylogenies. Nonetheless, there was higher bootstrap and posterior probability support for clades at the tribal level. COI had much more variation with 555 parsimony informative characters (867 invariable, 120 autapomorphic). Most of the codon changes were synonymous substitutions (471 versus 125 nonsynonymous substitutions), and the resulting trees had much more resolution and higher support values than 28S. Likelihood, on the other hand, produced several long branches in the middle of the tree that were usually found as more basal in the other analyses and unsupported by morphology. With the exception of these long branches, the supported clade topology is consistent with the trees from maximum parsimony and Bayesian analyses. Combining 28S and COI data resulted in a Bayesian tree with good support values in clades higher in the tree but a large polytomy at the base of Archipini. Maximum parsimony and likelihood analysis of the same data produced weak support and also placed some of the basal archipines as terminal taxa and the combined parsimony had almost no support for deeper nodes. Overall the COI and combined 28S+COI analyses agreed well with each other and generally did not differ from each other.

A final summary tree (the whole tree is summarized in partitions, Figs. 4-6–4-12) was assembled based upon all of the analyses. Support values are given for CO1 and combined CO1+28S analyses, but not for those from 28S sequence alone due to the poor resolution it provided at levels shallower than tribe. Where there were topological conflicts between trees, the clade that was best supported, as judged by the relative frequency of the clade among the six trees as well as its support values, was chosen for the summary tree. In a few cases where there was very little support, I relied on morphological characters to resolve any conflicts. Justifications for, and explanation of, the resolution for most nodes is explored in the discussion. In the final summary tree Archipini inclusive of Epitymbiini were found to be monophyletic. The basal Archipini group is recovered as a sister to the remainder of the Archipini, referred to henceforth as the core Archipini. *Adoxophyes*, *Thrincophora*, and *Cryptoptila* are found to be sister groups of the remainder of the core Archipini which form a large polytomy. There is some support for a sister group relationship for the *Archips* and *Choristoneura* groups, while *Ptycholoma, Ptycholomoides,* and two *Homona* species form another group. Most genera are found to be monophyletic, with a few notable exceptions. Paraphyletic relationships included *Leucotenes* within *Planotortrix*, *Thrincophora* within *Adoxophyes*, *Archepandemis* within *Pandemis*, *Diedra* within *Argyrotaenia*, *Epiphyas* within *Clepsis*, and *Cudonigera* within *Choristoneura*. Both *Aphelia* and *Homona* were polyphyletic.

Six SSCs in addition to the CF were examined in males, both by direct observation in specimens and from published descriptions. The CF was scored as present if there was at least some noticeable folding on the basal half of the forewing of the male. This could usually be corroborated by the presence of a few elongate scales projecting from underneath it. The only exception to this was *C. rosaceana* which had a unique small triangular costal fold with a median scale tuft (Fig. 4-3) that has been described as degenerate and non-functional by Grant (1978) as it lacks glandular tissue and hair pencils. The CF is widespread across the Tortricidae and has traditionally been considered pleisiomorphic to the group (Horak 1984). It is lost at many taxonomic levels, most notably for all members of *Argyrotaenia* and multiple times within *Clepsis* (Fig. 4-13). The antennal notch (Fig. 4-14) was only present in *Epitymbia alaudana* (Horak & Common 1985) and in all *Pandemis* species except *P. dumetana* (Treitschke) (Razowski 1978). A possible degenerate antennal notch was found in *Archepandemis coniferana* Mutuura, but it was coded as absent since its presence was ambiguous. A series of long flowing thoracic scales (Fig. 4-15) was found in both *Syndemis* species examined and in *Dichelia histrionana* (Frölich) (J. W. Brown, *pers. comm.*), and Svensson (2006) mentions it as a unifying character in both *S. musculana* (Hübner) and *D. histrionana*. A distinct hair pencil between the pro- and mesocoxae (Fig. 4-16) was observed only in *Lozotaenia hesperia* Powell, as mentioned in the original description (Powell 1962). A distinct pouch in the hindwing was not directly observed, but is mentioned as being present in *E. alaudana* by Horak & Common (1985). Distinct broad dark scales set into pouches in the basal abdominal sternites (Fig. 4-17) were found in all examined *Pandemis* species (Razowski 1978), except for *P. lamprosana* (Robinson). All examined *Pandemis* species also had the pregenital sternite modified into distinct sclerotized structures with elaborate slender deciduous scales (Fig. 4-18) (called "coremata" by Freeman (1958) and Jinbo (2000).

Several characters were not used, due to variation and ambiguity. All core Archipini are reported to have the pregenital sternite modified with long setae or scales (Jinbo 2000). Upon examination it became clear that this character varied from being an almost obsolete bar with short setae, as in *Adoxophyes* and most *Argyrotaenia*, to a broad plate with longer setae in *Ar. mariana* (Fernald) (JJD *pers. obs.*), and extreme modification in *Pandemis* as mentioned above. Because of this ambiguity, and the rarity of mentions of this structure in the literature, I chose to code only the extreme modification as seen in *Pandemis* as a SSC. Razowski (1987) reported that there were abdominal scent organs in *Epiphyas* and some *Clepsis* species, but this was not easily observed using traditional dissection methods, so this character was excluded. Elongate setae are present on the valve of the male genitalia, and in some species of *Clepsis* they are modified to such extremes that they seem likely to be used as a mating stimulus, not just the primary mechanical act of mating. This is most obvious in *Clepsis consimilana* (Hübner) which has enlarged scales (Fig. 4-19). These scales are often deciduous, vary greatly in density, and are frequently lost in genitalic preparations (JJD *pers. obs.*). Because of the difficulty of consistent observation, the fact that genitalic drawings produced by some artists lack indications of setae (e.g. Freeman 1958), and that they are arguably primary sexual characters since they are on the genitalia, I have excluded them as a character. Finally the pecten on the CuP vein of the hindwing were noticeably longer and denser in *Choristoneura parallela* (Robinson) (Fig. 4-20) than in other examined archipines, although this character was excluded because it is usually found in both sexes, is difficult to characterize, and is rarely reported in the literature.

No strong association was noted between any of the three hypotheses tested when correlations of individual evolutionary events were compared (Table 4-5), though sample sizes were to small for statistical tests. χ^2 values of character correlation among terminal taxa returned a strong correlation between SSCs and host plant breadth ($p = 0.0045$) and SSCs and zoogeography ($p = 0.00039$), but no significant correlation was found between CF and novel SSCs ($p = 0.13$).

Ancestral character state reconstruction of zoogeographic distribution (Fig. 4-21) shows a strong likelihood for an Australasian origin of the Archipini, the basal Archipini group, *Adoxophyes*, and the core Archipini (Appendix 4-11). Strong likelihood values were also obtained for an Old World origin for the *Pandemis* group, the *Clepsis* group, *Cacoecimorpha*+*Choristoneura*+*Cudonigera*, and the

Archips group. The only major group likely to have originated in the New World is *Argyrotaenia*, although the origin of the *Choristoneura* group is ambiguously placed between the Old and New Worlds.

Discussion

Comparison of bootstrap and posterior probability support values was straightforward for most clades, since clades were often consistently well supported by most analyses. I generally considered a value of 95 or more as strong bootstrap support for maximum parsimony and maximum likelihood analyses, and a value of 70 or more as strong posterior probability with Bayesian analyses, as discussed in Alfaro, *et al.* (2003). Several of the deeper clades were more challenging to resolve since support was much weaker; consequently I often relied upon ad hoc consideration of morphology when molecular data were ambiguous or scarce. The large polytomy within the core Archipini made ancestral character state reconstructions more difficult, but this lack of resolution may reflect historically rapid radiation of these lineages.

Clade justifications

Only clades with weak support or additional morphological comments are presented.

Archipini summary tree (Fig. 4-6)

2 – The clade of Sparganothini plus Archipini is poorly supported, although it is in agreement with Powell's (1964) phylogenetic hypothesis.

3 – The monophyly of Archipini inclusive of Epitymbiini (represented by *Epitymbia alaudana*) is strongly supported by Bayesian analyses and not contradicted by other analyses of combined sequence data. Parsimony and likelihood analyses of COI do not support this clade, placing Ceracini near

Xenothictis and *Clepsis*, respectively, neither of which are supported morphologically (JJD *pers. obs.*).

4 – The core Archipini are weakly supported, potentially due to the variable positioning of basal Archipini. This group is morphologically well supported by obsolete costal sclerotization of the male genitalia (Horak 1999) (Figs. 4-18–4-19, 4-22–4-27), but see comments for clades 17 and 20 for *Cryptoptila* and *Epichoristodes*.

5 – Monophyly of *Adoxophyes* is weakly supported if *Thrincophora* is included. While *Thrincophora* has an obviously enlarged point on the sacculus that is lacking in *Adoxophyes* (Diakonoff 1939), the transtilla is obsolete in the middle and dentate at the base, which is similar to that in *Adoxophyes* (JJD *pers. obs.*). I do not suggest any generic changes pending a broader sampling of the large genus *Adoxophyes*.

7 – The very strong molecular support for this clade is supported by morphological similarity between these two species (Freeman 1958).

8 – This pair of *Adoxophyes* species is also well supported by both morphology and DNA (Lee, *et al.* 2005).

13 – The relationship between the *Choristoneura* and *Archips* groups is weakly supported, but both have overall similar male genitalia (Razowski 1987) (Fig. 4-22) and a typically very long ductus bursae and prominent cestum in the female genitalia (JJD *pers. obs.*) (Fig. 4-4).

15 – These two *Homona* species have good support as sister taxa, which agrees with Hulcr, *et al.* (2007). They are isolated from other *Homona* species within the genus *Archips*, which agrees with Razowski's (1987) concept of *Homona* as polyphyletic.

16 – These two genera have strong support as sister taxa, which is also well supported by morphology (Razowski 2002a).

Basal Archipini (Fig. 4-7)

17 – There is weak support for the basal Archipini group, potentially due to the uncertain placement of *Xenothictis* and *Cryptoptila*. These two genera, along with the other genera in this group, all have a partially sclerotized costa of the valve in the male genitalia (Fig. 4-5), although this may be pleisiomorphic (Horak & Brown 1991; Razowski 1987). *Xenothictis* fits well in this group based on male genitalia (Brown, *et al.* 2003), but together with *Acropolitis*, there is uncertainty over what their nearest relatives are. I chose to exclude *Cryptoptila* from the basal Archipini and placed it in the core Archipini near *Adoxophyes* and *Thrincophora*, based on similarity with the latter genus in their male genitalia, as noted by Common (1956) (see also comments on clade 5). Also included in this group are the Epitymbiini, represented in these analyses by *Epitymbia alaudana*. This agrees with the morphological similarity between Epitymbiini and Archipini (Common 1956). See clade 20 for comments on *Epichoristodes*.

20 – This clade is well supported by my analyses, although with a basal polytomy. *Epichoristodes* has usually been placed in the core group of Archipini based on the reduced costa of the valve (Razowski 2002a). Diakonoff (1960) suggested that *Epichoristodes* was similar to *Epichorista* (not examined in my analyses) which also has obsolete costal sclerotization (Diakonoff 1939); implicating it as belonging to the basal Archipini. This may be a convergent reduction as the overall valve shape is less plicate and Dugdale (1990) places it in the basal Archipini.

22 – The monophyly of *Ctenopseustis* is weakly supported but agrees with the molecular phylogeny of Newcomb & Gleeson (1998) and the morphological characters of Dugdale (1990).

26 – This poorly supported clade disagrees with Dugdale's (1990) suggestion that *Leucotenes* is closer to *Ctenopseustis* based upon overall appearance and phallus shape, which are often variable characters. *Leucotenes* appears closer to *Planotortrix* if consideration is given to both of these genera having cubital pecten on the hindwing, which is a rare character in the Archipini (Freeman 1958). The status of *Leucotenes* will remain unresolved until more DNA or morphological work is done to supplement the 472 bp of CO1 available in my analyses.

27 – This clade is variably supported, but agrees with parsimony analysis of this data by Newcomb and Gleeson (1998). See also clade 26.

29 – This clade is well supported by all analyses and agrees with the parsimony analysis of this data by Newcomb & Gleeson (1998).

30 – This clade is well supported by all analyses and agrees with the parsimony analysis of this data by Newcomb & Gleeson (1998).

***Pandemis* group (Fig. 4-8)**

33 – *Pandemis,* with a few exceptions, is well defined morphologically with a modified pregenital sternite (Fig. 4-18), basal ventral abdominal scale tufts (Fig. 4-17), and antennal notch (Fig. 4-14) (Chapter 3). *Archepandemis* is very similar in venation and genitalia to *Pandemis*, but lacks the defining SSCs present in most species (Mutuura 1978). This is likely due to a loss of these characters, a phenomenon that is frequent in certain *Pandemis* species (Fig. 4-13), and is supported by the presence of a subtle antennal notch present in *Archepandemis*. Maintaining *Archepandemis* as a valid taxon would require the erection of many genera with few synapomorphies from basal *Pandemis* species. Based on DNA sequence, similar morphology, presence of a partial antennal notch, and nomenclatural stability, I chose to synonymize *Archepandemis* with *Pandemis*.

34 – The position of *Pandemis corylana* (Fabricius) as sister to the remainder of the *Pandemis* group is well supported in these analyses (see also Fig. 4-6), although this conflicts with the analyses in Chapter 3 using COI and ITS2, which place it as a well supported sister clade to *P. cinnamomeana* (Treitschke). Arguments could be made for either clade since *P. corylana* has reduced basal abdominal scale tufts (Razowski 1987). Treating *P. corylana* as basal to the other *Pandemis* is supported if it is assumed to have a pleisiomorphic weak development of this SSC. Placing it as sister to *P. cinnamomeana* is supported if the SSC is assumed to be secondarily reduced. I chose the first scenario based on the stronger bootstrap values and posterior probabilities of that grouping.

35 – This clade is weakly supported but I chose it based partially on the basis of these species having a noticeably straighter sacculus relative to *P. corylana* and *P. cinnamomeana* (JJD *pers. obs.*).

36 – The phylogenetic position of *Archepandemis* within the *Pandemis* group is well supported, which agrees with the results from Chapter 3, although the topology differs.

37 – This clade and the clades within it are well supported by all analyses and are consistent with Chapter 2.

***Argyrotaenia* group (Fig. 4-9)**

41 – The monophyly of the *Argyrotaenia* group (Fig. 4-6) varies in support and has deep divisions between the two main clades. Based on genitalic similarity among these two clades, they are likely monophyletic (Freeman 1958).

42 – This clade is present in all analyses, though only with good support for the COI parsimony analysis and both Bayesian analyses. *Diedra* was described based on five very similar species with several distinct synapomorphies, including a relatively sclerotized valve and basal flange on the phallobase (Rubinoff & Powell 1999). These species were traditionally considered to be *Argyrotaenia* (Powell 1964), and their placement inside *Argyrotaenia*, as sister group to a southwest Nearctic clade, is supported by their similarly thickened sacculus (JJD *pers. obs.*). The simplest solution to dealing with the paraphyly of *Argyrotaenia* would be to synonymise *Diedra*; however, I am reluctant to do this since the support for maintaining clade 42 within *Argyrotaenia* is weak. Other solutions are to either broaden the definition of *Diedra* to include clade 43, or erect a new genus or subgenus for clade 43. Until further SW Nearctic species in this group are examined, I chose to maintain the nomenclatural *status quo*.

43 – This clade is fairly well supported. Alhough it has been stated that *Argyrotaenia* genitalia are invariant (Freeman 1944), these three species can be separated from the other main *Argyrotaenia* lineage by the much broader sacculus in the male genitalia (JJD *pers. obs.*).

44 – The close relationship of these two species is well supported by my molecular analyses and by genitalic morphology (Powell 1960; 1964).
45 – The position of this clade is weak with half of the anlyses placing clade 46 as sister to clade 42. They are positioned here based on the Bayesian analyses which consistently produced high posterior probabilities, and by a similar slender sacculus compared to clade 42.
47 – This clade is well supported by all analyses and agrees with parsimony analysis of CO1 sequence data in Landry, *et al.* (1999).
48 – This clade is strongly supported by these analyses and by similar herbivory of most species on Fagales (Brown, *et al.* 2008), despite *A. juglandana* (Fernald) being treated as an entirely separate group by MacKay (1962) based on larval morphology. However, the clades within it are weakly supported and contradict each other or lack resolution in some analyses.
51 – This clade is also well supported by some molecular analyses as well as by genitalia which are barely morphologically distinguishable from each other in the included species (JJD *pers. obs.*).
52 – *Argyrotaenia provana* (Kearfott) is recovered as basal to *A. coloradana* (Fernald) in both parsimony analyses, though with weak support, but is placed here as sister to the remaining *Argyrotaenia* on the basis of higher support from ML and Bayesian analyses.
54 – This strongly supported group is also supported by wing patterns that can be scarcely distinguishable between species, and nearly identical genitalia among the included species (JJD *pers. obs.*).
55 – This weakly supported clade was contradicted in both parsimony analyses, which placed *A. repertana* Freeman as basal to *A. ljungiana* (Thunberg), but with no support. The topology in Fig. 4-9 is supported, however, by both species being polyphagous on predominantly marsh-inhabiting shrubs (Brown, *et al.* 2008), and adults being found in boggy habitats for *A. repertana* (JD *pers. obs.*) and moors and mires for *A. ljungiana* (Svensson 2006).

***Clepsis* group (Fig. 4-10)**

61 – A potential reason for the weak support for the *Clepsis* group, and many clades within it, is the placement of basal Archipini, *Cacoecimorpha,* or *Lozotaeniodes* within this clade in some analyses. There are no good morphological characters supporting the first two inclusions (JJD *pers. obs.*), and these are unsupported by other analyses. The inclusion of *Lozotaeniodes* has some merit since it has the incomplete and dentate transtilla of the male genitalia (Fig. 4-23) typical of *Clepsis* (Fig. 4-19) (Razowski 1987). In three of the analyses the genus appears within *Clepsis*, though never in a stable position and with a long branch. In two analyses the species is placed as sister to some of the basal Archipini, which is unsupported by morphology. Because of this uncertainty, I have kept *Lozotaeniodes* outside of *Clepsis* as part of the large polytomy of the core Archipini (Fig. 4-6). *Clepsis* is considered to have no reliable synapomorphies (Razowski 1979a) as it is currently defined since many of the characters that are traditionally used are found in some form in a variety of other genera (JJD *pers. obs.*). However, Razowski (1979a; 1987) is confident of its monophyly. For comments on the inclusion of *Epiphyas*, see clade 68.

62 – This clade is recovered as a mix of the *C. rogana* (*C. clemensiana* & *C. moeschleriana* in my analyses) and *C. pallidana* (*C. consimilana*, *C. melaleucana*, *C. persicana*, *C. siciliana* & *C. spectrana* in my analyses) species groups (Razowski 1979a) with neither being monophyletic. The tree topology in Fig. 4-10 was selected due to the presence of this clade in both likelihood and Bayesian analyses using combined sequence data, and since no anomalous taxa are included within this clade.

67 – This clade unites two well supported groups, although with weak support values for similar reasons to those mentioned for clade 61. See clade 68 for a potential synapomorphy.

68 – *Clepsis fucana* (Walsingham) is strongly supported as sister to *Epiphyas,* which is also supported by the total replacement of *Clepsis* in Australia by *Epiphyas* and their male genitalic similarity (JJD *pers. obs.*). *Epiphyas* also has nearly identical glands in the male abdomen to those found in the *C. peritana* group (Razowski 1987). Since molecular results squarely place *Epiphyas* within *Clepsis*, and there are no reliable morphological characters to separate the genera (JJD *pers. obs.*), I propose that *Epiphyas* be synonymised with *Clepsis*.

69 – The genus *Epiphyas* is usually recovered as monophyletic with strong support values, which is also supported by genitalic characters and its zoogeographic restriction to Australia (Razowski 2002a).

71 – This clade is usually well supported and agrees with the *C. peritana* group (*sensu* Razowski 1979b). See also clade 72 comments.

72 – *Clepsis anderslaneyii* Dombroskie & Brown has moderate support as sister to *C. virescana* (Clemens 1865). This conflicts with Dombroskie & Brown (2009) where it was considered closest to *C. fucana* based on male genitalia. However, except for the much broader uncus, it can reasonably be placed in the *C. peritana* group based on the similar saccular bulge and prolonged valval apex (JD *pers. obs.*) (Chapter 2, Fig. 4-2).

73 – This clade is well supported by Bayesian analyses, although the position of *C. listerana* (Kearfott) is unclear. In the COI likelihood, and both Bayesian analyses it is recovered as monophyletic with *C. penetralis* Razowski, which would be reasonable if *C. listerana* has at least a partially coiled ductus bursae. This sequence was obtained through GenBank; however, I have examined this specimen so the identity is not in doubt. Unfortunately however, the genitalia of this rarely encountered species are undescribed and the only mention of its morphology in the literature is from the original description by Kearfott (1907).

74 – This clade is supported in half of the analyses, but the topology shown here agrees with the overall similarity in the genitalia and wing pattern of these two species (JJD *pers. obs.*). See also comments on clade 73.

***Choristoneura* group (Fig. 4-11)**

75 – The *Choristoneura* group has weak support, perhaps due to the uncertain placement of *Archips purpurana*. I chose to put it basally in the *Choristoneura* group rather than the *Archips* group because the support for this topology was overall slightly higher. *Archips purpurana* is problematic, and despite placing it within the *A. xylosteana* group Razowski (1977) commented on its anomalous placement. Its valve shape is unique within *Archips*, with the saccular margin not prominently bulging below the sacculus, a much shorter uncus, and overall appearance (Figs. 4-27, 4-28) and lack of dorsal abdominal pits (JJD *pers. obs.*). Therefore it likely does not belong in *Archips*.

76 – This clade has weak support, though these genera are considered to be closely related (Razowski 1987).

77 – While this group has weak support in my analyses, its members have enough genitalic similarities that their placement together by Razowski (1987) is reasonable. There is also strong support to elevate two of the subgenera in *Aphelia* (*Aphelia s. s.* clade 78, and *Zelotherses* clade 81) to genera to maintain generic monophyly according to these analyses. Synapomorphies for clades 78 and 83 are discussed below. *Aphelia (Zelotherses)* and *Lozotaenia* do not have known synapomorphies (Razowski 1987). Obraztsov (1954) originally treated *Aphelia* as having three subgenera (*Aphelia s. s.*, *Djakonovia*, and *Zelotherses*), and he (1959) later elevated his three subgenera to the genus level. Razowski (1981) later synonymised *Djakonovia* under *Zelotherses* and described two other subgenera, *Anaphelia* and *Sacaphelia*. Razowski (1981; 2002a) argued for maintenance of all four taxa as subgenera until all archipine genera are revised. Despite the lack of synapomorphies for *Zelotherses* (Fig. 4-24), the other remaining subgenera have distinct characters in the male genitalia that separate them and are good candidates for synapomorphies. I were unable to examine specimens of *Anaphelia* or *Sacaphelia* due to their restricted east Palaearctic distribution; however, the genitalia figures and descriptions in Razowski (1981) are of excellent quality. *Anaphelia* has paired dentate processes in the center of the transtilla, *Aphelia s. s.* has dentate lateral processes on the transtilla (Fig. 4-25), and *Sacaphelia* has large dentate processes at the base of the valve, fused with the dentate transtilla. For a thorough discussion of these characters, see Razowski (1981). The dentate processes on the transtilla or valve are a potentially unifying character for *Anaphelia*, *Aphelia s. s.*, *Lozotaenia*, *Sacaphelia*, and *Xenotemna*. For this reason and the non-monophyly of *Aphelia* according to my analyses, I propose that *Anaphelia*, *Sacaphelia*, and *Zelotherses* be raised to generic status separate from *Aphelia s. s*. See also Clade 81.

78 – This clade is variably supported. Likelihood and Bayesian analyses of COI conflict with this topology and place *A. purpurana* (Clemens) and *A. alleniana* (Fernald) in a weakly supported monophyletic group, with *X. pallorana* (Robinson) basal to them. Both species have traditionally been included in the genus *Aphelia* because they have a dentate gnathos that is probably an synapomorphy for *Aphelia s. s.* (Razowski 1987), and the larvae are similar (MacKay 1962). Curiously, MacKay also finds the larvae similar to *Clepsis*, and this may have influenced *X. pallorana* being placed in that genus in Chapman & Lienk (1971). While *X. pallorana* has distinct male and female genitalia, no justification has been published for the erection of the genus *Xenotemna*. The name was first published in Powell (1964) who variably treated it as *"Tortrix"* and *Xenotemna*. Because of the very large, dentate gnathos and dentate spines in the center of the valve in the male genitalia (Fig. 4-26), and the pointed eighth tergite and broad dentate signum in the female, I choose to maintain *X. pallorana* in its monotypic genus. See also comments on *Aphelia* under clade 77.

81 – This well supported clade agrees with the subgenus *Zelotherses* of *Aphelia* (Razowski 1981; 1987). Its phylogenetic placement is also supported by the unmodified transtilla of *Zelotherses* which is more similar to *Dichelia* and *Syndemis* than to other *Aphelia* subgenera (JJD *pers. obs.*). See comments for clade 77.

82 – This clade is well supported in my analyses and supported by the close similarity of the two species (Razowski 1981).

83 – This clade is strongly supported and is united by the male having a pair of long tufts of modified scales anteriorly on the thorax (Fig. 4-15). The genera are also similar enough that Svensson (2006) lumps them both into *Syndemis*. Until more species of both *Dichelia* and *Syndemis* are examined, I choose to maintain them as separate genera for nomenclatural stability.

84 – These two *Syndemis* species are morphologically virtually inseparable (Freeman 1958) and have excellent support in my analyses.

85 – This clade is well supported by both Bayesian analyses, and even though *Cacoecimorpha* has such divergent genitalia that it is difficult to compare to typical *Choristoneura*, there are genitalic similarities in valve shape to the enigmatic *Ch. lafauryana* (Ragonot) (JJD *pers. obs.*). *Choristoneura lafauryana* was unfortunately not obtained for my molecular analyses.

86 – The monophyly of *Choristoneura* inclusive of *Cudonigera* has weak but fairly consistent support. However, in two of the trees, *C. albaniana* (Walker) is found as sister to *Cacoecimorpha* with weak support. My retention of *C. albaniana* within *Choristoneura* is supported by its lack of synapomorphies for *Cacoecimorpha* (Razowski 1987), and the dorsal raised area on the uncus in the male genitalia that place it in *Choristoneura* (Dang 1992a; Razowski 1987). See also note for clade 92.

88 – Both parsimony and Bayesian analyses of COI placed *C. murinana* (Hübner) as basal to the remainder of clade 87, but with weak support.

89 – This clade is well supported and agrees with the male genitalic similarity of these two species (Razowski 2002a).

91 – This well supported clade is also unified by the broad uncus in the male genitalia (*pers. obs.*).

92 – This clade has support from four of the analyses, although both likelihood and Bayesian analyses of CO1 place *C. argentifasciata* Heppner as basal to the remainder of clade 91. While the host plant of *C. argentifasciata* is unknown, it is strongly suspected to be *Taxodium distichum* (Heppner 1989). This would link both taxa as specialized Cupressaceae feeders and support this tree topology. While the characters that define the monotypic genus *Cudonigera* are convincing, this taxonomic treatment would render the genus *Choristoneura* polyphyletic according to my analyses. Powell & Obraztsov (1977) state that *C. houstonana* is derived from *Choristoneura*, but they suspected that it would fit closely with MacKay's (1962) *Choristoneura* group 2 (clade 95 in my analyses), while my analyses place it confidently in group 3 (clade 91 in my analyses). *Cudonigera* is strongly supported as being within *Choristoneura* in clades 87, 90, and 91 and, rather than divide *Choristoneura* into several genera, I synonymise *Cudonigera* with *Choristoneura*.

93 – This well supported clade agrees with the overall similarity of these species as adults and larvae, corresponding to *Choristoneura* group 3 (MacKay 1962).

95 – It is not surprising that the conifer-feeding *Choristoneura* group (group 2 of MacKay 1962) is well supported since the included species are often very difficult to distinguish. These species often share haplotypes across species (Lumley & Sperling 2010) and my analyses only used a single representative of each species, so the specific tree topology should be taken as a generalization only.

Archips group (Fig. 4-12)

100 – The *Archips* group is well supported only by Bayesian analysis of COI, although most analyses also support it weakly (Fig. 4-6). The exclusion of *A. purpurana* from this group is consistent with the molecular analyses of Kruse & Sperling (2002) which had similar taxon coverage. See also clade 75.

101 – This clade is weakly supported, and in those analyses that disagree, the four *Homona* species in this clade are placed as basal to the core Archipini, usually with weak support. Though these *Homona* lack the costal fold typical of *Archips*, they are genitalically similar in both males and females, including the long ductus bursae with prominent cestum common to both *Archips* and *Choristoneura* groups (JJD *pers. obs.*). *Homona salaconis* (Meyrick) has previously been placed in *Archips* by Diakonoff (1967). Razowski (2004) commented on the similarities between *Choristoneura, Homona,* and other genera. Due to the weak support for the inclusion of these four *Homona* species within *Archips* and my sampling of only six of the 34 total described species, I maintain them in their existing genus. However, it is clear that that *Homona* is polyphyletic if *H. spargotis* and *H. trachyptera* are included in the genus (Fig. 4-6: clade 15). Examining sequence data from *H. coffearia,* the type species of *Homona* (as *H. fasciculana* Walker) may help resolve which taxa belong to this genus.

102 – This clade is strongly supported and consistent with the same data used in Hulcr, *et al.* (2007).

103 – While this clade has very weak support, it is consistent with the same weakly supported node in the NJ tree of Hulcr, *et al.* (2007).

104 – This clade is strongly supported by all analyses and is also supported both molecularly and morphologically by Miller, *et al.* (2010).

105 – This clade is present in most trees, and although usually weakly supported it is consistent with the phylogeny of Razowski (1977).

106 – The strong support for this clade agrees with the similar genitalia (Razowski 1977) and larval morphology of its members (MacKay 1962). This is also consistent with the concept of *Archippus* (Freeman 1958) and agrees with the molecular analysis of COI by Kruse & Sperling (2002).

108 – This strongly supported clade corresponds well with the concept of the *A. xylosteana* group (Razowski 1977). It disagrees slightly with the phylogeny of Kruse & Sperling (2002) due to their placement of the *A. packardiana* group as sister to the *A. cerasivorana* group, a placement that had weak bootstrap support in their analyses.

109 – While strongly supported in my analyses, this conflicts with the views of Razowski (1977) who, without clear justification, grouped *Archips rosana* as closer to the main Nearctic clade than to *A. xylosteana* (Linnaeus).

110 – The placement of clade 111 has some uncertainty. Where analyses disagree with this topology, clade 111 is either placed as sister to clade 109 or basal to 109 + 114. See also comments under clade 109 and 114.

111 – This well supported clade agrees with the adult morphology since the adults of all four species lack the dorsal abdominal pits typical of most *Archips* (Freeman 1958), the larval communal habits and morphology, which are distinct from other *Archips* (MacKay 1962).

113 – This clade is well supported, but conflicts with the phylogeny of Kruse & Sperling (2002), who place *A. infumatana* (Zeller) and *A. fervidana* (Clemens) as sister taxa. However, they used a smaller segment of COI (820 bp) was used in their analysis, and the clade had weak bootstrap support.

114 – This clade is well supported but conflicts with Razowski's (1977) view that *A. rosana* is closer to the main Nearctic clade, although he gives little justification for it. It is also inconsistent with a weakly supported portion of the tree of Kruse & Sperling (2002) (see comment for clade 109).

115 – This clade has weak support perhaps due to the uncertain position of *A. fuscocupreana* Walsingham, but was present in all analyses.

117 – Both parsimony analyses place *Archips grisea* (Robinson) and *A. magnoliana* (Fernald) in a monophyletic group, which is consistent with Kruse & Sperling (2002). The remainder of the analyses weakly support *A. grisea* as sister to *A. negundana* (Dyar) and *A. semiferanus* (Walker). I use the latter arrangement, due to the genitalic similarity of these three species (Razowski 1977).

118 – The relationship of these two closely related species is also supported by very similar genitalia (Freeman 1958).

119 – While this clade is supported by all analyses and agrees with the analysis of COI by Kruse & Sperling (2002), it conflicts with the suggestion by Razowski (1977) that *A. georgiana* (Walker) and *A. grisea* are closely related because of their very similar male genitalia.

120 – This clade and the more terminal clades are consistent with both mtDNA analyses by Kruse & Sperling (2001; 2002).

122 – These two species have overlapping morphological variation and COI sequences (Dombroskie & Sperling, *unpublished*) and *A. eleagnana* (McDunnough) may be a host plant race of the polymorphic species *A. argyrospila*.

Secondary sexual characters and correlations

The complexity and unknown utility of most of the SSC's examined here make it difficult to treat them as binary characters for phylogenetic analyses since I do not know if they are used as mating stimuli. While most of the broad costal folds seem undoubtedly functional, some of the smaller ones were questionable. Greater certainty of their functionality could be derived by conducting histological examinations, since some of the most slender costal folds are apparently fully functional with hairpencils and associated glands present (Grant

1978). There was often no clear distinction between regular elongate scales and distinctive SSCs. The modified pregenital sternite that is common to all core Archipini examined is a prime example. To more fully understand its function, the histology of this sternite needs to be examined across a range of its variation. However, it is clear that the relatively extreme modification of this pregenital sternite, which is found in most *Pandemis* species, qualifies as a SSC (Fig. 4-18). It is generally referred to as "coremata" (Freeman 1958; Jinbo 2000); however, I prefer to restrict this term to intersegmental inflatable tube-like organs as in Birch *et al.* (1990).

I hypothesized that the CF should be lost more frequently in clades that have evolved novel SSCs. Since there were only seven independent origins of novel SSCs, the sample size was too small to test for statistical significance (Table 4-5), but nonetheless is unsupported by χ^2 analysis of terminal taxon character correlation. This may be due to under-representation or unrepresentative sampling of the low number of novel SSCs used in my analyses. The correlation between the presence of the CF and SSCs may be stronger within certain clades like the *Pandemis* group, but is not evident in others like *Dichelia* and *Syndemis*.

I hypothesized that monophagous and oligophagous species should be more likely to lose SSCs. The χ^2 analysis shows a strong non-random distribution and a correlation between presence of SSCs and polyphagy. These results are similar to those of Phelan & Baker (1987), even though for the Tortricidae they restrict their definition of SSCs to only the CF.
I could potentially obtain a more accurate estimate of correlations through more refined determination of SSCs. For example, clade 93 in *Choristoneura* consists of three polyphagous species that are often found together: *C. rosaceana*, *C. parallela*, and *C. zapulata* (Robinson). This clade has strong support in both of my analyses and the species are morphologically similar as both adults (Freeman 1958) and larvae (MacKay 1962). Geographically they overlap broadly and the larvae are polyphagous. In my analyses I coded them as having no SSCs since

none appear to have a functional costal fold. Therefore these species contradict my hypothesis that closely related polyphagous species are more likely to have SSCs. However, in some of these species there is more than the normal amount of scaling on the valve of the genitalia and on the male hindwing, which is best exemplified by *C. parallela* (Fig. 4-20). Histological investigation is needed to determine whether these modified scales are associated with any glandular structures.

The diversity of archipine genera by zoogeographic region (Fig. 4-29) is as follows (with genera endemic to that region in brackets): Australasian 81 (63), Indomalayan 50 (23), Palaearctic 40 (20), Afrotropical 44 (31), Nearctic 14 (5), and Neotropical 15 (12) (Fig. 4-29) (Appendix 4-1). Two distinct patterns are visible: 1) a group of genera in common between the Australasian and Indomalayan regions that are a mix of the basal and core Archipini, and 2) genera in common with the rest of the regions that are in the core Archipini (Appendix 4-1). This fits well with the ancestral character state reconstruction for zoogeography (Fig. 4-21) and agrees with Horak (1999). An Australasian origin of the Archipini has the highest likelihood, which is borne out by the preponderance of the basal Archipini in this region and by that region harbouring more archipine genera than any other region. It is also likely that the core Archipini and *Adoxophyes* originated there as well. Because of the large polytomy in the core Archipini, it is difficult to say where most major lineages originated, although it appears that they radiated from the Palaearctic, except for the primarily New World *Argyrotaenia* group. It is difficult to determine where the Afrotropical region fits into this pattern since only one genus from this continent was used in my phylogeny (*Epichoristodes*), but the affinities of Afrotropical genera are primarily considered to be with genera within the core Archipini that are found broadly through the Palaearctic (Razowski 2002b; 2004; Razowski, *et al.* 2010). The genus *Argyrotaenia* is supported as having radiated in the Nearctic, though it is also very diverse in the Neotropical region. The remainder of the Nearctic genera have close affinities with the northern

Palaearctic, but are much less diverse (Razowski 1997). Most of the endemic Nearctic genera were phylogenetically close to existing Holarctic genera in my analyses (*Archepandemis* within *Pandemis*, *Cudonigera* within *Choristoneura*, *Diedra* with *Argyrotaenia*, and *Xenotemna* with *Aphelia s. s.*). The Neotropical region also has a few genera in common with most of the rest of the world, and most of the few endemic genera are probably very close to *Argyrotaenia* and *Clepsis* (Razowski & Becker 2000).

The correlation between a supposed recent radiation into the Nearctic and the loss of SSCs, has a significant χ^2 value. This agrees with the original hypothesis that SSCs should be lost more frequently when radiating into regions previously uninhabited by congeners, and the pattern is most obvious in the *Argyrotaenia* group and the main Nearctic radiation in *Choristoneura* (clade 90) (Fig. 4-21).

Conclusions

Based on multiple analyses of sequences for two genes, with some resolution of ambiguous clades using classical morphological characters, my phylogeny of the Archipini had a topology that was largely congruent with recent systematic work by other workers on various component groups. However, my analysis produced a large polytomy within the core Archipini. Nonetheless, some parts of the phylogeny were well supported, and on this basis I propose the following generic changes: 1) *Anaphelia*, *Aphelia s. s.*, *Sacaphelia*, and *Zelotherses* should be raised from subgenera within *Aphelia s. l.*, to full genera; 2) *Archepandemis* should be synonymised with *Pandemis*; 3) *Cudonigera* should be synonymised with *Choristoneura*, and 4) *Epiphyas* should be synonymised with *Clepsis*. There were frequent gains and losses of SSC's, although the CF was most widespread. There was no significant correlation between the presence or absence of the CF and the development of other SSCs. There was a strong correlation between host plant breadth and SSCs using a χ^2 approach, although this was not apparent when looking at correlation of individual evolutionary events. Ancestral character state reconstruction supports an Australasian origin for the Archipini and limited radiation into the New World. This New World colonization was correlated with a greater frequency of loss of SSCs. Elucidation and testing of these fundamental patterns contributes to a stronger understanding of the evolutionof this economically important group of tortricids.

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Figure 4-1: Male *Archips eleagnana* with arrow indicating costal fold. CAN: AB: Kootenay Plains E. R.: 20 viii 2009. ©JJD.

Figure 4-2: Male *Clepsis melaleucana* with arrow indicating costal fold. CAN: ONT: Algonquin P. P.: 26 vi 2003. ©JJD.

Figure 4-3: Male *Choristoneura rosaceana* with arrow indicating vestigial costal fold. USA: MS: Delta N. F.: 01 vii 2008. ©JJD.

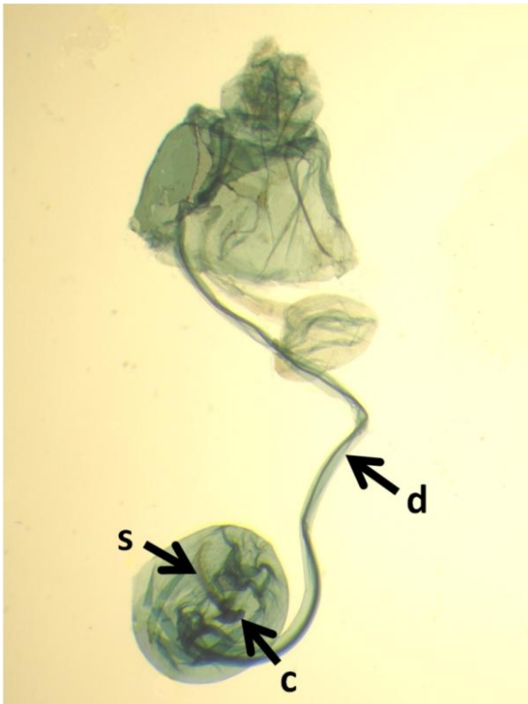


Figure 4-4: Female genitalia of *Archips xylosteana* with arrows indicating the ductus bursae (d), capitulum (c), and dagger-like signum (s). FRANCE: Massif des Maures: 19 vi 2009: T. M. Gilligan

Figure 4-5: Male genitalia of *Ditula angustiorana* with arrow indicating the sclerotized costa of the valve. JD6313: ITALIA: LOM: Samarate: 05 vi 2009: JJD & D. Lawrie

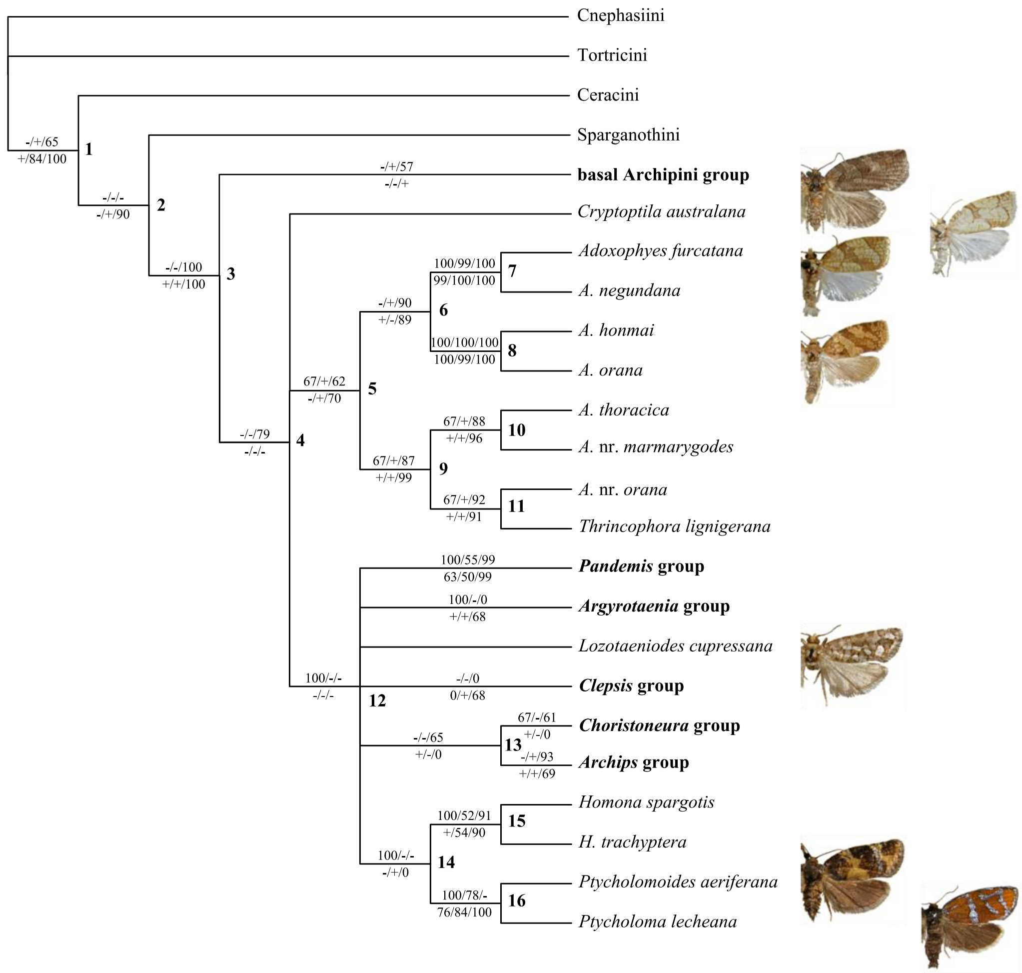


Figure 4-6: Summary tree of phylogenetic analyses. Clades are numbered in bold to the right of their respective nodes. Numerical values above and below branches are maximum parsimony bootstrap, maximum likelihood bootstrap, and Bayesian posterior probabilities, respectively (COI above, COI+28S below). "+" = a clade with less than 50% bootstrap support or posterior probability, "0" = a clade is part of a polytomy, and "-" = a clade contradicted by tree topology. Bolded terminal taxa are expanded in the following trees. Specimen photos are absent when no specimens were available for examination.

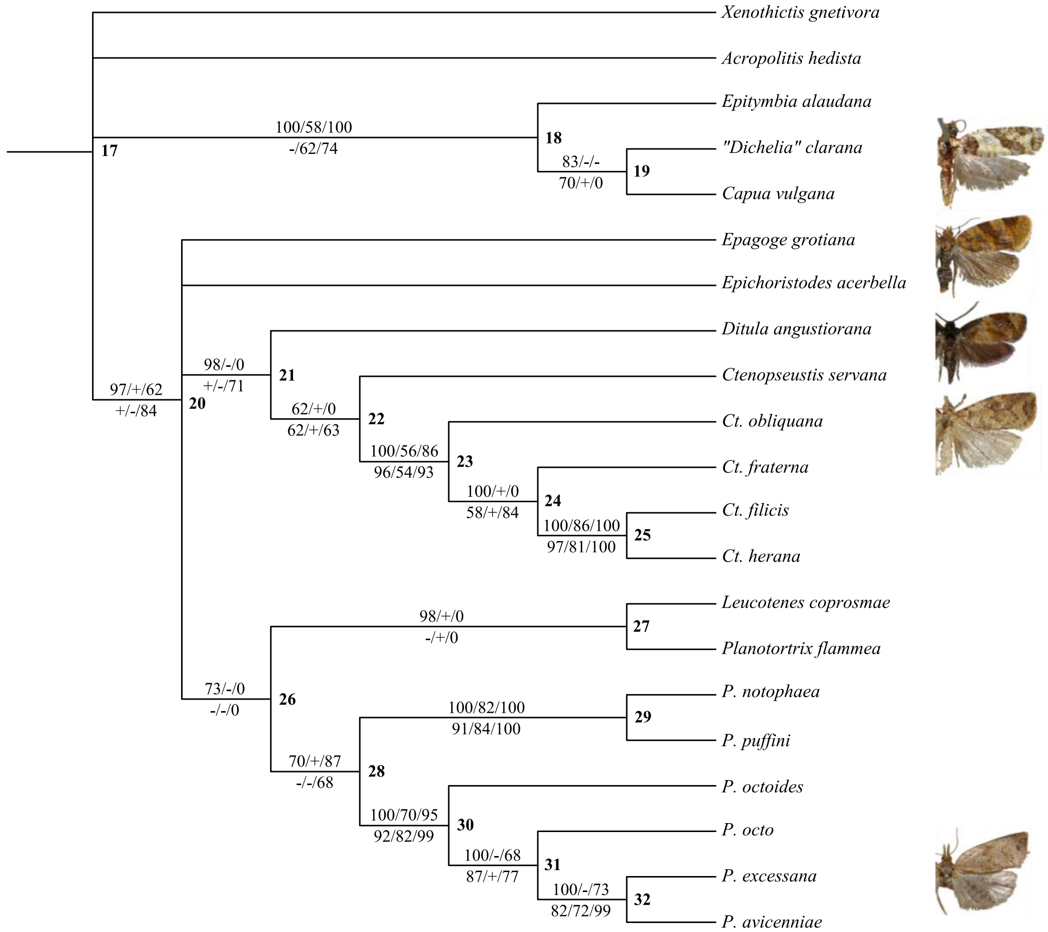


Figure 4-7: **Basal Archipini group** summary tree of phylogenetic analyses. Clades are numbered in bold to the right of their respective nodes. Numerical values above and below branches are maximum parsimony bootstrap, maximum likelihood bootstrap, and Bayesian posterior probabilities, respectively (COI above, COI+28S below). "+" = a clade with less than 50% bootstrap support or posterior probability, "0" = a clade is part of a polytomy, and "-" = a clade contradicted by tree topology. Specimen photos are absent when no specimens were available for examination.

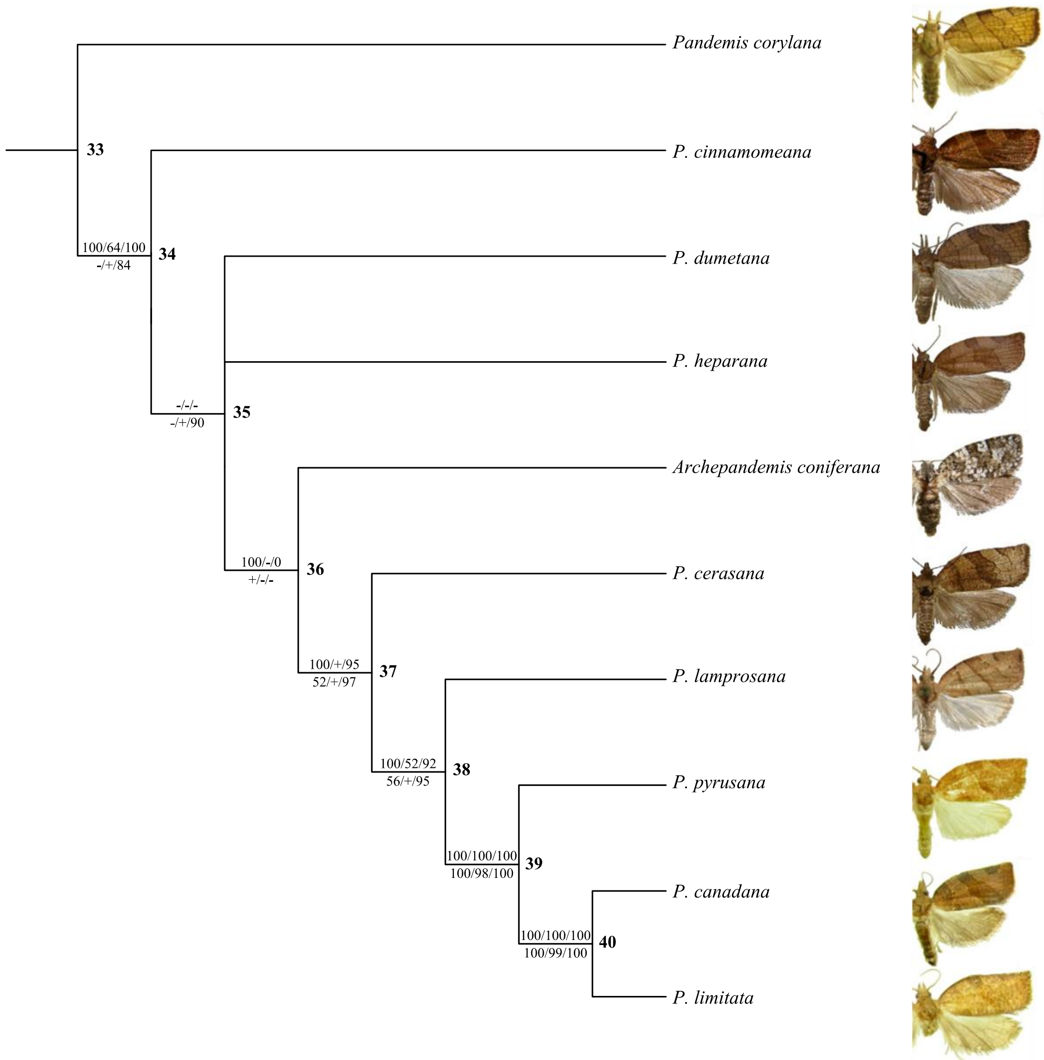


Figure 4-8: ***Pandemis* group** summary tree of phylogenetic analyses. Clades are numbered in bold to the right of their respective nodes. Numerical values above and below branches are maximum parsimony bootstrap, maximum likelihood bootstrap, and Bayesian posterior probabilities, respectively (COI above, COI+28S below). "+" = a clade with less than 50% bootstrap support or posterior probability, "0" = a clade is part of a polytomy, and "-" = a clade contradicted by tree topology.

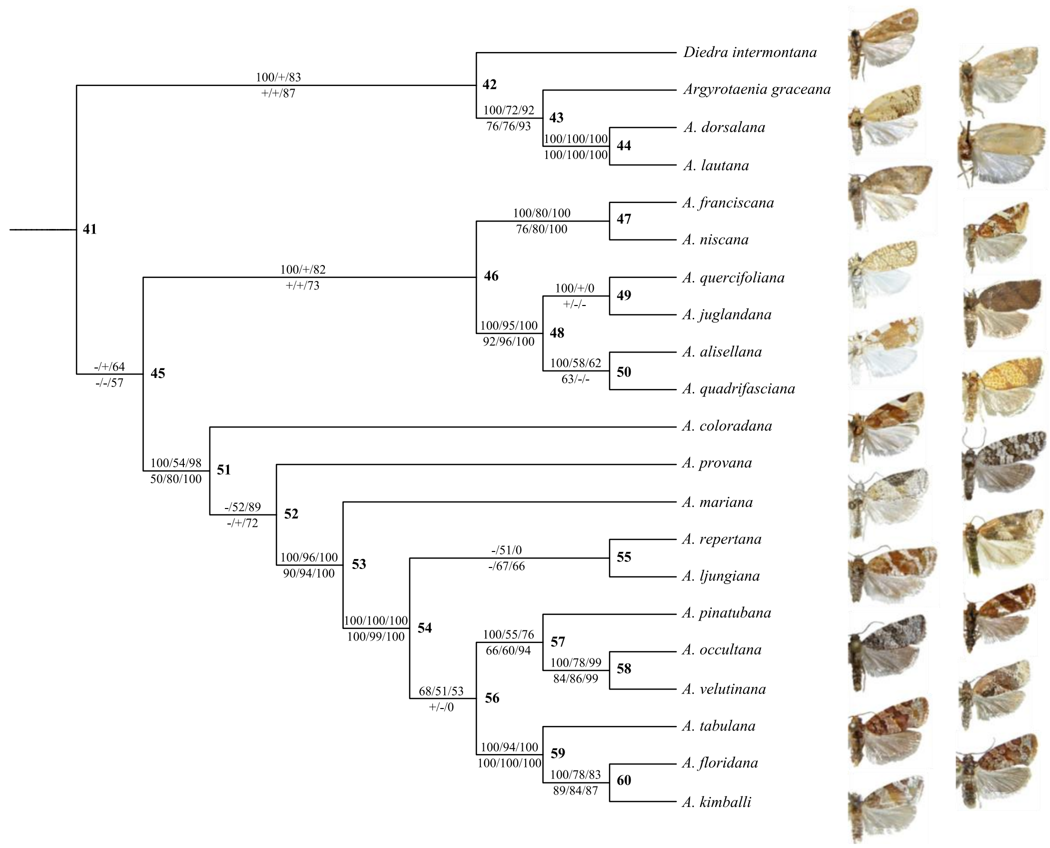


Figure 4-9: ***Argyrotaenia* group** summary tree of phylogenetic analyses. Clades are numbered in bold to the right of their respective nodes. Numerical values above and below branches are maximum parsimony bootstrap, maximum likelihood bootstrap, and Bayesian posterior probabilities, respectively (COI above, COI+28S below). "+" = a clade with less than 50% bootstrap support or posterior probability, "0" = a clade is part of a polytomy, and "-" = a clade contradicted by tree topology.

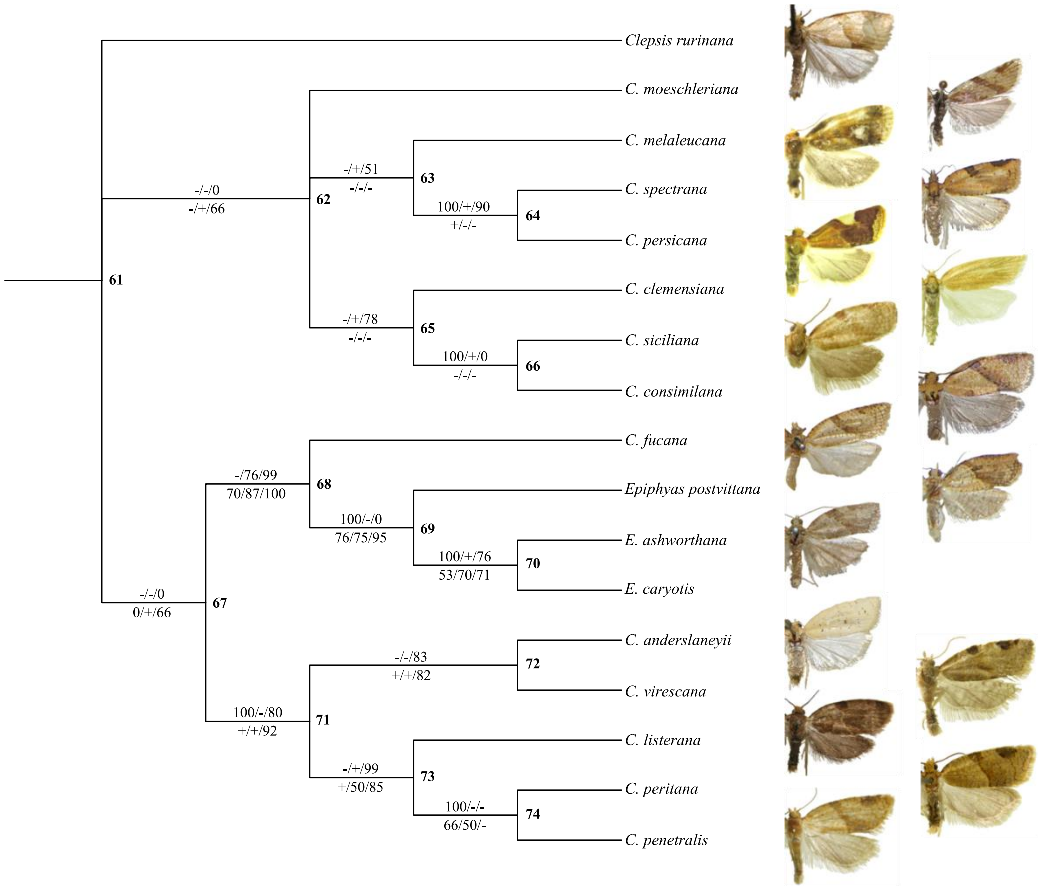


Figure 4-10: ***Clepsis* group** summary tree of phylogenetic analyses. Clades are numbered in bold to the right of their respective nodes. Numerical values above and below branches are maximum parsimony bootstrap, maximum likelihood bootstrap, and Bayesian posterior probabilities, respectively (COI above, COI+28S below). "+" = a clade with less than 50% bootstrap support or posterior probability, "0" = a clade is part of a polytomy, and "-" = a clade contradicted by tree topology. Specimen photos are absent when no specimens were available for examination.

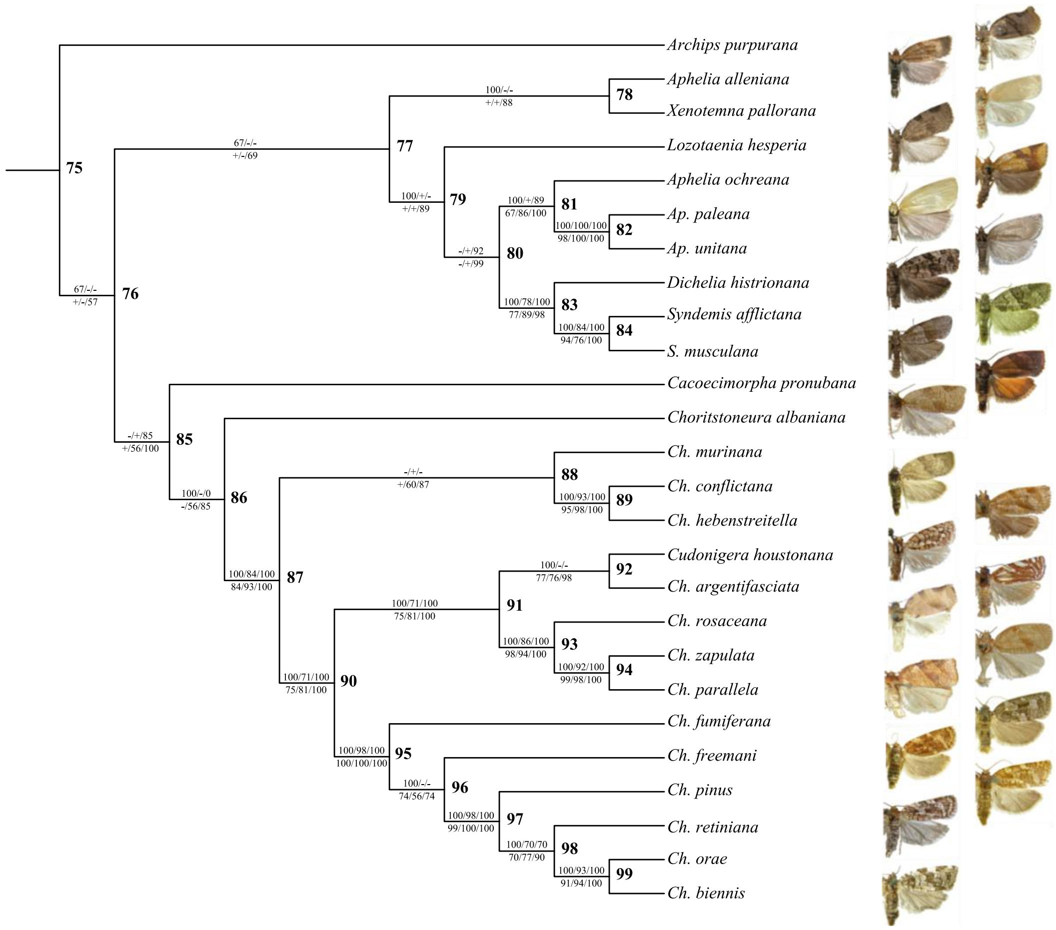


Figure 4-11: ***Choristoneura* group** summary tree of phylogenetic analyses. Clades are numbered in bold to the right of their respective nodes. Numerical values above and below branches are maximum parsimony bootstrap, maximum likelihood bootstrap, and Bayesian posterior probabilities, respectively (COI above, COI+28S below). "+" = a clade with less than 50% bootstrap support or posterior probability, "0" = a clade is part of a polytomy, and "-" = a clade contradicted by tree topology. Specimen photos are absent when no specimens were available for examination.

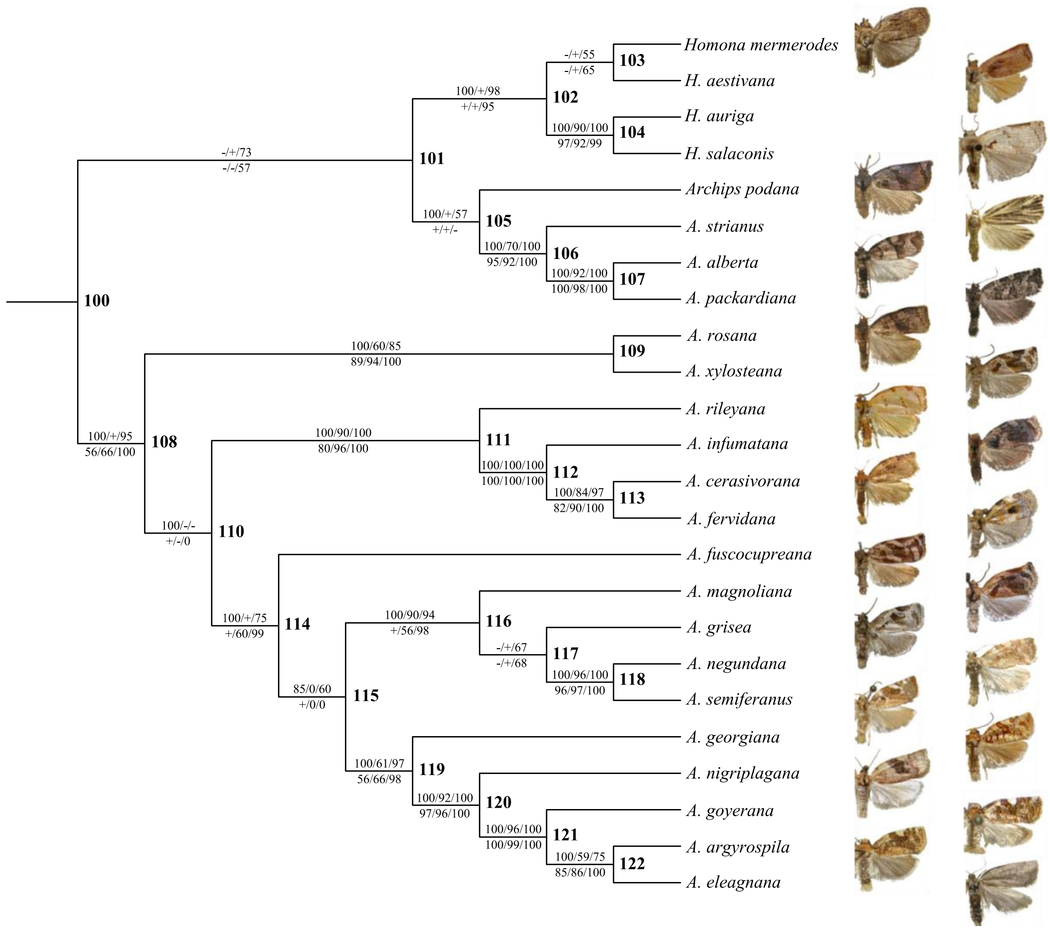


Figure 4-12: ***Archips* group** summary tree of phylogenetic analyses. Clades are numbered in bold to the right of their respective nodes. Numerical values above and below branches are maximum parsimony bootstrap, maximum likelihood bootstrap, and Bayesian posterior probabilities, respectively (COI above, COI+28S below). "+" = a clade with less than 50% bootstrap support or posterior probability, "0" = a clade is part of a polytomy, and "-" = a clade contradicted by tree topology. Specimen photos are absent when no specimens were available for examination.

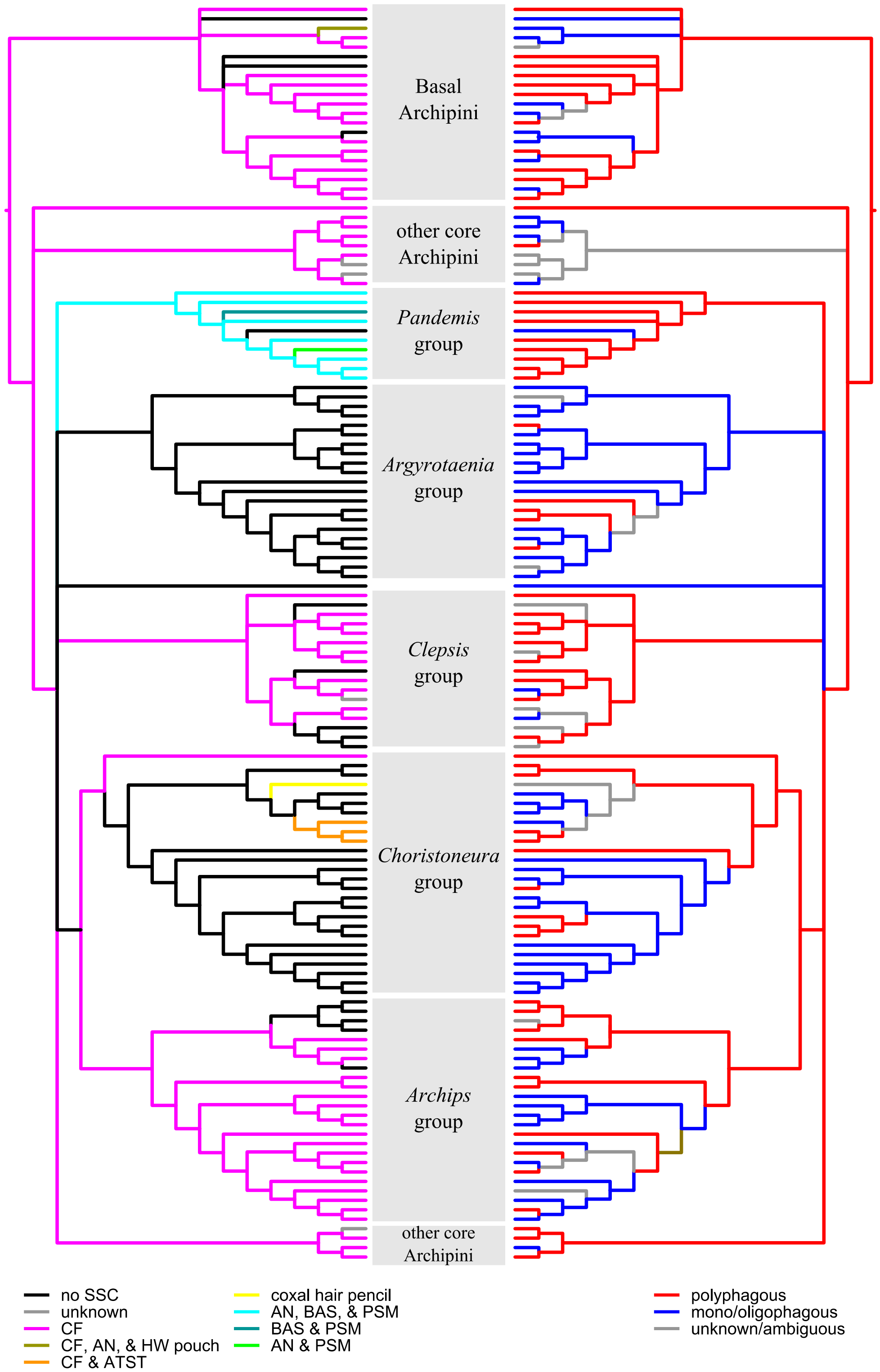


Figure 4-13: Trees with mapped parsimonious ancestral character state reconstructions. The left tree is of SSCs and the right is host plant breadth. AN = antennal notch, HW = hind wing, ATST = anterior thoracic scale tuft, BAS = modified basal abdominal scales, PSM = pregenital sternal modification.

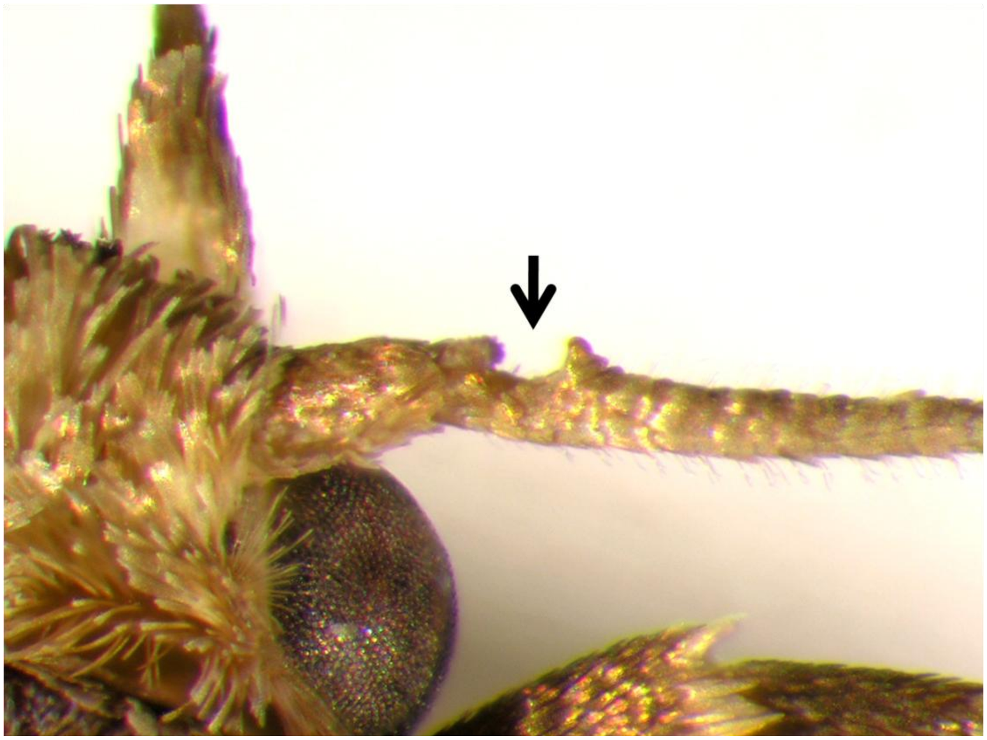


Figure 4-14: Antennal notch of male *Pandemis canadana* indicated by arrow. JD6757: CAN: AB: Edmonton: 01 viii 2009: JJD, *et al.*

Figure 4-15: Anterior thoracic scale tufts of male *Syndemis afflictana* indicated by arrows. JD4282: CAN: AB: North Cooking Lake: 17 v 2008: JJD, *et al.*

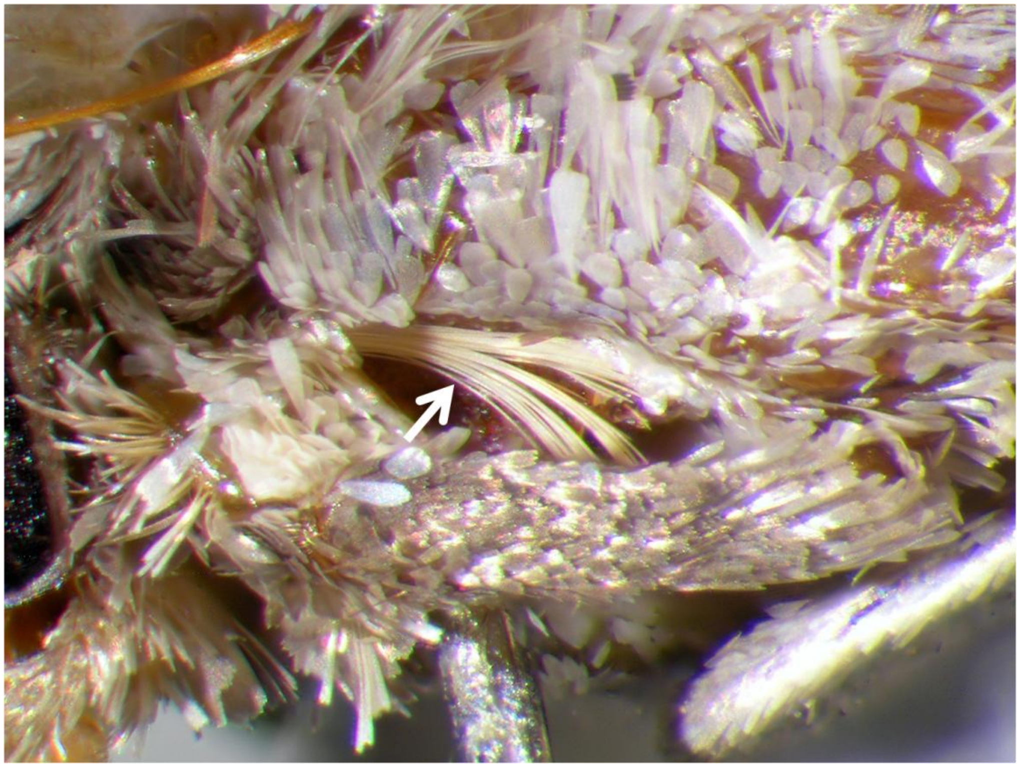


Figure 4-16: Hair pencil posterior of procoxa in male of *Lozotaenia hesperia*. JD1047: CAN: AB: Jasper N. P.: 27 vi 2006: B. C. Schmidt & G. A. Anweiler.

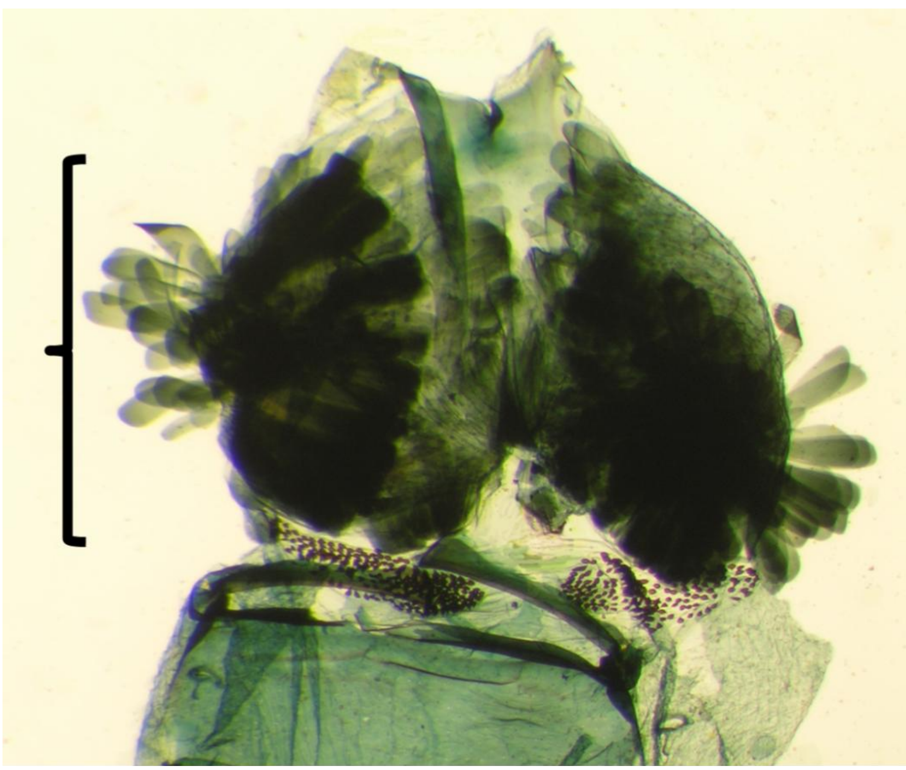


Figure 4-17: Base of male abdomen of *Pandemis canadana* showing modified scales. JD6054: CAN: AB: Bindloss: 23 vii 2008: JJD & B. Proshek.

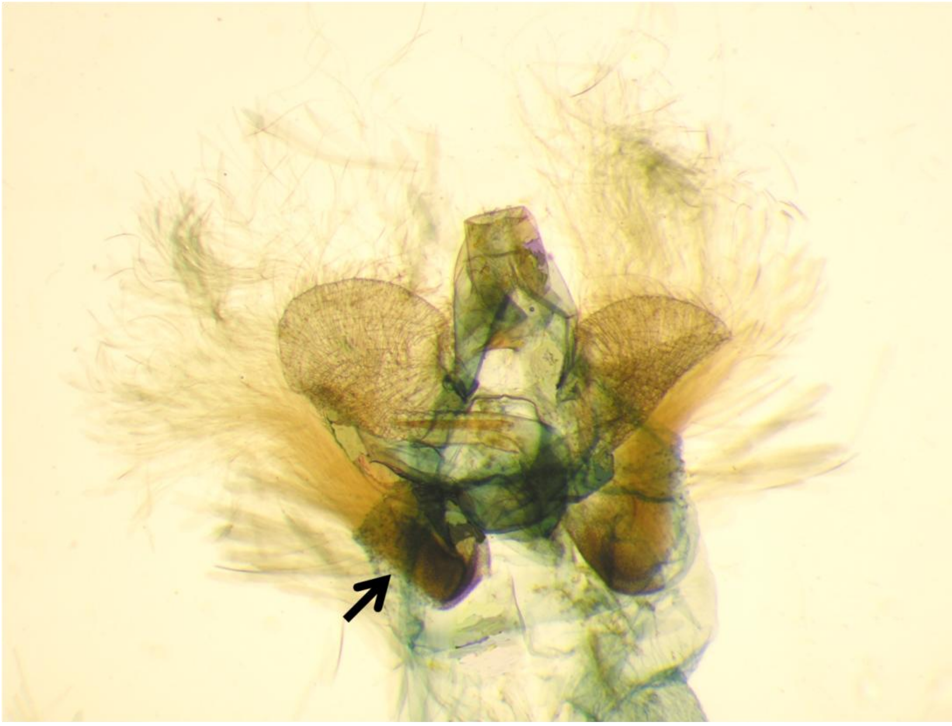


Figure 4-18: Male genitalia and modified pregenital sternite (indicated by arrow) of *Pandemis canadana*. JD6054: CAN: AB: Bindloss: 23 vii 2008: JJD & B. Proshek.

Figure 4-19: Male genitalia of *Clepsis consimilana* with arrows indicating modified socketed scales (s) and incomplete dentate transtilla (t). FRANCE: Massif des Maures: 19 vi 2009: T. M. Gilligan

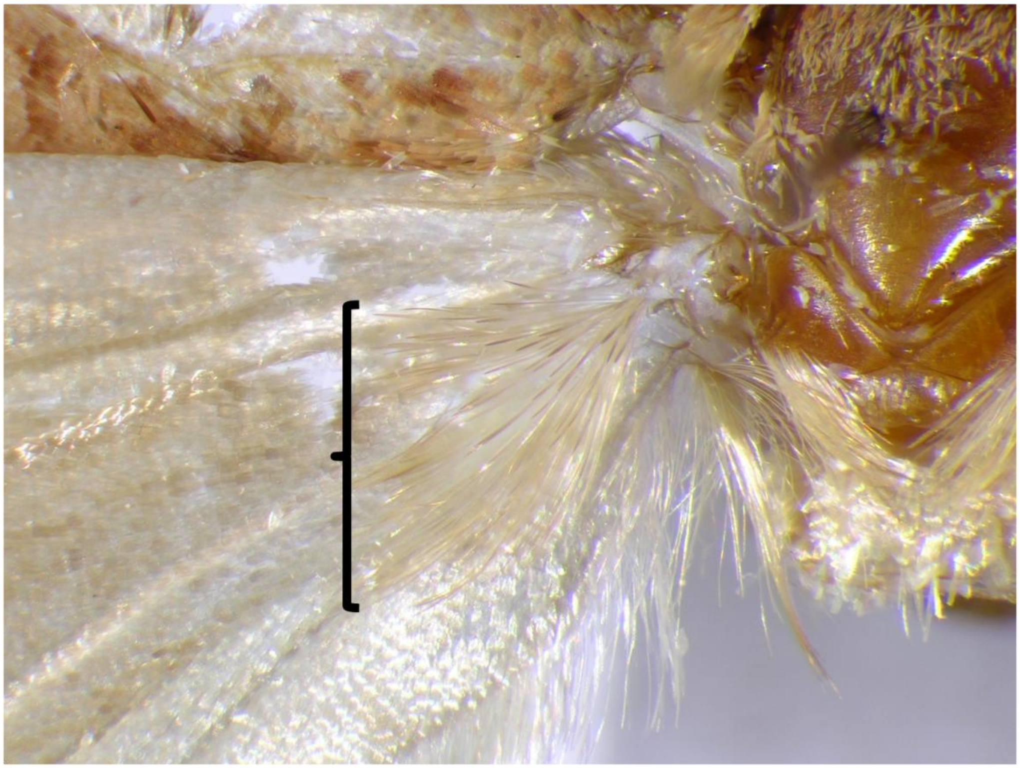


Figure 4-20: Hindwing base of male *Choristoneura parallela* showing modifed scales. JD0600: USA: FL: Osceola N. F.: 19 vi 2006: JJD, *et al.*

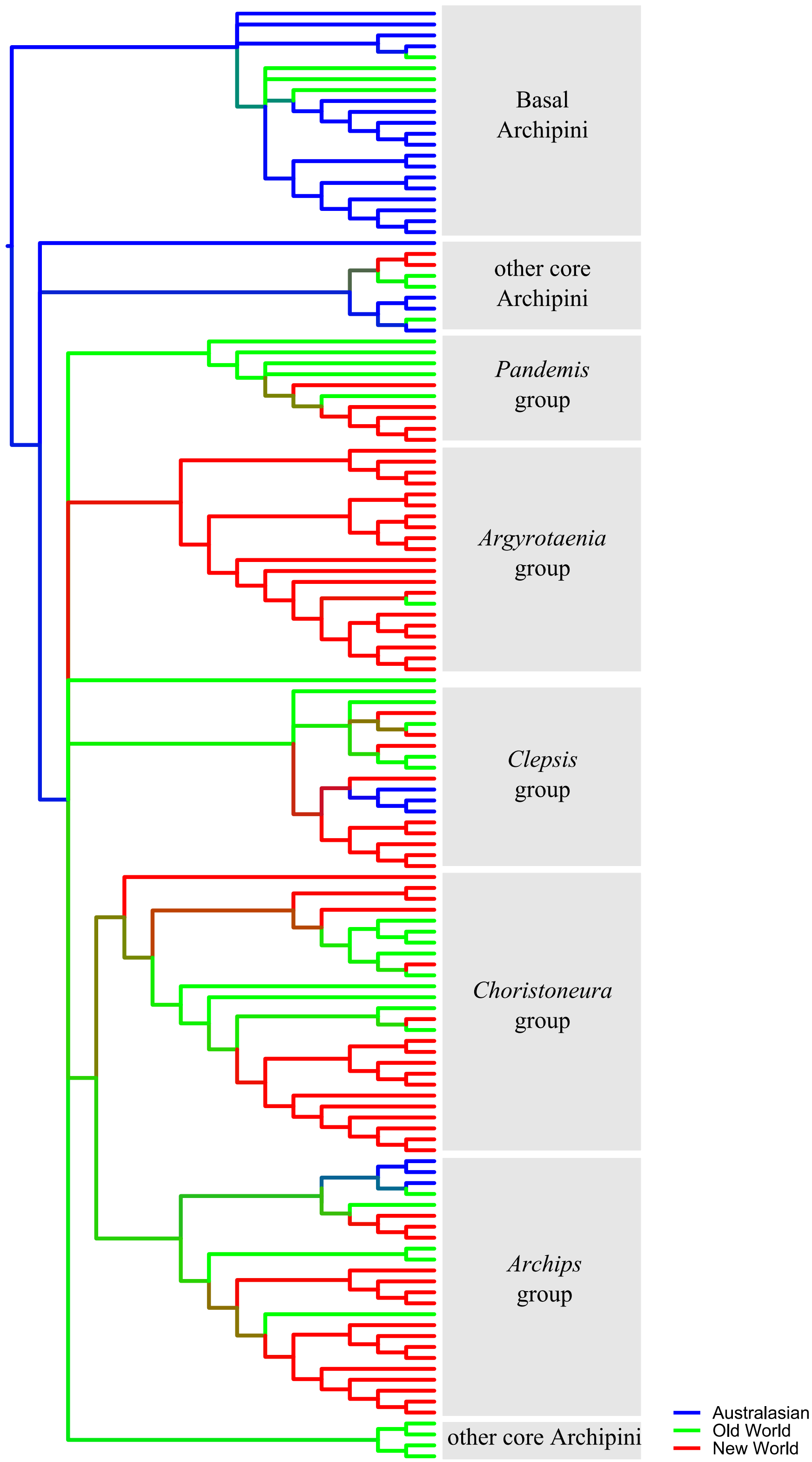


Figure 4-21: Tree with zoogeography mapped under likelihood ancestral character state reconstructions. Branch colours represent relative likelihoods of zoogeographic origin.

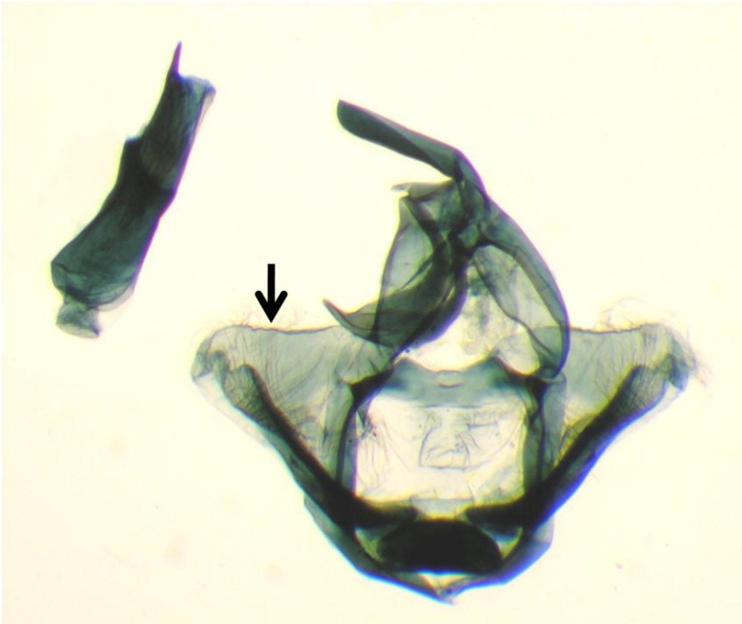


Figure 4-22: Male genitalia of *Choristoneura paralella* with phallus removed, unsclerotized costa of the valve indicated with arrow. JD0600: USA: FL: Osceola N. F.: 19 vi 2006: JJD, *et al.*

Figure 4-23: Male genitalia of *Lozotaeniodes cupressana* with arrow indicating incomplete dentate transtilla. SPAIN: Pobla de Benifassa: 24 vi 2009: T. M. Gilligan, *et al.*

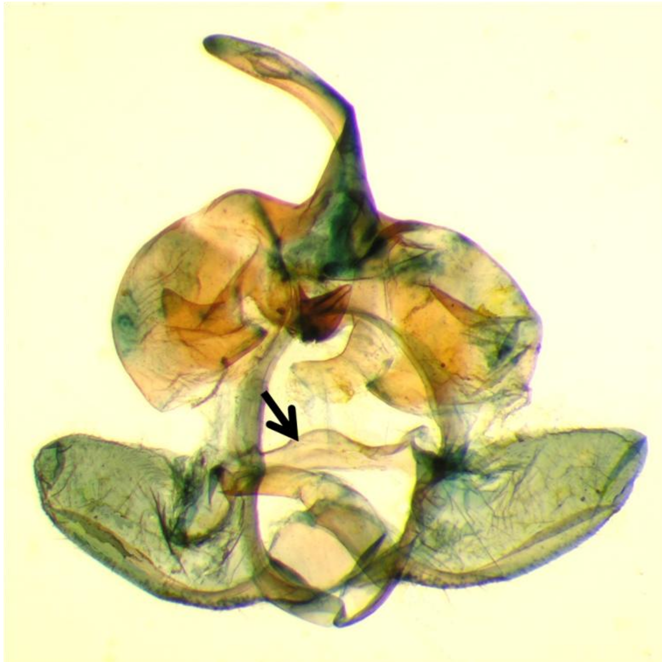


Figure 4-24: Male genitalia of *Aphelia (Zelotherses) ochreana* with arrow indicating unmodified transtilla. JD6160: ROMÂNIA: TL: Macim Mountains: 14 v 2009: JJD & A. Sandor.

Figure 4-25: Male genitalia of *Aphelia (A.) alleniana* with arrow indicating dentate lateral processes of transtilla. JD3709: CAN: AB: Porcupine Hills: 31 vii 2007: JJD, *et al.*

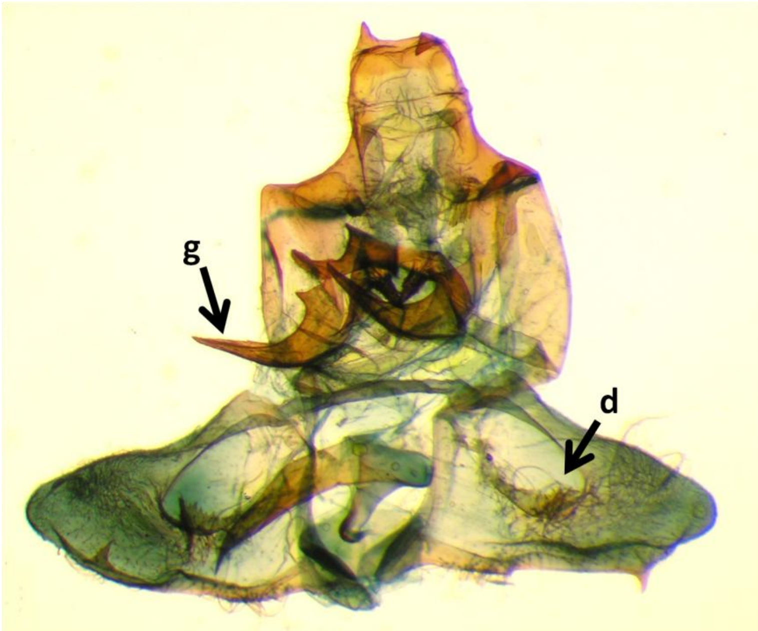


Figure 4-26: Male genitalia of *Xenotemna pallorana* with arrows indicating the large dentate gnathos (g) and dentate patches in the center of the valve (d). JD4959: CAN: AB: Pakowki Dunes: 08 vii 2008: JJD & A. Rose

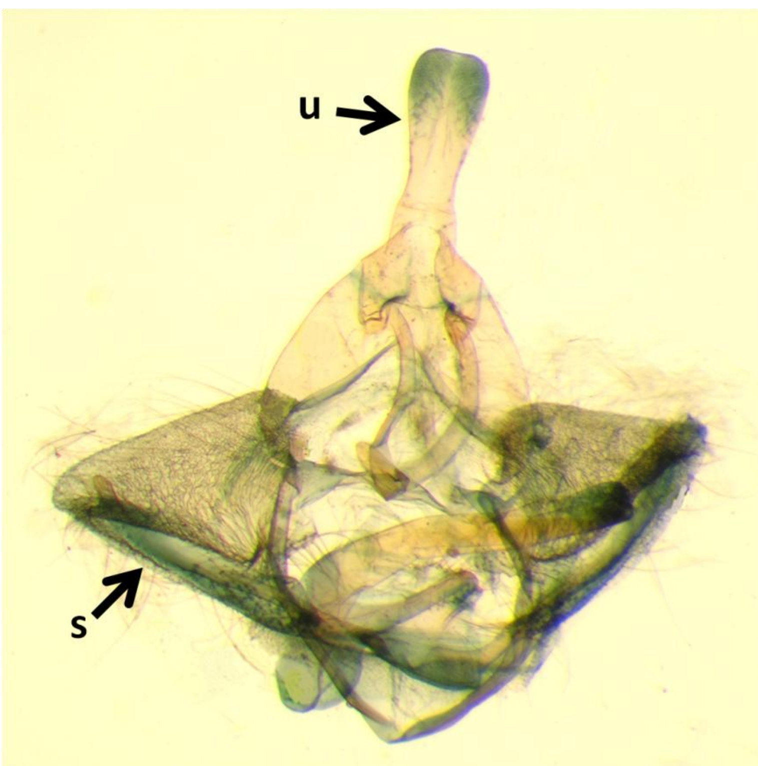


Figure 4-27: Male genitalia of *Archips purpurana* with arrows indicating the saccular margin (s) and uncus (u). JD6031: CAN: AB: Bindloss: 23 vii 2008: JJD & B. Proshek.

Figure 4-28: Female *Archips purpurana*; the phylogenetic placement of this species remains uncertain. CAN: ONT: Algonquin Park: 28 vii 2002. ©JJD.

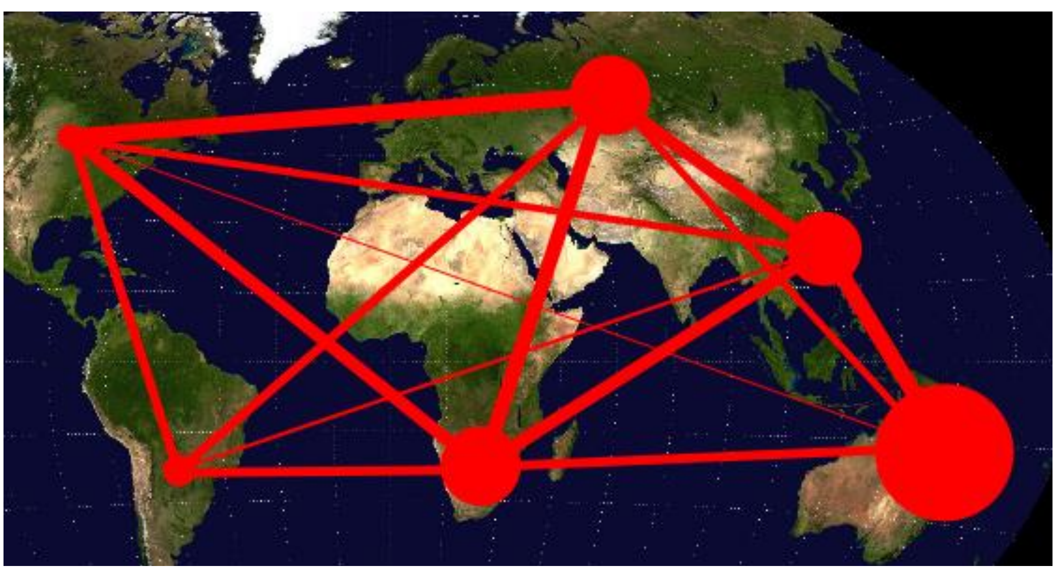


Figure 4-29: Relative number of genera by zoogeographic region (circles) and number of genera in common between each region (lines). Map modified from Wikimedia commons.

Table 4-1: Specimens sequenced for this study.

Species	DNA #	Location	latitude / longitude	date	collectors	COI (bp)	28S (bp)	Genbank numbers COI	Genbank numbers 28S
Adoxophyes negundana	4567	Canada: AB: Lethbridge	49.689 - 112.827	02 vi 2008	M. Vankosky	1516	865	JF703014	JF702925
Ad. orana	4599	România: CT: Canarau Feteii	44.068 27.645	17 v 2009	JJD, A. Sandor	1542	348	JF703015	JF702926
Aphelia alleniana	2999	Canada: AB: Porcupine Hills	49.972 - 114.087	31 vii 2007	JJD, *et al.*	1515	899	JF703016	JF702927
Ap. ochreana	4600	România: TL: Macim Mountains, Sulucu	45.234 28.194	14 v 2009	JJD, A. Sandor	1541	901	JF703017	JF702928
Ap. unitana	6302	România: BV: Staţiunea Sâmbăta	45.674 24.791	22 v 2009	JJD, *et al.*	1516	901	JF703018	JF702929
Archepand-emis coniferana	4571	Canada: AB: EMEND	56.751 - 118.330	11 vii 2007	E. Kamunya	1510	814	JF703021	JF702932
Archips alberta	2960	Canada: AB: Kootenay Plains Ecol. Res.	51.999 - 116.496	27 vii 2006	JJD, B. C. Schmidt	1518	900	JF703019	JF702930
Archips cerasivor-ana	2970	Canada: AB: Waterton Lakes	49.056 - 113.915	15 viii 2006	JJD, *et al.*	1521	900	JF703020	JF702931
Archips eleagnana	2914	Canada: AB: Kootenay Plains Ecol. Res.	52.003 - 116.465	27 vii 2006	JJD, B. C. Schmidt	1542	902	JF703022	JF702933
Archips fervidana	3000	United States: AR: Crawford Co.: Ozark-St. Francis Nat. For.	35.702 - 94.296	16 vi 2008	JJD, D. Lawrie	1533	900	JF703023	JF702934
Archips negundana	2912	Canada: AB: Edmonton	53.525 - 113.492	20 vii 2006	JJD, A. Rose	1542	902	JF703024	JF702935
Archips packard-iana	2947	Canada: AB: Jasper Nat. Pk., Jasper Lake	53.097 - 118.003	27 vi 2006	B. C. Schmidt, G. Anweiler	1542	900	JF703025	JF702936
Archips podana	4557	Denmark: LFM: Mandemarke	54.967 12.491	14-17 vii 2007	O. Karsholt	1515	867	JF703026	JF702937
Archips purpurana	6306	Canada: AB: Bindloss	50.901 - 110.294	22 vii 2008	JJD, B. Proshek	1541	900	JF703027	JF702938
Archips rosana	4563	Denmark: LFM: Mandemarke	54.967 12.491	14-17 vii 2007	O. Karsholt	1538	901	JF703028	JF702939
Archips striana	2945	Canada: AB: Jasper Nat. Pk., The Palisades	52.963 - 118.058	27 vi 2006	B. C. Schmidt, G. Anweiler	1492	900	JF703029	JF702940
Archips xylosteana	4559	Canada: NL: St. John's	47.575 - 52.738	2006	B. C. Schmidt	1539	899	JF703030	JF702941
Argyrotae-nia alisellana	2905	United States: VA: Fairfax Co.: Fairfax City	38.847 - 77.295	31 v 2006	J. W. Brown	1542	902	JF703031	JF702942
Arg. coloradana	4501	United States: UT: Cache Nat. For.: Logan Canyon	41.780 - 111.139	06 vii 2007	JJD, *et al.*	1542	899	JF703032	JF702943
Arg. dorsalana	4502	Canada: BC: Tranquille Ecol. Res.	50.755 - 120.589	15 viii 2007	JJD	1519	900	JF703033	JF702944

Arg. floridana	6328	United States: FL: Marion Co.: Ocala Nat. For., Delancey Lake	29.427 - 81.789	22 vi 2006	JJD, *et al.*	1542	899	JF703034	JF702945
Arg. franciscana	Afran13	United States: CA: Sonoma Co.: Bodega Bay Mar. Res.	38.306 - 123.066	24 v 1996	B. Landry		899	-	JF702946
Arg. graceana	4526	United States: CA: Ventura Co.: Los Padres Nat. For.: Mt. Pinos	34.812 - 119.099	15 vii 2007	JJD, *et al.*	1542	348	JF703035	JF702947
Arg. kimballi	2940	United States: FL: Baker Co.: Osceola Nat. For.	30.384 - 82.331	18 vi 2006	JJD, *et al.*	1517	899	JF703036	JF702948
Arg. lautana	4527	United States: CA: Ventura Co.: Los Padres Nat. For.: Mt. Pinos	34.812 - 119.099	16 vii 2007	JJD, *et al.*	1541	899	JF703037	JF702949
Arg. ljungiana	6310	France: Mormoiron: near Mormoiron	44.090 5.235	17 vi 2009	T. M. Gilligan	859	899	JF703038	JF702950
Arg. mariana	4528	Canada: AB: Buck Lake	54.656 - 112.522	31 v 2007	M. Schwarzf-eld	1498	900	JF703039	JF702951
Arg. occultana	4529	Canada: AB: Jasper Nat. Pk., Jasper Lake	53.097 - 118.003	27 vi 2006	B. C. Schmidt, G. Anweiler	1540	899	JF703040	JF702952
Arg. provana	4530	United States: OR: Wasco Co.: Mt. Hood Nat. For.	45.232 - 121.627	26 vii 2007	JJD, *et al.*	1542	824	JF703041	JF702953
Arg. quadrifasci-ana	4585	Canada: AB: Bindloss	50.901 - 110.294	23 vii 2008	JJD, B. Proshek	1528	897	JF703042	JF702954
Arg. quercifol-iana	2938	United States: VA: Fairfax Co.: Fairfax City	38.847 - 77.295	03 vi 2006	J. W. Brown	1541	828	JF703043	JF702955
Arg. repertana	2934	Canada: AB: Wagner Bog	53.565 - 113.832	15 v 2006	JJD, *et al.*	1542	858	JF703044	JF702956
Arg. tabulana	6308	United States: AR: Pulaski Co.: Little Rock	34.826 - 92.459	16 vi 2008	JJD, *et al.*	1513	899	JF703045	JF702957
Arg. velutinana	2909	United States: VA: Fairfax Co.: Fairfax City	38.847 - 77.295	03 vi 2006	J. W. Brown	1541	877	JF703046	JF702958
Cacoeci-morpha pronubana	6329	Spain: Catalonia: Sant Fost de Campsentelles	41.515 2.235	1 vii 2009	T. Gilligan & V. Santo Monteys	859	854	JF703047	JF702959
Capua vulgana	4554	Denmark: LFM: Mandemarke	54.967 12.491	01 vi 2007	O. Karsholt	1536	845	JF703048	JF702960
Choristo-neura albaniana	2948	Canada: AB: Jasper Nat. Pk., Jasper Lake	53.097 - 118.003	27 vi 2006	B. C. Schmidt, G. Anweiler	1542	865	JF703050	JF702962
Ch. argentifas-ciata	2942	United States: FL: Baker Co.: Osceola Nat. For.	30.384 - 82.331	19 vi 2006	JJD, *et al.*	1520	896	JF703051	JF702963
Ch. biennis	2616	Canada: AB: Peter Lougheed Prov. Pk.	50.618 - 115.122	05 vii 2005	L. M. Lumley, A. Roe	-	898	-	JF702964

Ch. conflictana	4532	Canada: AB: Jasper Nat. Pk., The Palisades	52.963 - 118.058	27 vi 2006	B. C. Schmidt, G. Anweiler	1542	863	JF703052	JF702965
Ch. freemani	2313	Canada: AB: Porcupine Hills: Beaver Creek CG	49.804 - 113.948	07 vii 2005	L. M. Lumley	-	899	-	JF702966
Ch. fumiferana	2582	Canada: AB: Ft McMurray	56.686 - 111.354	21 vi 2005	L. M. Lumley	-	899	-	JF702967
Ch. hebenstre-itella	4535	Denmark: NEZ: Copenhagen	55.676 12.568	31 v-06 vi 2007	O. Karsholt	1542	893	JF703053	JF702968
Ch. murinana	814	France: Alsace: Geubwiller	47.750 - 7.333	31 v 1996	M. Kenis	-	898	-	JF702969
Ch. orae	2644	Canada: BC: Kincolith	55.005 - 129.839	08 vi 2006	L. M. Lumley, *et al.*	-	898	-	JF702970
Ch. parallela	2941	United States: FL: Baker Co.: Osceola Nat. For.	30.384 - 82.331	19 vi 2006	JJD, *et al.*	1542	897	JF703054	JF702971
Ch. pinus	3568	Canada: AB: Redwater Nat. Area	53.937 - 112.952	17-25 vii 2006	L. M. Lumley	-	894	-	JF702972
Ch. retiniana	4835	United States: CA: Madera Co.: Bass Lake	37.505 - 119.410	10 vii 2007	L. M. Lumley, *et al.*	-	899	-	JF702973
Ch. rosaceana	2937	United States: VA: Fairfax Co.: George Washington Mem. Pkwy	38.817 - 77.228	04 vi 2006	J. W. Brown	1542	893	JF703055	JF702974
Ch. zapulata	4533	Canada: AB: Pakowki Dunes	49.397 - 110.875	16 viii 2006	JJD, *et al.*	1542	828	JF703056	JF702975
Clepsis anderslan-eyii	6330	United States: AZ: Cochise Co.: SW Res. Sta., Chiricahua Mountains	31.881 - 109.207	9 viii 2010	J. W. Brown	1516	900	JF703057	JF702976
Cl. clemens-iana	2913	Canada: AB: Edmonton	53.525 - 113.492	23 vii 2006	JJD, A. Rose	1542	898	JF703058	JF702977
Cl. consimilana	6332	France: Massif des Maures: near La Londe-les-Maures	43.169 6.215	19 vi 2009	T. M. Gilligan	859	891	JF703059	JF702978
Cl. fucana	6315	United States: CA: Alameda Co.: Berkeley	37.872 - 122.273	03 v 1995	J. A. Powell	1511	856	JF703060	JF702979
Cl. melaleuc-ana	4534	Canada: AB: Edmonton	53.545 - 113.434	15 vi 2007	G. Anweiler	1537	896	JF703061	JF702980
Cl. penetralis	4544	Canada: AB: Jasper Nat. Pk., The Palisades	52.963 - 118.058	27 vi 2006	B. C. Schmidt, G. Anweiler	1541	901	JF703062	JF702981
Cl. peritana	2906	United States: VA: Fairfax Co.: Fairfax City	38.847 - 77.295	31 v 2006	J. W. Brown	1540	901	JF703063	JF702982
Cl. persicana	2910	Canada: AB: Jasper Nat. Pk., The Palisades	52.963 - 118.058	27 vi 2006	B. C. Schmidt, G. Anweiler	1542	817	JF703064	JF702983
Cl. rurinana	6317	Italia: LOM: Samarate	45.621 8.798	05 vi 2009	JJD, D. Lawrie	1519	891	JF703065	JF702984

Cl. siciliana	6318	Spain: CAS: Pobla de Benifassa, Latemaia Form del Vidre	40.669 0.212	25 vi 2009	T. M. Gilligan, *et al.*	859	348	JF703066	JF702985
Cl. spectrana	4558	Denmark: LFM: Mandemarke	54.967 12.491	07-13 vii 2007	O. Karsholt	1540	348	JF703067	JF702986
Cl. virescana	2956	Canada: AB: Waterton Lakes Nat. Pk., Belleview Hill	49.099 - 113.905	15 viii 2006	JJD, *et al.*	1521	348	JF703068	JF702987
Cudonigera houstonana	4546	United States: AR: Logan Co.: Ozark-St. Francis Nat. For.	35.193 - 93.645	19 vi 2008	JJD, *et al.*	1514	900	JF703069	JF702988
Dichelia histrionana	4556	Denmark: LFM: Mandemarke	54.967 12.491	27-28 vii 2007	O. Karsholt	1534	890	JF703070	JF702989
Diedra intermon-tana	4548	United States: UT: Lander Co.: Toiyabe Nat. For.	39.225 - 117.139	08 vii 2007	JJD, *et al.*	1542	348	JF703071	JF702990
Ditula angustior-ana	4572	United States: CA: Alameda Co.: Berkeley	37.872 - 122.273	22 iv 1996	F. A. H. Sperling	1520	821	JF703072	JF702991
Epagoge grotiana	4555	Denmark: LFM: Mandemarke	54.967 12.491	07-13 vii 2007	O. Karsholt	1542	818	JF703074	JF702993
Epiphyas ashworth-ana	6320	Australia	[data pending]		T. Gilligan	1541	884	JF703075	JF702994
Epi. caryotis	6321	Australia	[data pending]		T. Gilligan	1541	899	JF703076	JF702995
Epi. postvittana	6333	United States: CA: Alameda Co.: Berkeley	37.872 - 122.273	10-18 v 2010	J. A. Powell	1541	819	JF703077	JF702996
Lozotaenia hesperia	2949	Canada: AB: Jasper Nat. Pk., Jasper Lake	53.097 - 118.003	27 vi 2006	B. C. Schmidt, G. Anweiler	1531	752	JF703079	JF702998
Lozotaen-iodes cupressana	6323	Spain: CAS: Pobla de Benifassa, Latemaia Form del Vidre	40.669 0.212	24 vi 2009	T. M. Gilligan, *et al.*	1541	755	JF703078	JF702997
Pandemis canadana	2911	Canada: AB: Edmonton	53.545 - 113.434	30 vii 2006	G. Anweiler	1542	900	JF703080	JF702999
Pa. cerasana	4539	Denmark: LFM: Mandemarke	54.967 12.491	09 vi 2007	O. Karsholt	1542	899	JF703081	JF703000
Pa. cinnamom-eana	4561	Denmark: LFM: Mandemarke	54.967 12.491	07-13 vii 2007	O. Karsholt	1540	899	JF703082	JF703001
Pa. corylana	4594	Italia: LOM: Samarate	45.621 8.798	05 vi 2009	JJD, D. Lawrie	1542	898	JF703083	JF703002
Pa. dumetana	4553	Denmark: LFM: Mandemarke	54.967 12.491	07-13 vii 2007	O. Karsholt	1542	900	JF703084	JF703003
Pa. heparana	4590	România: GJ: Cheile Sohodolului	45.139 23.139	01 vi 2009	JJD, D. Lawrie	1542	899	JF703085	JF703004
Pa. lamprosana	4573	United States: MD: Prince George's Co.: Patuxeut W. R.	39.027 - 76.798	xii 1997	J. A. Powell	1538	899	JF703086	JF703005

Pa. limitata	2907	United States: VA: Fairfax Co.: Fairfax City	38.847 - 77.295	31 v 2006	J. W. Brown	1542	890	JF703087	JF703006
Pa. pyrusana	4551	United States: CA: Modoc Co.: Modoc Nat. For.	41.519 - 120.233	23 vii 2007	JJD, *et al.*	1541	901	JF703088	JF703007
Ptycholoma lecheana	4536	Denmark: NEZ: Copenhagen	55.676 12.568	31 v-06 vi 2007	O. Karsholt	1542	900	JF703090	JF703009
Ptycholom-oides aeriferana	4564	Denmark: LFM: Mandemarke	54.967 12.491	25-26 vii 2007	O. Karsholt	1512	901	JF703089	JF703008
Syndemis afflictana	2933	Canada: AB: Dunvegan Prov. Pk.	55.926 - 118.594	10 v 2006	JJD, *et al.*	1541	899	JF703092	JF703011
Xenotemna pallorana	4547	Canada: AB: Pakowki Dunes	49.397 - 110.875	08 vii 2008	JJD, A. Rose	1541	897	JF703093	JF703012
Ceracini	2943	Taiwan: Yilan Co. Fu-Shan Res. Sta.	24.765 121.595	22 v 2006	L. C. Shih	1539	902	JF703049	JF702961
Eana argentana	4545	Canada: AB: Kakwa Wildland Pk., Deadhorse Meadows	54.140 - 119.928	12 vii 2006	JJD, *et al.*	1539	901	JF703073	JF702992
Spargano-this vocaridor-sana	2959	Canada: AB: Kootenay Plains Ecol. Res.	52.003 - 116.465	27 vii 2006	JJD, B. C. Schmidt	1432	894	JF703091	JF703010
Acleris braunana	2953	Canada: AB: Wagner Bog	53.565 - 113.832	15 v 2006	JJD, *et al.*	1532	893	JF703013	JF702924

Table 4-2: Sequences used in this study from GenBank and other researchers.

Species	GenBank haplotype number	source	COI (bp)	28S (bp)
Acropolitis hedista	-	Zwick, Sperling, & Horak *unpublished*	1536	901
Adoxophyes furcatana	GU089610	Hebert, *et al.* 2010	658	-
Adoxophyes honmai	DQ073916	Lee, *et al.* 2006	1542	-
Adoxophyes sp. nr. *marmarygodes*	EF432743	Hulcr, *et al.* 2007	658	-
Adoxophyes sp. nr. *orana*	FJ499909	Craft, *et al.* 2010	658	-
Adoxophyes thoracica	FJ499942	Craft, *et al.* 2010	658	-
Aphelia paleana	GU828404	Mutanen, *et al.* 2010	803	-
Archips argyrospila	AF308931	Kruse & Sperling 2001	1536	-
Archips fuscocupreana	AF441272	Kruse & Sperling 2002	820	-
Archips georgiana	AF441275	Kruse & Sperling 2002	820	-
Archips goyerana	AF309509	Kruse & Sperling 2001	820	-
Archips grisea	AF441277	Kruse & Sperling 2002	820	-
Archips infumatana	AF441280	Kruse & Sperling 2002	820	-
Archips magnoliana	AF441276	Kruse & Sperling 2002	820	-
Archips nigriplagana	AF309510	Kruse & Sperling 2001	820	-
Archips rileyana	AF441281	Kruse & Sperling 2002	820	-
Archips semiferana	AF441273	Kruse & Sperling 2002	820	-
Argyrotaenia franciscana	AF093681	Landry, *et al.* 1999	1536	-
Argyrotaenia juglandana	GU089664	Hebert, *et al.* 2010	658	-
Argyrotaenia niscana	AF309513	Landry, *et al.* 1999	799	-
Argyrotaenia pinatubana	GU096226	Hebert, *et al.* 2010	659	-
Choristoneura biennis	DQ792587	Lumley & Sperling 2010	1536	-
Choristoneura freemani	L19094	Sperling, *et al.* 1994	1536	-
Choristoneura fumiferana	GQ890278	Lumley & Sperling 2010	1542	-
Choristoneura murinana	GQ890294	Lumley & Sperling 2010	1542	-
Choristoneura orae	DQ792586	Roe & Sperling 2007	1536	-
Choristoneura pinus	L19095	Sperling, *et al.* 1994	1536	-
Choristoneura retiniana	HM223218	Lumley & Sperling 2011	1536	-
Clepsis listerana	GU096279	Hebert, *et al.* 2010	658	-
Clepsis moeschleriana	GU096722	Hebert, *et al.* 2010	658	-
Cryptoptila australana	-	Zwick, Sperling, & Horak *unpublished*	1536	849
Ctenopseustis filicis	AF016466	Newcomb & Gleeson 1998	472	-
Ctenopseustis fraterna	AF016467	Newcomb & Gleeson 1998	472	-
Ctenopseustis herana	AF016468	Newcomb & Gleeson 1998	472	-
Ctenopseustis obliquana	AF016481	Newcomb & Gleeson 1998	472	-
Ctenopseustis servana	AF016471	Newcomb & Gleeson 1998	472	-
"Dichelia" clarana	-	Zwick, Sperling, & Horak *unpublished*	1530	896

Epichoristodes acerbella	EU031651	Timm, *et al.* 2010	429	-
Epitymbia alaudana	-	Zwick, Sperling, & Horak *unpublished*	1536	878
Homona aestivana	EF070743	Hulcr, *et al.* 2007	658	-
Homona auriga	EF070825	Hulcr, *et al.* 2007	658	-
Homona mermerodes	EF070749	Hulcr, *et al.* 2007	661	-
Homona salaconis	GU440205	Miller, *et al.* 2010	658	-
Homona spargotis	EF070839	Hulcr, *et al.* 2007	658	-
Homona trachyptera	EF070863	Hulcr, *et al.* 2007	466	-
Leucotenes coprosmae	AF016473	Newcomb & Gleeson 1998	472	-
Planotortrix avicenniae	AF016474	Newcomb & Gleeson 1998	472	-
Planotortrix excessana	AF016475	Newcomb & Gleeson 1998	472	-
Planotortrix flammea	AF016476	Newcomb & Gleeson 1998	472	-
Planotortrix notophaea	AF016477	Newcomb & Gleeson 1998	472	-
Planotortrix octo	AF016478	Newcomb & Gleeson 1998	472	-
Planotortrix octoides	AF016479	Newcomb & Gleeson 1998	472	-
Planotortrix puffini	AF016480	Newcomb & Gleeson 1998	472	-
Syndemis musculana	-	San Jose & Rubinoff *unpublished*	1483	-
Thrincophora lignigerana	GU828783	Mutanen, *et al.* 2010	670	-
Xenothictis gnetivora	AY313944	Brown, *et al.* 2003	639	-

Table 4-3: Primers used in this study.

	primer name	sequence	source
COI	Jerry	CAACATTTATTTTGATTTTTTGG	Simon, *et al.* 1994
	Pat2	TCCATTACATATAATCTGCCATATTAG	Sperling, *et al.* 1994
	K525	ACTGTAAATATATGATGAGCTCA	Simon, *et al.* 1994
	K698	TACAATTTATCGCCTAAACTTCAGCC	Sperling, *et al.* 1994
28S	28SD2fwtort	ACGYGCACGCGTTCWTAC	Sperling, *unpublished*
	28SD2rctort	GACTCCTTGGTCCGTTC	Sperling, *unpublished*
	A1	TCCKGTKTTCAAGACGGGGTC	Whiting, *et al.* 1997
	A335	TCGGARGGAACCAGCTACTA	Whiting, *et al.* 1997
	D2R	TTGGTCCGTGTTTCAAGACGG	Campbell, *et al.* 1994
	S1	GACCCGTCTTGAAMCAMGGA	Whiting, *et al.* 1997
	S3660	GAGAGTTMAASAGTACGTGAAAC	Dowton & Austin 1998
	WF&LD2F	GTGGGTGGTAAACTCCATCTAAG	Zwick, *unpublished*

Table 4-4: Non-molecular characters used in analyses from specimens examined and from the literature. ? = missing data; for zoogeography 0 = New World, 1 = Old World, 2 = Australasian; for hosts 0 = monophagous/oligophagous, 1 = polyphagous; for all others 0 = absent, 1 = present; for specimen source L = literature, S = specimen.

species	**zoogeography**	**hosts**	**costal fold**	**antennal notch**	**anterior thoracic scale tufts**	**coxal hair pencil**	**hindwing pouch**	**basal abdominal scales**	**pregenital sternite modification**	**specimen source**
Acropolitis hedista	2	1	1	?	?	?	0	0	?	L
Adoxophyes furcatana	0	0	1	0	0	0	0	0	0	S
Adoxophyes honmai	1	0	1	0	?	?	0	0	0	L
Adoxophyes near *marmarygodes*	2	?	?	?	?	?	0	0	0	L
Adoxophyes near *orana*	1	?	?	?	?	?	0	0	0	L
Adoxophyes negundana	0	0	1	0	0	0	0	0	0	S
Adoxophyes orana	1	1	1	0	0	0	0	0	0	S
Adoxophyes thoracica	2	?	1	?	?	?	0	0	0	L
Aphelia alleniana	0	1	0	0	0	0	0	0	0	S
Aphelia ochreana	1	0	0	0	0	0	0	0	0	S
Aphelia paleana	1	0	0	?	?	?	0	0	0	L
Aphelia unitana	1	0	0	0	0	0	0	0	0	S
Archepandemis coniferana	0	0	0	0	0	?	0	0	0	L
Archips alberta	0	0	1	0	0	0	0	0	0	S
Archips argyrospila	0	1	1	0	0	0	0	0	0	S
Archips cerasivorana	0	0	1	0	0	0	0	0	0	S
Archips eleagnana	0	0	1	0	0	0	0	0	0	S
Archips fervidana	0	0	1	0	0	0	0	0	0	S
Archips fuscocupreana	1	1	1	0	0	?	0	0	0	L
Archips georgiana	0	0	1	0	0	0	0	0	0	S
Archips goyerana	0	0	1	0	0	?	0	0	0	L
Archips grisea	0	1	1	0	0	0	0	0	0	S
Archips infumatana	0	0	1	0	0	0	0	0	0	S
Archips magnoliana	0	0	1	0	0	?	0	0	0	L
Archips negundana	0	0	1	0	0	0	0	0	0	S
Archips nigriplagana	0	?	1	0	0	?	0	0	0	L
Archips packardiana	0	0	0	0	0	0	0	0	0	S

Archips podana	1	1	1	0	0	0	0	0	0	S
Archips purpurana	0	1	1	0	0	0	0	0	0	S
Archips rileyana	0	0	1	0	0	0	0	0	0	S
Archips rosana	1	1	1	0	0	0	0	0	0	S
Archips semiferana	0	1	1	0	0	0	0	0	0	S
Archips striana	0	0	1	0	0	0	0	0	0	S
Archips xylosteana	1	1	1	0	0	0	0	0	0	S
Argyrotaenia alisellana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia coloradana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia dorsalana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia floridana	0	?	0	0	0	0	0	0	0	S
Argyrotaenia franciscana	0	1	0	0	?	0	0	0	0	S
Argyrotaenia graceana	0	?	0	0	0	0	0	0	0	S
Argyrotaenia juglandana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia kimballi	0	0	0	0	0	0	0	0	0	S
Argyrotaenia lautana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia ljungiana	1	1	0	0	0	0	0	0	0	S
Argyrotaenia mariana	0	1	0	0	0	0	0	0	0	S
Argyrotaenia niscana	0	0	0	0	0	?	0	0	0	L
Argyrotaenia occultana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia pinatubana	0	0	0	0	0	?	0	0	0	S
Argyrotaenia provana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia quadrifasciana	0	0	0	0	?	0	0	0	0	S
Argyrotaenia quercifoliana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia repertana	0	1	0	0	?	0	0	0	0	S
Argyrotaenia tabulana	0	0	0	0	0	0	0	0	0	S
Argyrotaenia velutinana	0	1	0	0	0	0	0	0	0	S
Cacoecimorpha pronubana	1	1	0	0	0	0	0	0	?	S
Capua vulgana	1	0	1	0	?	0	0	0	0	L
Choristoneura albaniana	1	0	0	0	0	0	0	0	0	S
Choristoneura argentifasciata	0	0	0	0	0	0	0	0	0	S
Choristoneura biennis	0	0	0	0	0	0	0	0	0	S
Choristoneura conflictana	0	0	0	0	0	0	0	0	0	S
Choristoneura freemani	0	0	0	0	0	0	0	0	0	S
Choristoneura fumiferana	0	0	0	0	0	0	0	0	0	S
Choristoneura hebenstreitella	1	1	0	?	?	?	0	0	0	L
Choristoneura murinana	1	0	0	?	?	?	0	0	0	L
Choristoneura orae	0	0	0	0	0	0	0	0	0	S
Choristoneura parallela	0	1	0	0	0	0	0	0	0	S
Choristoneura pinus	0	0	0	0	0	0	0	0	0	S
Choristoneura retiniana	0	0	0	0	0	0	0	0	0	S
Choristoneura rosaceana	0	1	0	0	0	0	0	0	0	S

Choristoneura zapulata	0	1	0	0	0	0	0	0	0	S
Clepsis anderslaneyii	0	?	1	0	0	0	0	0	0	S
Clepsis clemensiana	0	1	1	0	0	0	0	0	0	S
Clepsis consimilana	1	1	1	0	0	0	0	0	0	S
Clepsis fucana	0	1	0	?	?	?	0	0	0	L
Clepsis listerana	0	?	0	0	0	?	0	0	0	L
Clepsis melaleucana	0	1	1	0	0	0	0	0	0	S
Clepsis moeschleriana	1	?	0	?	?	?	0	0	0	L
Clepsis penetralis	0	?	0	0	0	0	0	0	0	S
Clepsis peritana	0	1	0	0	0	0	0	0	0	S
Clepsis persicana	0	1	1	0	0	0	0	0	0	S
Clepsis rurinana	1	1	1	0	0	0	0	0	0	S
Clepsis siciliana	1	?	1	0	0	0	0	0	0	S
Clepsis spectrana	1	1	1	?	?	?	0	0	0	L
Clepsis virescana	0	0	1	0	0	0	0	0	0	S
Cryptoptila australana	2	1	1	?	0	?	0	0	?	L
Ctenopseustis filicis	2	0	1	?	?	?	0	0	0	L
Ctenopseustis fraterna	2	0	1	?	?	?	0	0	0	L
Ctenopseustis herana	2	1	1	?	?	?	0	0	0	L
Ctenopseustis obliquana	2	1	1	?	0	?	0	0	0	L
Ctenopseustis servana	2	1	1	?	?	?	0	0	0	L
Cudonigera houstonana	0	0	0	0	0	0	0	0	0	S
Dichelia histrionana	1	0	1	0	1	?	0	0	0	L
"Dichelia" clarana	2	?	1	?	?	?	0	0	?	L
Diedra intermontana	0	0	0	0	0	0	0	0	0	S
Ditula angustiorana	1	1	1	0	0	0	0	0	0	S
Epagoge grotiana	1	1	0	0	0	?	0	0	?	L
Epichoristodes acerbella	1	1	0	?	0	?	0	0	?	L
Epiphyas ashworthana	2	0	1	0	0	?	0	0	0	L
Epiphyas caryotis	2	1	?	?	?	?	0	0	0	L
Epiphyas postvittana	2	1	1	0	0	0	0	0	0	S
Epitymbia alaudana	2	0	1	1	0	?	1	0	?	L
Homona aestivana	2	1	0	?	0	?	0	0	?	L
Homona auriga	2	?	?	?	?	?	0	0	?	L
Homona mermerodes	2	1	?	?	?	?	0	0	?	L
Homona salaconis	1	1	0	0	0	?	0	0	?	L
Homona spargotis	2	1	?	?	?	?	0	0	?	L
Homona trachyptera	2	1	1	?	?	?	0	0	?	L
Leucotenes coprosmae	2	0	0	?	?	?	0	0	?	L
Lozotaenia hesperia	0	?	0	0	0	1	0	0	0	S
Lozotaeniodes cupressana	1	0	0	0	0	0	0	0	0	S
Pandemis canadana	0	1	0	1	0	0	0	1	1	S

Pandemis cerasana	1	1	0	1	0	0	0	1	1	S
Pandemis cinnamomeana	1	1	0	1	0	0	0	1	1	S
Pandemis corylana	1	1	0	1	0	0	0	1	1	S
Pandemis dumetana	1	1	0	0	0	?	0	1	1	L
Pandemis heparana	1	1	0	1	0	0	0	1	1	S
Pandemis lamprosana	0	1	0	1	0	0	0	0	1	S
Pandemis limitata	0	1	0	1	0	0	0	1	1	S
Pandemis pyrusana	0	1	0	1	0	0	0	1	1	S
Planotortrix avicenniae	2	0	1	?	?	?	0	0	?	L
Planotortrix excessana	2	1	1	0	0	?	0	0	?	L
Planotortrix flammea	2	0	1	?	?	?	0	0	?	L
Planotortrix notophaea	2	1	1	?	?	?	0	0	?	L
Planotortrix octo	2	1	1	?	?	?	0	0	?	L
Planotortrix octoides	2	1	1	?	?	?	0	0	?	L
Planotortrix puffini	2	0	1	?	?	?	0	0	?	L
Ptycholoma lecheana	1	1	1	0	0	0	0	0	0	S
Ptycholomoides aeriferana	1	0	1	0	0	?	0	0	?	L
Syndemis afflictana	0	1	1	0	1	0	0	0	0	S
Syndemis musculana	1	1	1	0	1	0	0	0	0	S
Thrincophora lignigerana	2	0	1	0	0	?	0	0	?	L
Xenotemna pallorana	0	1	0	0	0	0	0	0	?	S

Table 4-5. Tables of correlated changes. The total correlation values refer to separate χ^2 analyses of terminal taxa.

	novel SSC	
	0	+
loss of CF	13	2
	CF	
	0	-
gain novel SSC	3	4
total correlation, p = 0.13		

	oligophagy	
	0	+
loss of SSCs	5	7
	SSCs	
	0	-
gain oligo	10	8
total correlation, p = 0.0045		

	Nearctic	
	0	+
loss of SSCs	7	8
	SSCs	
	0	-
Nearctic	7	8
total correlation, p = 0.00039		

Appendix 4-1: Zoogeography of Archipini genera.

genus	number of spp.	Nearctic	Neotropical	Palaearctic	Afrotropic	Indomalaysian	Australian/Oceania	References
Abrepagoge	1			X				Razowski 2001; 2002a
Acroceuthes	2						X	Brown 2005
Acropolitis	9						X	Brown 2005
Adoxophyes	50	X		X	X	X	X	Brown 2005; Byun, *et al.* 2003; Diakonoff 1939; 1941a; 1941b; 1941c; 1941d; 1951; 1952; 1957; 1960; 1961; 1967; 1976; 1982; Freeman 1958; Hulcr, *et al.* 2007; Lee, *et al.* 2005; Liu & Li 2002; Razowski 2001; Robinson, *et al.* 1994
Allodemis	6					X		Brown 2005; Diakonoff 1939; 1941; Robinson, *et al.* 1994
Ancyroclepsis	2					X		Brown 2005; Diakonoff 1976; Liu & Li 2002
Aneuxanthis	1			X				Razowski 2002a
Anisotenes	21					X	X	Brown 2005; Diakonoff 1941; 1953; Liu & Li 2002
Anthophrys	1				X			Diakonoff 1960; 1973
Antiphrastis	1					X		Diakonoff 1939
Aphelia	36	X		X	X			Brown 2005; Byun, *et al.* 2003; Gaedike 1990; Jürivete & Õunap 2008; Liu & Li 2002; Obraztsov 1959; Razowski 1981; 2001; 2002a; Trematerra 2010b
Aphthonocosma	1						X	Brown 2005
Archepandemis	3	X						Freeman 1965; Mutuura 1978
Archidemis	1					X		Diakonoff 1967
Archips	108	X	X	X	X	X		Brown 2005; Byun, *et al.* 1998; 2003; Chapman 1973; Diakonoff 1941c; 1951; 1952; 1976; 1982; Duncan 2006; Franclemont 1986; Freeman 1958; Hoebeke, *et al.* 2008; Jinbo 2006; Kruse 2000; Kruse & Sperling 2001; Liu & Li 2002; MacKay 1962; Maier 2003; Razowski 1977; 2000; 2001; Robinson, *et al.* 1994; Trematerra 2010a; 2010b
Argyrotaenia	99	X	X	X				Brown & Cramer 1999; Brown 2005; Chapman 1973; Chapman & Lienk 1971; Duncan 2006; Freeman 1944; 1958; Heppner 1989; Liu & Li 2002; MacKay 1962; Obraztsov 1961; 1962; Powell 1960; 1964; Razowski 2001; Razowski & Becker 2000; Trematerra 2010b; Trematerra & Brown 2004
Aristocosma	1						X	Brown 2005
Arizelana	2						X	Brown 2005
Ascerodes	1						X	Meyrick 1905
Asteriognatha	2					X		Brown 2005
Atelodora	2						X	Brown 2005
Authomaema	3						X	Brown 2005

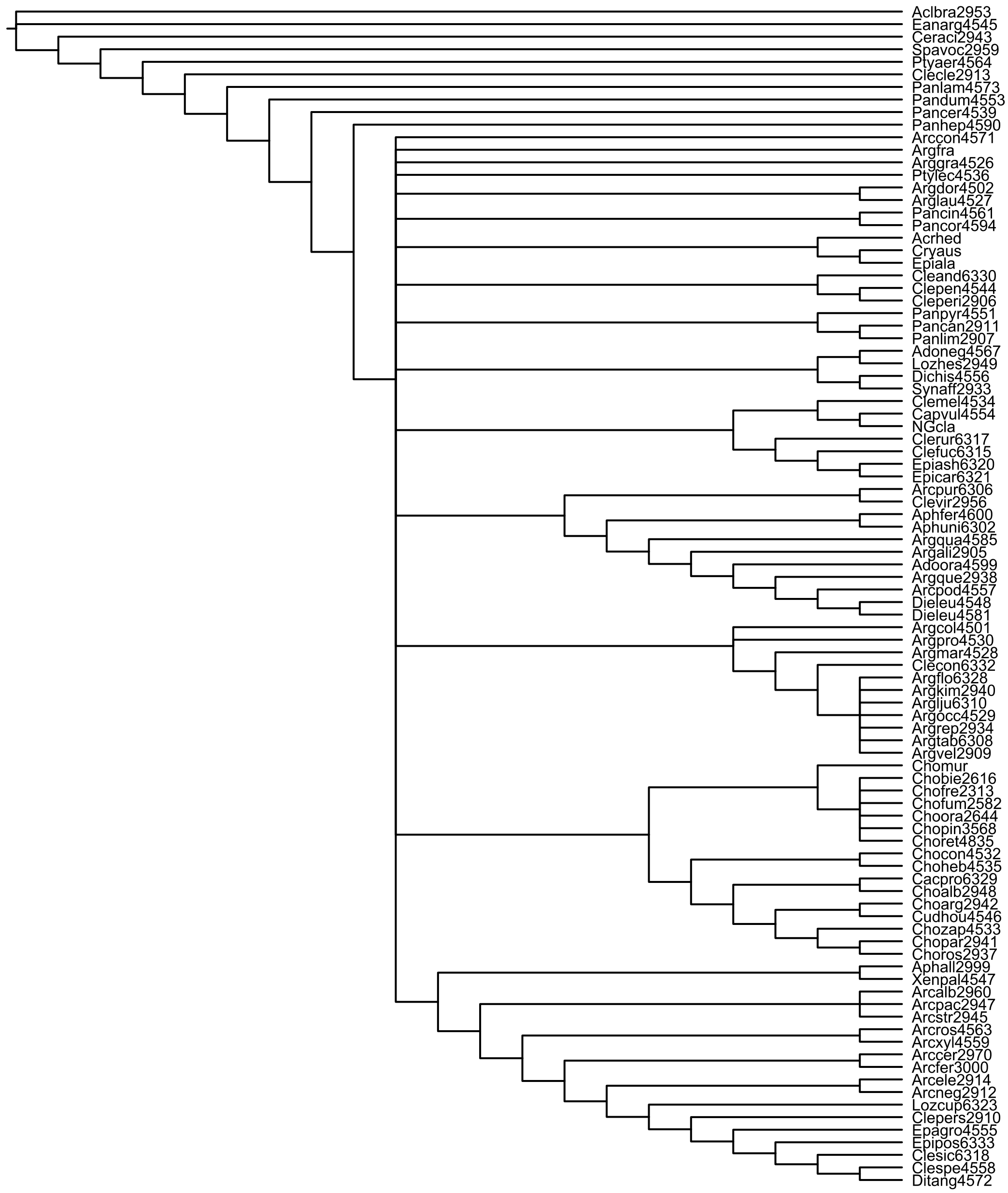
Avaria	2			X				Brown 2005; Razowski 2002a
Balioxena	1				X			Diakonoff 1960; 1973
Battalia	21						X	Brown 2005; Diakonoff 1953
Borboniella	16				X			Brown 2005; Diakonoff 1957; 1961
Borneogena	1					X		Diakonoff 1941d
Brachyvalva	1				X			Diakonoff 1960
Bradleyella	5						X	Brown 2005
Cacoecimorpha	1			X				Razowski 2001
Callibryastis	1					X		Diakonoff 1939
Capua	22			X	X	X	X	Brown 2005; Diakonoff 1967; 1976; Jürivete & Õunap 2008; Liu & Li 2002; Razowski 2001
Carphomigma	1						X	Brown 2005
Catamacta	5				X		X	Brown 2005; Diakonoff 1939; Diakonoff 1941d
Ceramea	1					X		Diakonoff 1951
Ceritaenia	1		X					Razowski & Becker 2000
Chionothremma	29						X	Brown 2005
Chiraps	4					X		Brown 2005; Liu & Li 2002; Robinson, et al. 1994
Choanograptis	15			X		X	X	Brown 2005; Diakonoff 1941d; 1948
Choristoneura	46	X		X	X	X		Bradley, *et al.* 1973; Brown 2005; Byun, et al. 2003; Dang 1992a; 1992b; Duncan 2006; Freeman 1958; Heppner 1989; Liu & Li 2002; Lumley & Sperling 2010; Obraztsov 1962; Razowski 2001; 2002a; 2008; Razowski & Trematerra 2010; Trematerra 2010b
Claduncaria	2		X					Brown 2005; Razowski & Becker 2000
Clepsis	150	X	X	X	X	X		Brown 2005; Chapman & Lienk 1971; Clifton 2007; Dang *et al.* 1996; Diakonoff 1957; 1976; Dombroskie & Brown 2009; Duncan 2006; Freeman 1958; Jürivete & Õunap 2008; Kearfott 1907; Liu & Li 2002; MacKay 1962; Obraztsov 1962; 1968; Razowski 1979a; 1979b; 2001; 2002a; 2004; Razowski, *et al.* 2010; Trematerra 2010a; Wang, *et al.* 2003
Coeloptera	3						X	Brown 2005
Cornips	2				X			Razowski, *et al.* 2010
Cornuclepsis	1		X					Razowski & Becker 2000
Cornusaccula	1				X			Diakonoff 1960
Cosmiophrys	2				X			Diakonoff 1960; 1970
Cryptomelaena	1					X		Brown 2005
Cryptoptila	4						X	Brown 2005; Diakonoff 1953
Ctenopseustis	6				X		X	Brown 2005; Green & Dugdale 1982; Newcomb & Gleeson 1998
Cudonigera	1	X						Freeman 1958; Powell & Obraztsov 1977
Cununcus	1		X					Razowski & Becker 2000
Cuspidata	10				X			Diakonoff 1960; 1963; 1970; 1973
Daemilus	2			X				Byun, *et al.* 1998; Jinbo 2000; Liu & Li 2002

Dentisociaria	1			X				Jinbo 2000
Dicanticinta	1			X				Brown 2005
Dicellitis	3					X	X	Brown 2005; Diakonoff 1939; 1941b; 1952; 1976
Dichelia	4			X		X		Brown 2005; Křenek 2000; Razowski 2001; 2002a
Dichelopa	50						X	Brown 2005
Diedra	5	X						Rubinoff & Powell 1999
Digitosa	6				X			Diakonoff 1960; 1970; 1973
Diplocalyptis	6			X		X		Brown 2005; Byun, *et al.* 2003; Diakonoff 1976; 1982; Liu & Li 2002; Razowski 2000
Ditula	2			X				Razowski 2002a
Droceta	1				X			Brown 2005
Durangarchips	1	X						Brown 2005
Dynatocephala	1					X		Robinson, *et al.* 1994
Ecclitica	4						X	Brown 2005; Meyrick 1905
Egogepa	2			X				Brown 2005
Electraglaia	4					X		Brown 2005; Diakonoff 1976
Epagoge	8			X		X	X	Brown 2005; Baixeras & Dominguez 1993; Diakonoff 1941b; 1941c; 1941d; 1948; Razowski 2001
Epalxiphora	1						X	Brown 2005
Epichorista	32				X		X	Brown 2005; Diakonoff 1939; 1941a
Epichoristodes	15				X			Brown 2005; Diakonoff 1960; 1970; 1973; Razowski 2002a; Razowski, *et al.* 2010; Timm, et al. 2010
Epiphyas	40						X	Brown 2005; Newcomb & Gleeson 1998; Razowski 2002a
Ericodesma	14						X	Brown 2005; Meyrick 1905
Eurythecta	8						X	Brown 2005; Meyrick 1905
Exorstaenia	2		X					Razowski & Becker 2000
Furcataenia	5		X					Razowski & Becker 2000
Gelophaula	9						X	Brown 2005
Geogepa	8			X		X		Brown 2005; Jinbo 2000; Liu & Li 2002
Gephyraspis	3				X			Diakonoff 1960; 1973
Glyphidoptera	2						X	Brown 2005
Gnorismoneura	24			X		X		Brown 2005; Byun, et al. 1998; 2003; Liu & Li 2002
Gongylotypa	1					X		Brown 2005
Goniotorna	36				X			Brown 2005; Diakonoff 1960; 1963; 1970; 1973
Harmologa	13						X	Brown 2005; Diakonoff 1939
Hectaphelia	6				X			Brown 2005
Heterochorista	20						X	Brown 2005; Diakonoff 1953
Hiceteria	3						X	Brown 2005
Homona	34			X		X	X	Brown 2005; Byun, *et al.* 1998; Diakonoff 1941a; 1941b; 1941c; 1941d; 1948; 1952; 1967; 1982; Hulcr, *et al.* 2007; Liu & Li 2002; Miller, *et al.* 2010; Razowski 2008; Robinson, *et al.* 1994

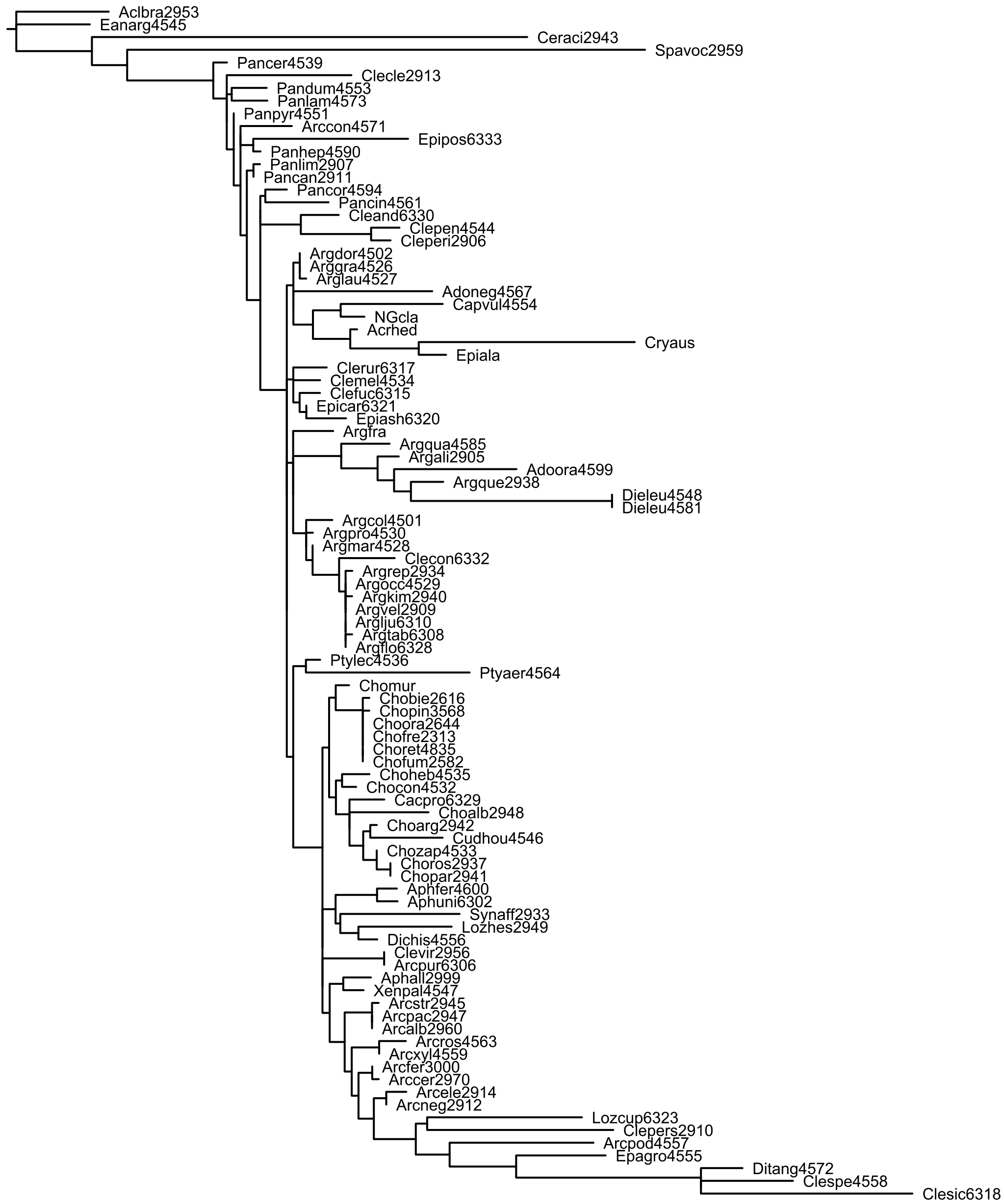
Homonoides	1				X			Diakonoff 1960
Homonopsis	4			X				Brown 2005; Byun, *et al.* 1998; Liu & Li 2002
Hypsidracon	1				X			Brown 2005
Idolatteria	11		X					Brown 2005
Isochorista	10						X	Brown 2005; Diakonoff 1939
Isodemis	4					X		Brown 2005; Diakonoff 1976; Liu & Li 2002; Robinson, *et al.* 1994
Isotenes	24					X	X	Brown 2005; Diakonoff 1939; 1941a; 1941c; 1941d; 1948; 1952; 1953; 1960; Liu & Li 2002; Robinson, *et al.* 1994
Labidosa	2				X			Brown 2005; Diakonoff 1960
Leontochroma	5					X		Brown 2005; Diakonoff 1976; Liu & Li 2002
Leptochroptila	1						X	Diakonoff 1939; 1952
Leucotenes	1						X	Newcomb & Gleeson 1998
Lozotaenia	24	X		X	X			Brown 2005; Byun, *et al.* 1998; Franclemont 1986; Jinbo 2000; Liu & Li 2002; Obraztsov 1962; Powell 1962b; Razowski 2001; 2002a; Razowski & Trematerra 2010; Razowski, *et al.* 2010
Lozotaeniodes	3			X				Bradley, et al. 1973; Brown 2005; Razowski 2002a
Lumaria	10				X	X		Brown 2005; Diakonoff 1941; 1948; Razowski 2002b; Razowski, et al. 2010; Robinson, et al. 1994
Mantua	1						X	Brown 2005
Meridemis	11				X	X		Brown 2005; Diakonoff 1976; 1979; 1982; Robinson, et al. 1994; Razowski 2008; Razowski, *et al.* 2010
Merophyas	10						X	Brown 2005; Patrick & Dugdale 1994
Mesocalyptis	2						X	Brown 2005
Metamesia	21				X			Brown 2005; Diakonoff 1960; 1973; Razowski & Trematerra 2010
Midaellobes	1				X			Diakonoff 1960
Minutargyrotoza	2			X		X		Brown 2005; Diakonoff 1976; 1982
Neocalyptis	29			X		X	X	Brown 2005; Byun, *et al.* 2003; 2007; Diakonoff 1941d; 1948; 1951; 1967; Liu & Li 2002; Razowski 2000; Robinson, *et al.* 1994; Wang, *et al.* 2003
Niphothixa	4				X			Brown 2005; Diakonoff 1960; 1970
Notioclepsis	1					X		Brown 2005
Ochetarcha	1						X	Brown 2005
Ochrotaenia	1		X					Razowski & Becker 2000
Orilesa	2				X			Brown 2005
Panaphelix	2						X	Brown 2005; Diakonoff 1957
Pandemis	63	X		X	X	X		Brown 2005; Byun, et al. 2003; Chapman & Lienk 1971; Diakonoff 1960; 1963; 1970; 1973; Liu & Li 2002; MacKay 1962; Mutuura 1980; Razowski 1978; 2001; Trematerra 2010a; 2010b
Paradichelia	8						X	Brown 2005; Diakonoff 1941
Paramesia	4			X				Brown 2005; Razowski 2001; 2002a
Paramesiodes	5				X			Brown 2005; Diakonoff 1960

Paraphasis	1						X	Brown 2005
Pararrhaptica	19						X	Brown 2005
Periclepsis	2			X				Brown 2005; Křenek 2000; Razowski 2001
Peteliacma	1				X			Diakonoff 1960
Petridia	1					X		Brown 2005
Phaenacropista	2					X		Brown 2005; Diakonoff 1941a; 1941b; 1941c; 1941d
Philedone	1			X				Bradley, *et al.* 1973; Razowski 2001
Philedonides	3			X				Bradley, *et al.* 1973; Razowski 2001; 2002a
Philocryptica	1						X	Brown 2005
Phlebozemia	1				X			Brown 2005
Planostocha	4					X	X	Brown 2005; Byun, et al. 1998; Diakonoff 1941; Liu & Li 2002
Planotortrix	7						X	Newcomb & Gleeson 1998
Platyhomonopsis	1			X				Brown 2005
Platysemaphora	1				X			Diakonoff 1960
Procalyptis	3						X	Brown 2005; Diakonoff 1939
Procrica	14				X			Brown 2005; Diakonoff 1960; 1963; Razowski 2008; Razowski & Trematerra 2010
Pseudeulia	1			X				Liu & Li 2002; Razowski 2002a
Pteridoporthis	1						X	Brown 2005
Pternozyga	4					X	X	Brown 2005; Diakonoff 1939; 1941
Ptycholoma	5			X				Brown 2005; Byun, et al. 2003; Liu & Li 2002; Razowski 2001; 2002a
Ptycholomoides	1			X				Liu & Li 2002; Razowski 2001
Pyrgotis	12					X	X	Brown 2005
Pysarcha	1					X		Brown 2005
Saetotaenia	1		X					Brown 2005
Scotiophyes	3					X		Brown 2005; Liu & Li 2002; Robinson, et al. 1994
Snodgrassia	4					X	X	Brown 2005; Diakonoff 1941; 1967
Sorensenata	1						X	Brown 2005
Spheterista	17						X	Brown 2005
Spinotaenia	1		X					Razowski & Becker 2000
Sychnochlaena	1					X		Brown 2005
Sychnovalva	4		X					Razowski 1997; Razowski & Becker 2000
Syndemis	10	X		X		X	X	Brown 2005; Diakonoff 1948; 1953; Liu & Li 2002; Razowski 2001; Trematerra 2010b
Tacertaenia	1		X					Razowski 1997
Terricula	5			X		X		Brown 2005; Jinbo 2000
Terthreutis	11					X		Brown 2005; Diakonoff 1951; 1976; Liu & Li 2002
Thrincophora	14						X	Brown 2005; Diakonoff 1939; 1952; 1953
Tosirips	2			X				Byun, et al. 2003; Liu & Li 2002; Razowski 2002a

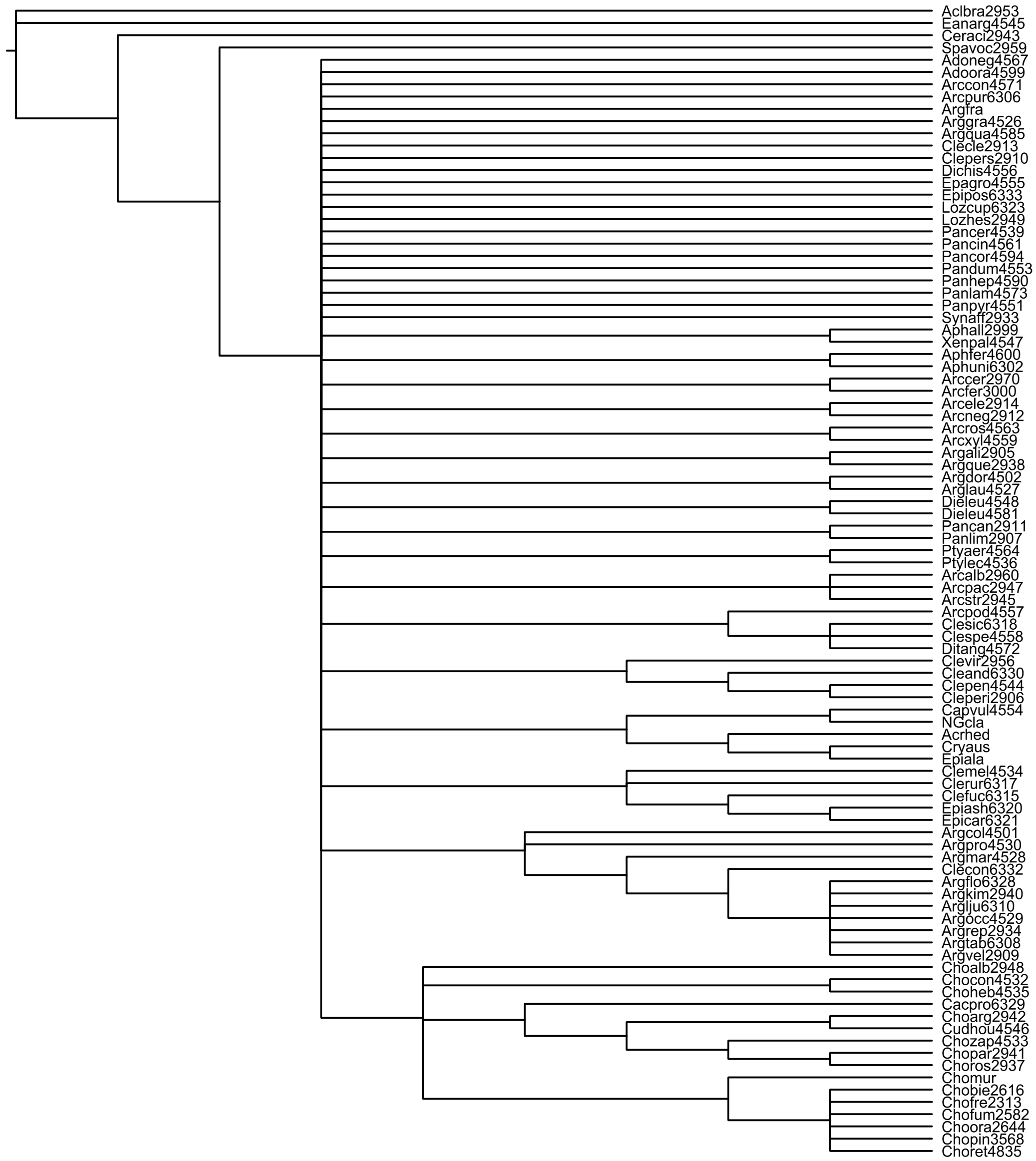
Tremophora	6						X	Brown 2005; Diakonoff 1953
Tuckia	2				X			Brown 2005
Ulodemis	5					X		Diakonoff 1941c; 1941d; 1976; Liu & Li 2002; Robinson, *et al.* 1994
Vialonga	2				X			Diakonoff 1960; 1973
Viettea	1				X			Diakonoff 1960
Williella	2						X	Brown 2005
Worcestaria	1				X			Brown 2005
Xeneda	1						X	Diakonoff 1961
Xenophylla	1				X			Diakonoff 1960
Xenotemna	1	X						Chapman & Lienk 1971; Razowski 1981
Xenothictis	6						X	Brown, *et al.* 2003
Zacorisca	30					X	X	Brown 2005; Diakonoff 1941a; 1941d; 1948; 1967; Robinson, et al. 1994
new genus 1	8						X	Brown 2005
new genus 2	10						X	Brown 2005
new genus 3	1						X	Brown 2005
new genus 4	3						X	Brown 2005
new genus 5	6						X	Brown 2005
new genus 6	19						X	Brown 2005
new genus 7	9						X	Brown 2005
new genus 8	2						X	Brown 2005
new genus 9	18						X	Brown 2005
new genus 10	14						X	Brown 2005
new genus 11	1						X	Brown 2005
new genus 12	13						X	Brown 2005
new genus 13	1						X	Brown 2005
new genus 14	1						X	Brown 2005
new genus 15	6						X	Brown 2005
new genus 16	1						X	Brown 2005
unplaced	20		X	X	X	X		Brown 2005
total	**1709**	**14**	**15**	**40**	**44**	**50**	**81**	



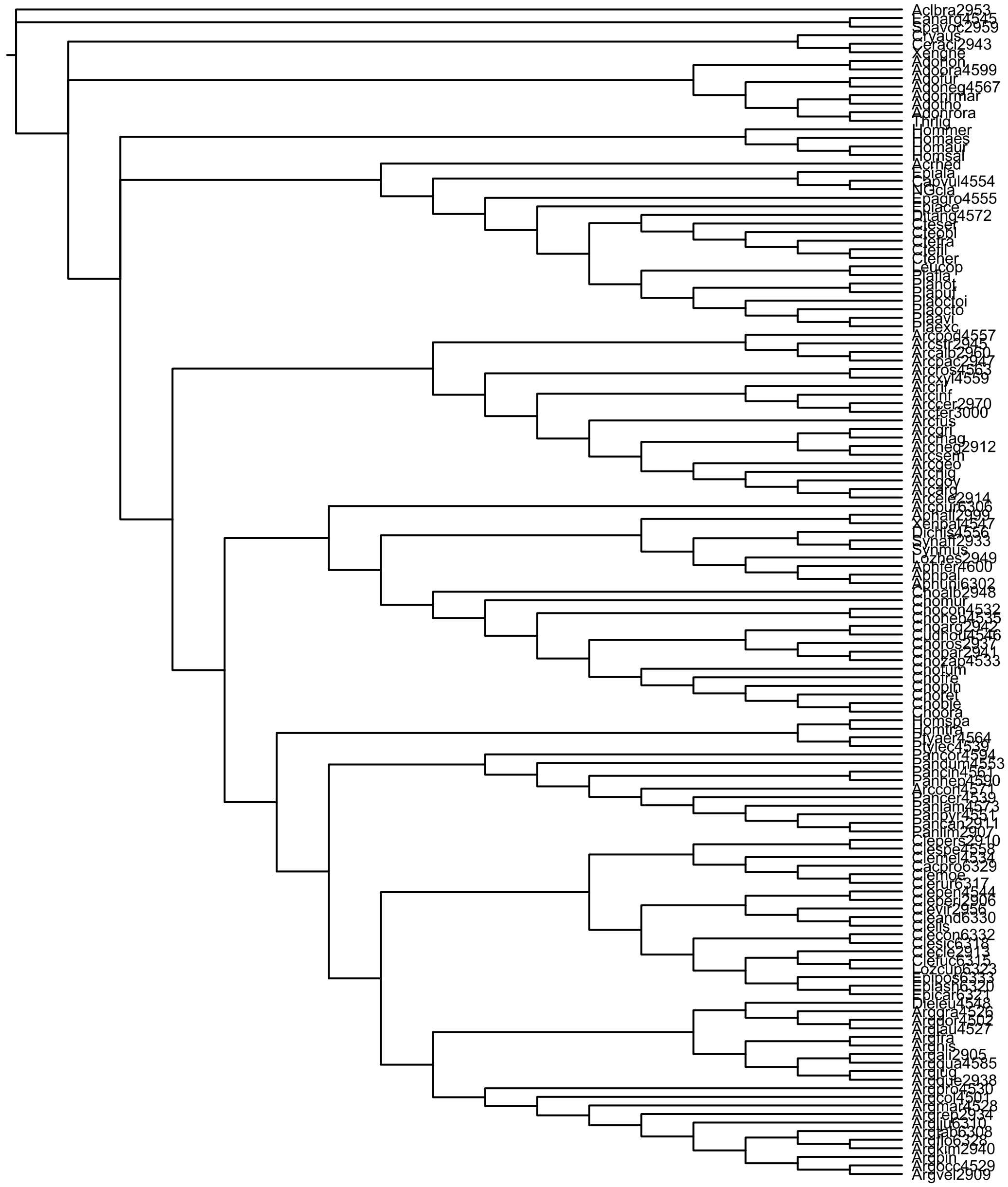
Appendix 4-2: Consensus tree obtained from parsimony analysis of 28S.



Appendix 4-3: Maximum likelihood tree obtained from Bayesian analysis of 28S.

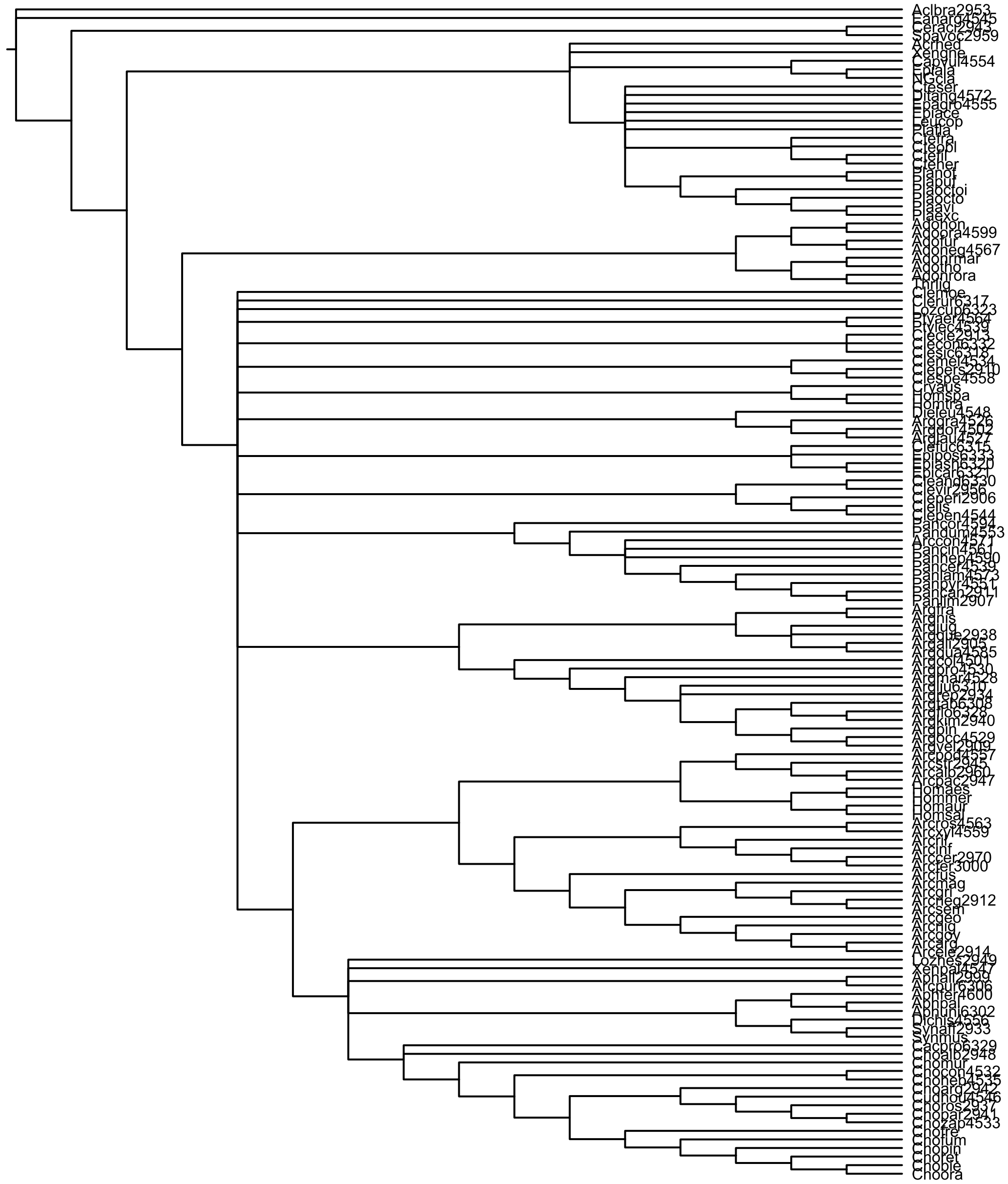


Appendix 4-4: Consensus tree obtained from Bayesian analysis of 28S.

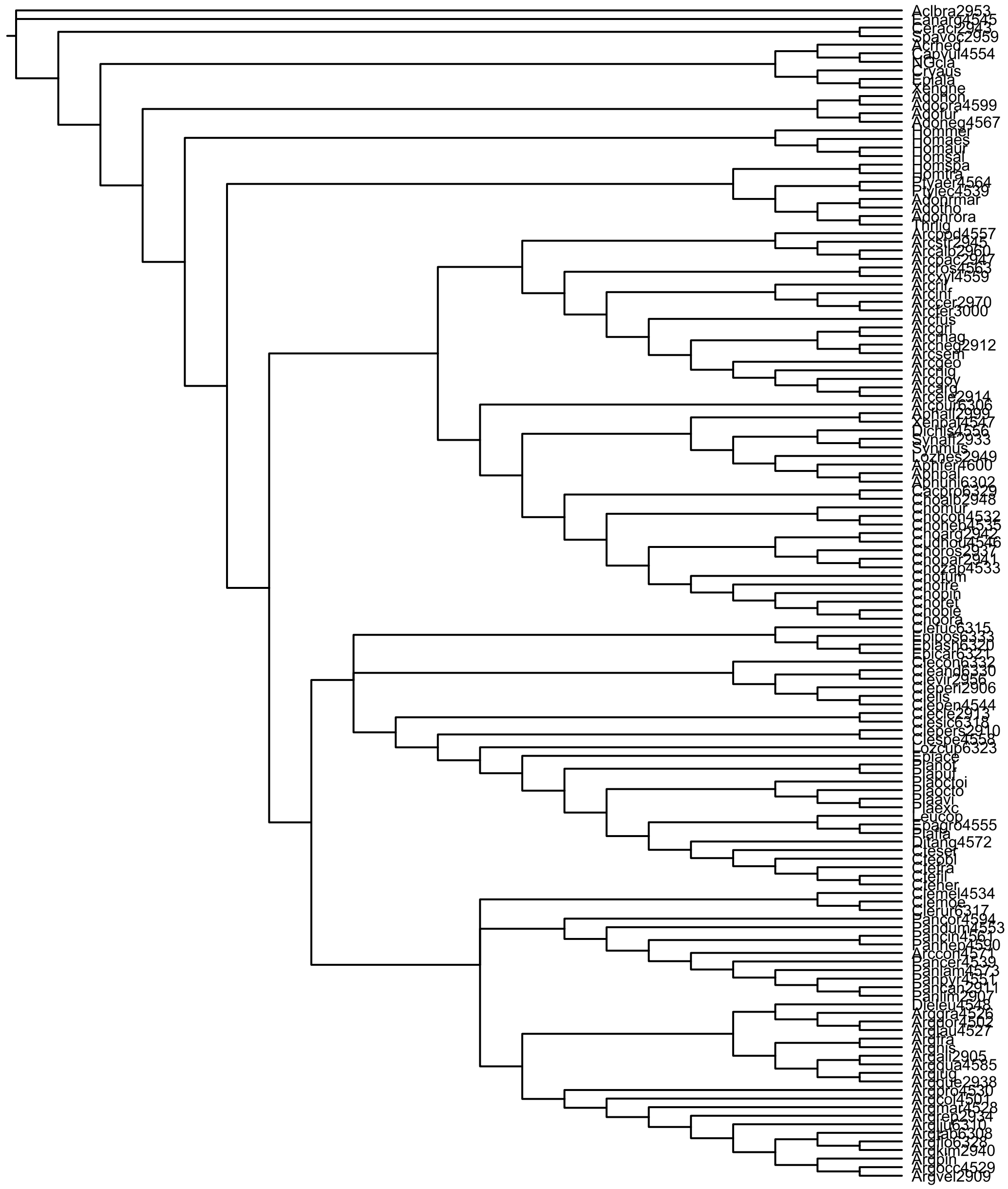


Appendix 4-5: Consensus tree obtained from parsimony analysis of COI.

Appendix 4-6: Tree obtained from likelihood analysis of COI.

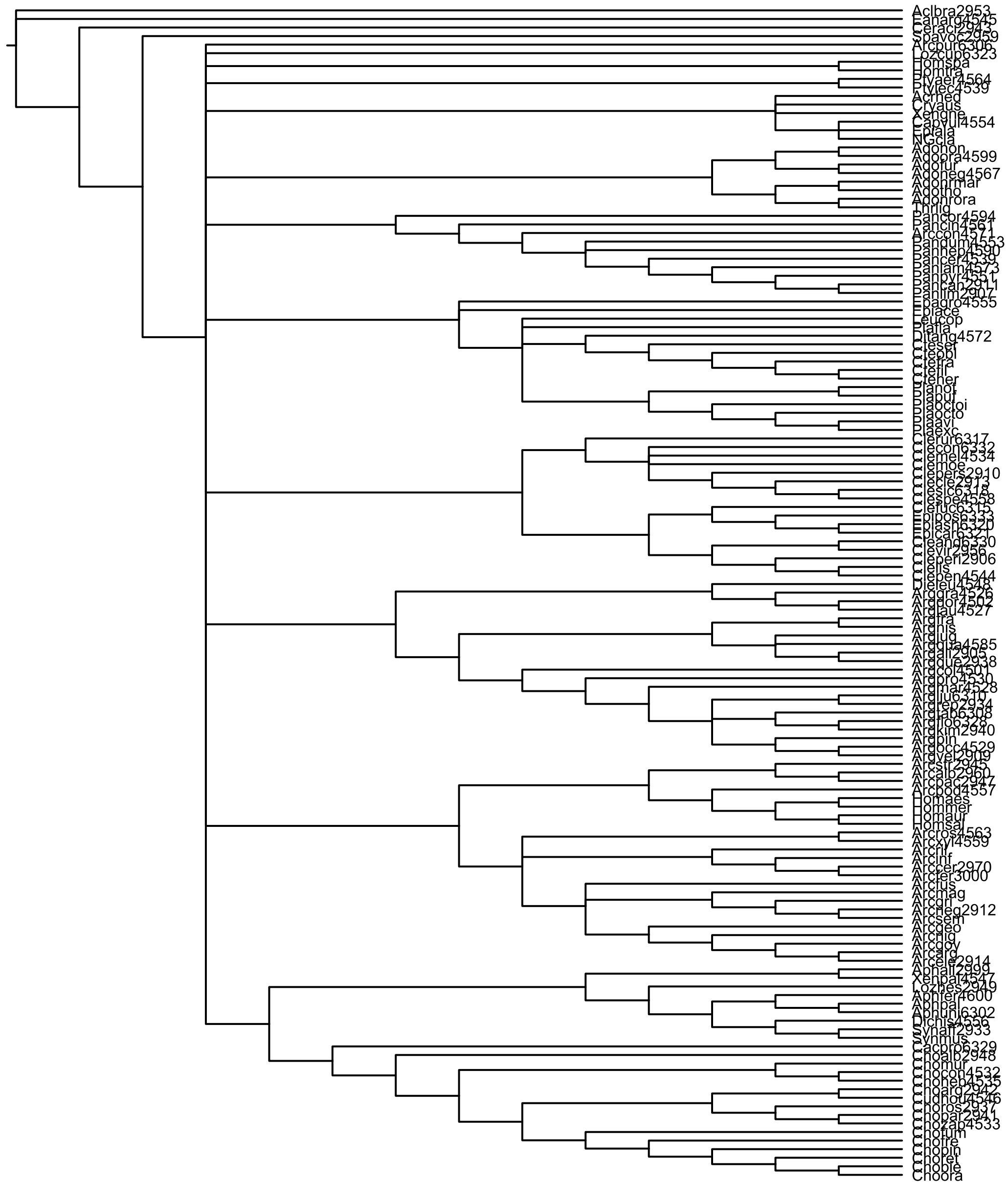


Appendix 4-7: Consensus tree obtained from Bayesian analysis of COI.



Appendix 4-8: Consensus tree obtained from parsimony analysis of 28S+COI.

Appendix 4-9: Tree obtained from likelihood analysis of 28S+COI.



Appendix 4-10: Consensus tree obtained from Bayesian analysis of 28S+COI.

Appendix 4-11: Ancestral zoogeographic character reconstruction and proportional likelihoods.

Clade #	proportional likelihoods		
	New World	Old World	Australasian
3	0.0118	0.0591	0.9290
4	0.0066	0.1070	0.8865
5	0.0371	0.1381	0.8248
6	0.3117	0.3982	0.2901
7	0.9486	0.0292	0.0223
8	0.0232	0.9549	0.0218
9	0.0085	0.0784	0.9131
10	0.0014	0.0058	0.9928
11	0.0080	0.1385	0.8535
12	0.0157	0.9815	0.0028
13	0.1605	0.8289	0.0106
14	0.0110	0.9134	0.0756
15	0.0055	0.0633	0.9312
16	0.0015	0.9928	0.0057
17	0.0000	0.0049	0.9950
18	0.0012	0.0080	0.9908
19	0.0056	0.0763	0.9181
20	0.0006	0.5420	0.4574
21	0.0056	0.5388	0.4556
22	0.0036	0.0405	0.9559
23	0.0009	0.0035	0.9956
24	0.0005	0.0007	0.9988
25	0.0005	0.0005	0.9991
26	0.0035	0.0439	0.9526
27	0.0009	0.0035	0.9957
28	0.0010	0.0040	0.9950
29	0.0005	0.0007	0.9988
30	0.0005	0.0008	0.9987
31	0.0005	0.0005	0.9990
32	0.0005	0.0005	0.9991
33	0.0017	0.9976	0.0007
34	0.0008	0.9987	0.0005
35	0.0030	0.9968	0.0003
36	0.4801	0.5120	0.0078
37	0.4769	0.5151	0.0080
38	0.9576	0.0387	0.0037
39	0.9958	0.0033	0.0009
40	0.9989	0.0007	0.0005

41	0.9142	0.0796	0.0062
42	0.9923	0.0064	0.0013
43	0.9985	0.0009	0.0006
44	0.9991	0.0005	0.0005
45	0.9916	0.0069	0.0014
46	0.9983	0.0011	0.0006
47	0.9990	0.0005	0.0005
48	0.9989	0.0006	0.0005
49	0.9991	0.0005	0.0005
50	0.9991	0.0005	0.0005
51	0.9984	0.0010	0.0006
52	0.9989	0.0006	0.0005
53	0.9985	0.0010	0.0006
54	0.9920	0.0066	0.0014
55	0.9192	0.0752	0.0056
56	0.9983	0.0010	0.0006
57	0.9990	0.0005	0.0005
58	0.9991	0.0005	0.0005
59	0.9990	0.0005	0.0005
60	0.9991	0.0005	0.0005
61	0.0464	0.9523	0.0014
62	0.0775	0.9216	0.0009
63	0.5349	0.4577	0.0073
64	0.5293	0.4631	0.0076
65	0.1409	0.8533	0.0058
66	0.0101	0.9884	0.0015
67	0.7802	0.1630	0.0568
68	0.7862	0.0602	0.1536
69	0.0588	0.0089	0.9323
70	0.0045	0.0013	0.9942
71	0.9803	0.0138	0.0059
72	0.9977	0.0014	0.0009
73	0.9975	0.0015	0.0010
74	0.9990	0.0005	0.0005
75	0.4950	0.4967	0.0084
76	0.4631	0.5295	0.0074
77	0.7360	0.2580	0.0061
78	0.9798	0.0182	0.0021
79	0.7110	0.2818	0.0072
80	0.0991	0.8954	0.0055
81	0.0078	0.9908	0.0014
82	0.0010	0.9985	0.0005

83	0.0544	0.9429	0.0027
84	0.1165	0.8774	0.0061
85	0.0770	0.9190	0.0039
86	0.0567	0.9406	0.0027
87	0.1679	0.8252	0.0069
88	0.0883	0.9084	0.0034
89	0.1457	0.8480	0.0063
90	0.9274	0.0670	0.0056
91	0.9928	0.0059	0.0013
92	0.9986	0.0008	0.0005
93	0.9985	0.0009	0.0006
94	0.9991	0.0005	0.0005
95	0.9933	0.0055	0.0012
96	0.9986	0.0009	0.0006
97	0.9990	0.0005	0.0005
98	0.9990	0.0005	0.0005
99	0.9991	0.0005	0.0005
100	0.1516	0.8249	0.0235
101	0.1489	0.7392	0.1118
102	0.0316	0.3906	0.5778
103	0.0044	0.0274	0.9681
104	0.0155	0.4120	0.5724
105	0.2196	0.7374	0.0430
106	0.9375	0.0551	0.0074
107	0.9946	0.0042	0.0012
108	0.1658	0.8232	0.0110
109	0.0119	0.9862	0.0020
110	0.5486	0.4425	0.0089
111	0.9633	0.0333	0.0034
112	0.9962	0.0029	0.0009
113	0.9989	0.0006	0.0005
114	0.5352	0.4564	0.0084
115	0.9592	0.0371	0.0037
116	0.9959	0.0032	0.0009
117	0.9988	0.0007	0.0005
118	0.9991	0.0005	0.0005
119	0.9959	0.0032	0.0009
120	0.9988	0.0007	0.0005
121	0.9990	0.0005	0.0005
122	0.9991	0.0005	0.0005

Chapter 5

Key to the Lepidopteran Subfamilies of Canada

*A version of this chapter has been submitted for publication to the Canadian Journal of Arthropod Identification.

Introduction

Lepidoptera, consisting of moths and butterflies, is one of the most diverse insect orders, with over 4700 species known in Canada, and their actual number probably over 6000 (Danks 1988). Although the majority are phytophagous as larvae, a few species feed on fungi, lichens, detritus, animal products, or other insects. Because of their abundance and generally phytophagous habits, Lepidoptera can have very important ecological roles and include many important agricultural and forestry pests. In addition, their showiness and variable life histories have resulted in the more charismatic species being used in biodiversity and ecological studies.

Obtaining accurate identifications is a vital step in any study. Most butterflies and many macrolepidoptera are readily identified by 'picture-booking' using various internet resources (e.g. Troubridge & Lafontaine 2004a; 2004b; 2004c; 2004d; Patterson 2010; Gilligan 2010), field guides (e.g. Powell & Opler 2009; Handfield 1999; Covell 1984; Brock & Kaufman 2006; Layberry, *et al.* 1998), or visually skimming insect collections; however, this method is not practical for some macrolepidoptera and most microlepidoptera. Field guides are most useful for butterflies, but are less comprehensive for moths due to their much larger diversity. Even with these resources, picture-booking can be error prone, especially for beginners, and offers no obvious starting point. Alternatively, while traditional dichotomous keys can be helpful in giving a place to start, it is difficult to see many characters due to the covering of scales. The reliable identification of specimens often requires careful examination of genitalia or wing venation. There are a few user-friendly dichotomous keys; however, they do not have a comprehensive coverage of lepidopteran subfamilies and tribes. Consequently, relying on expert opinion has remained the best means for identifying microlepidoptera and difficult macrolepidoptera. However, such taxonomists are already overworked and experts are often lacking for key taxa.

This matrix-based key is an attempt to give the novice a place to start for lepidopteran identifications. It uses characters that are non-destructive to specimens and that can be observed under a dissecting microscope. The key works well for most microlepidoptera, while for many macrolepidoptera it may only narrow identifications down to several taxon groups. The key covers all Lepidoptera of Canada, and includes 222 taxon groups and is based on 73 characters with 266 character states.

Methods

A total of 1656 specimens of 1388 species in 1151 genera were examined, covering roughly 85% of the Lepidoptera genera in Canada (Appendix 5-1). I attempted to cover the range of variation by examining a minimum of five specimens for each taxon group. Specimens were obtained from the University of Alberta Strickland Museum, the Canadian National Collection, the Northern Forestry Centre, and the personal collections of Greg Pohl and of the author. All specimens were examined under a dissecting microscope at no more than 50X magnification, and depending upon the size of the feature being measured, either an ocular micrometer, digital callipers, or a ruler was used. In addition to examining specimens in hand, images of every species from Troubridge and Lafontaine (2004a; 2004b; 2004c; 2004d) and Layberry, *et al.* (1998) were examined and the extent of variation in wing pattern and colour was recorded for each taxon group. Data were recorded in a spreadsheet, and a summary for each taxon group was entered into XID (http://xidservices.com/).

The taxonomy employed here generally follows Kristensen (1999), except that Scoble (1999) and Ferguson (2008) were used for the Geometridae and Lafontaine and Schmidt (2010) for the Noctuoidea. Butterfly names follow Pelham (2008). Taxon diagnoses are based on all examined specimens, and references represent a selection of what were considered to be the most comprehensive and useful sources. For a more thorough list of taxonomic references, refer to Pohl (2006).

General Anatomy

For a thorough coverage of lepidopteran anatomy, Scoble (1992) or Kristensen (2003) should be consulted. The terminology used in this key follows Covell (1984).

The head of Lepidoptera is typically dominated by a pair of large compound eyes composed of many ommatidia. Immediately dorsal to the compound eyes may be ocelli, although these are frequently lost. Ocelli are typically small, but can be noticeably larger in a few microlepidopteran families. The dorsal region between the compound eyes is the vertex, which is bordered anteroventrally by the frons. Scale vestiture can differ between these two regions and can be useful for identification. Chaetosemata are patches of regularly arranged, slender scales located dorsal to the compound eyes and posterior to the ocelli, and are found in many different families. Each antenna is composed of a basal and usually broad scape that is followed by the second segment termed the pedicel, and a followed by a slender, multi-segmented flagellum. It is often scaled dorsally, and these scales may be arranged in rows on the flagellum, the number of which may be important in identification. Most Lepidoptera have well-developed, three segmented labial palps. Maxillary palps are five segmented, but are usually reduced in size and number of segments in all but some of the most basal lineages. The most basal lineages may also have functional mandibles, although these are difficult to see. Most Lepidoptera have a coiled proboscis, although this can be secondarily reduced or lost entirely. In some lineages the proboscis is covered by overlapping scales, at least basally, and this is one of the most useful characters in identifying microlepidoptera.

The thorax is divided into a prothorax, mesothorax, and metathorax, of which each has a pair of legs and the last two have a pair of wings each. When the wings are spread open, triangular, scaled projections, termed tegulae jut slightly outwards from the forewing base. The scale covering of the wings usually conceals their transparency and venation. The most basal lineages have homoneurous wings, which have a forewing and hindwing that are similarly veined and shaped and may be coupled together by a jugal lobe on the posterior edge of the forewing. However, the vast majority of the Lepidoptera have heteroneurous wings in which shape and venation differ between forewings and hindwings. In many of these families, the wings are coupled together by a frenulum, which is a curved bristle or series of bristles originating on the leading edge of the base of the hindwing that latches into a retinaculum on the underside of the forewing. Each leg is composed of a coxa which rests next to the thorax, a tiny trochanter, an elongate and usually thick femur, a long slender tibia, and the tarsus (usually composed of five tarsomeres) ending in a pair of claws. The tibiae on the prothorax usually have an elongate scaled projection, termed an epiphysis. The tibiae located on the meso- and metathoracic segments often have movable spurs, with the mid-legs typically having two, and the hind-legs typically having four.

The abdomen is usually rather soft and consists of eight segments and terminal genitalia. The dorsal plates of the abdomen are termed tergites and the ventral plates sternites. Females will often have small ovipositor lobes at the end of the abdomen, though these may be modified into a sclerotized piercing structure in some taxa. Males have a pair of claspers associated with the genitalia, and these may be visible without dissection, especially if the scales are brushed off at the tip of the abdomen.

How To Use This Key

The key uses XID software developed by Richard Old (on attached CD-ROM). This software was chosen over other software titles due to its ease of use, excellent technical support, and its lack of glitches related to Java platform incompatibility that some other programs have. It can be run from a web-based platform or downloaded with the XID runtime software. Run XIDRO.exe and open the file "Key to the Lepidoptera of Canada.xid". Upon initializing the program you will see a hierarchical list of characters (Appendix 5-2) in the upper left frame and these can be expanded by clicking on the "+" to reveal characters nested within. Once you reach a set of attributes, you will see a dotted box where you can enter your character state and a number that states how many taxon groups will remain if you mark that character state. If you click on the characters or attributes, a photo and a description may appear in the frame on the right. If a character is ambiguous, you can mark more than one box with "or".

In the frame on the bottom left is a list of the taxon groups. The number at the top will show how many of the taxa have not been eliminated out of the 222 groups. Once a taxon group has been eliminated, the checkmark in front of it will change to an "X", the font will turn red, and it will be moved down the list. Clicking on any of the taxon groups will show a thumbnail picture that can be expanded by clicking on it, and a taxon description followed by a selection of taxonomic references (Appendix 5-3).

Several of the buttons in the top menu bar are useful when identifying a specimen. Hover over the button with the mouse cursor to see the name of each button.

Clicking on the “item/species list” button will show pictures and descriptions for the remaining taxa for easy comparison.

The “gallery” button will show thumbnail pictures of the remaining taxa for quick comparison.

Marking “marked & eliminated” button will give a list of characters marked.

Clicking on the “analyze” button will list the most useful characters to narrow down the search, and is the most useful button to quickly key out a specimen.

The “clear all marks” button is a quick way to restart the key.

The “show/hide references” button will reveal a full list of references used in the taxon descriptions.

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Fig. 5-1. Vertex of head.

Fig. 5-2. Roughly scaled head.

Fig. 5-3. Smoothly scaled head.

Fig. 5-4. Frons of head.

Fig. 5-5. Compound eye.

Fig. 5-6. Hairy compound eye.

Fig. 5-7. Ocellus.

Fig. 5-8. Eye cap.

Fig. 5-9. Antenna with no scales.

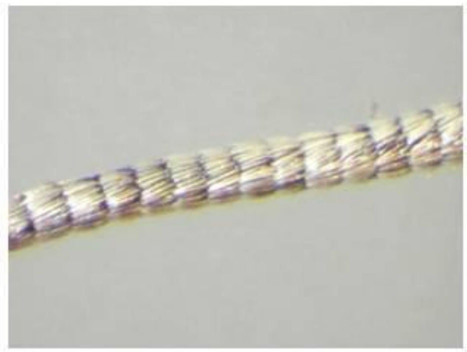

Fig. 5-10. Antenna with 1 scale row per antennal segment.

Fig. 5-11. Antenna with 2 scale rows per antennal segment.

Fig. 5-12. Antenna with scales not in rows.

Fig. 5-13. Antenna less than ½ forewing length.

Fig. 5-14. Antenna greater than ½ forewing length.

Fig. 5-15. Antenna greater than the forewing length.

Fig. 5-16. Antenna greater than twice the forewing length.

Fig. 5-17. Antennal sensillae.

Fig. 5-18. Filiform antenna.

Fig. 5-19. Pectinate antenna.

Fig. 5-20. Antenna with an elongate club.

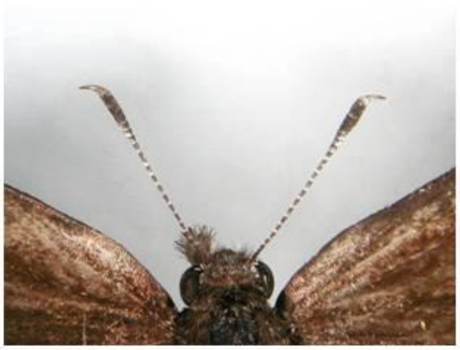

Fig. 5-21. Hooked antennae.

Fig. 5-22. Antenna with an abrupt club.

Fig. 5-23. Ascending labial palps.

Fig. 5-24. Porrect labial palps.

Fig. 5-25. Descending labial palps.

Fig. 5-26. Un-tufted labial palps.

Fig. 5-27. Long maxillary palps.

Fig. 5-28. Short maxillary palps.

Fig. 5-29. Naked proboscis.

Fig. 5-30. Scaled proboscis.

Fig. 5-31. Proboscis absent.

Fig. 5-32. Dorsal thoracic scale tuft.

Fig. 5-33. Wings reduced.

Fig. 5-34. Wings normally-sized.

Fig. 5-35. Raised scales on the forewing.

Fig. 5-36. Costal fold.

Fig. 5-37. Notched wings.

Fig. 5-38. Forewing with a single colour.

Fig. 5-39. Forewing with more than one colour.

Fig. 5-40. Reniform spot.

Fig. 5-41. Orbicular spot.

Fig. 5-42. Claviform spot.

Fig. 5-43. Discal spot.

Fig. 5-44. Antemedian line.

Fig. 5-45. Median line.

Fig. 5-46. Postmedian line.

Fig. 5-47. Subterminal line.

Fig. 5-48. Forewing with streaks.

Fig. 5-49. Long hindwing fringe.

Fig. 5-50. Short hindwing fringe.

Fig. 5-51. Hindwing tail.

Fig. 5-52. Boldly marked hindwing of similar pattern to forewing.

Fig. 5-53. Drab hindwing of different pattern to forewing.

Fig. 5-54. Discal lunule.

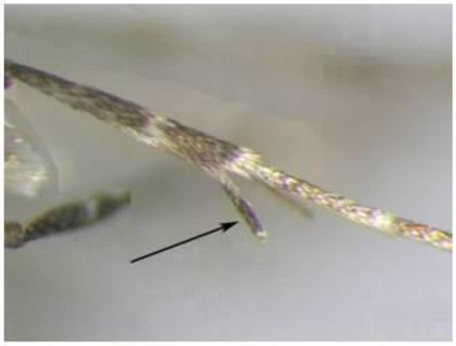

Fig. 5-55. Tibial spur.

Fig. 5-56. Tibial spines.

Fig. 5-57. Tarsal spines present.

Fig. 5-58. Tarsal spines absent.

Fig. 5-59. Thorax width.

Fig. 5-60. Forewing length.

Fig. 5-61. Forewing width.

Fig. 5-62. Hindwing width.

Fig. 5-63. Ratio forewing length : thorax width.

Fig. 5-64. Ratio forewing length : forewing width.

Fig. 5-65. Ratio forewing width : hindwing width.

Fig. 5-66. Sclerotized ovipositor.


Fig. 5-67. Dorsal abdominal scale tuft.


Fig. 5-68. Boldly patterned abdomen.


Fig. 5-69. Drab abdomen.


Fig. 5-70. Micropterigidae: *Epimartyria auricrinella*


Fig. 5-71. Eriocraniidae: *Eriocrania semipurpurella*


Fig. 5-72. Acanthopteroctetidae: *Acanthopteroctetes bimaculata.*

Fig. 5-73. Hepialidae: *Sthenopis purpurascens*

Fig. 5-74. Nepticulidae: *Stigmella corylifoliella*

Fig. 5-75. Opostegidae: *Pseudopostega* sp.

Fig. 5-76. Heliozelidae: *Antispila freemani*

Fig. 5-77. Adelidae: *Adela ridingsella*

Fig. 5-78. Prodoxidae, Lamproniinae: *Lampronia russatella*

Fig. 5-79. Prodoxidae, Prodoxinae: *Prodoxus quinquepunctella*

Fig. 5-80. Incurvariidae: *Paraclemensia acerifoliella*

Fig. 5-81. Tischeriidae: *Coptotriche citrinipennella*

Fig. 5-82. Tineidae: *Haplotinea insectella*

Fig. 5-83. Acrolophidae: *Amydria effrentella*

Fig. 5-84. Psychidae: *Dahlica walshella*

Fig. 5-85. Douglasiidae: *Tinagma obscurofasciella*

Fig. 5-86. Bucculatricidae: *Bucculatrix canadensisella*

Fig. 5-87. Gracillariidae, Gracillariinae: *Parornix* sp.

Fig. 5-88. Gracillariidae, Lithocolletinae: *Cameraria aceriella*

Fig. 5-89. Gracillariidae, Phyllocnistinae: *Phyllocnistis populiella*

Fig. 5-90. Yponomeutidae, Attevinae: *Atteva aurea*

Fig. 5-91. Yponomeutidae, Yponomeutinae: *Swammerdamia* sp.

Fig. 5-92. Yponomeutidae, Argyresthiidae: *Argyresthia pygmaeella*

Fig. 5-93. Ypsolophidae, Ypsolophinae: *Ypsolopha canariella*

Fig. 5-94. Ypsolophidae, Ochsenheimeriinae: *Ochsenheimeria vaculella*

Fig. 5-95. Plutellidae: *Plutella xylostella*

Fig. 5-96. Acrolepiidae: *Acrolepiopsis assectella*

Fig. 5-97. Glyphipterigidae: *Glyphipterix haworthana*

Fig. 5-98. Heliodinidae: *Neoheliodines nyctaginella*

Fig. 5-99. Bedelliidae: *Bedellia somnulenta*

Fig. 5-100. Lyonetiidae: *Lyonetia prunifoliella*

Fig. 5-101. Elachistidae, Stenomatinae: *Antaeotricha leucillana*

Fig. 5-102. Elachistidae, Ethmiinae: *Ethmia monticola*

Fig. 5-103. Elachistidae, Depressariinae: *Agonopterix fusciterminella*

Fig. 5-104. Elachistidae, Elachistinae: *Elachista* sp.

Fig. 5-105. Elachistidae, Agonoxenidae: *Blastodacna curvilineella*

Fig. 5-106. Xyloryctidae, Scythridinae: *Scythris eboracensis*

Fig. 5-107. Chimbachidae: *Dasytromma salicella* male

Fig. 5-108. Chimbachidae: *Dasytromma salicella* female

Fig. 5-109. Glyphidoceridae: *Glyphidocera lithodoxica*

Fig. 5-110. Oecophoridae: *Eido trimaculella*

Fig. 5-111. Batrachedridae: *Batrachedra praeangusta*

Fig. 5-112. Coleophoridae, Coleophorinae: *Coleophora trifolii*

Fig. 5-113. Coleophoridae, Momphinae: *Mompha eloisella*

Fig. 5-114. Coleophoridae, Blastobasinae: *Blastobasis glandulella*

Fig. 5-115. Coleophoridae, Pterolonchinae: *Pterolonche inspersa*

Fig. 5-116. Autostichidae: *Oegoconia deauratella*

Fig. 5-117. Amphisbatidae: *Machimia tentoriferella*

Fig. 5-118. Cosmopterigidae: *Cosmopterix clemensella*

Fig. 5-119. Gelechiidae, Gelechiinae: *Chionodes lugubrella*

Fig. 5-120. Gelechiidae, Dichomeridinae: *Dichomeris ?gnoma*

Fig. 5-121. Limacodidae: *Tortricidia testacea*

Fig. 5-122. Zygaenidae: *Harrisina americana*

Fig. 5-123. Sesiidae, Tinthiinae: *Pennisetia marginata*

Fig. 5-124. Sesiidae, Sesiinae: *Sesia tibiale*

Fig. 5-125. Cossidae: *Acossus populi*

Fig. 5-126. Choreutidae: *Choreutis pariana*

Fig. 5-127. Tortricidae, Tortricinae, Tortricini: *Acleris brittania*

Fig. 5-128. Tortricidae, Tortricinae, Cnephasiini: *Eana argentana*

Fig. 5-129. Tortricidae, Tortricinae, Cochylini: *Cochylis voxcana*

Fig. 5-130. Tortricidae, Tortricinae, Euliini: *Eulia ministrana*

Fig. 5-131. Tortricidae, Tortricinae, Sparganothini: *Sparganothis reticulatana*

Fig. 5-132. Tortricidae, Tortricinae, Archipini: *Archips myricanus*

Fig. 5-133. Tortricidae, Chlidanotinae: *Thaumatographa youngiella*

Fig. 5-134. Tortricidae, Olethreutinae, Endotheniini: *Endothenia affiliana*

Fig. 5-135. Tortricidae, Olethreutinae, Bactrini: *Bactra verutana*

Fig. 5-136. Tortricidae, Olethreutinae, Olethreutini: *Pseudosciaphila duplex*

Fig. 5-137. Tortricidae, Olethreutinae, Enarmoniini: *Ancylis burgessiana*

Fig. 5-138. Tortricidae, Olethreutinae, Eucosmini: *Eucosma serpentana*

Fig. 5-139. Tortricidae, Olethreutinae, Grapholitini: *Cydia pomonella*

Fig. 5-140. Urodidae: *Wockia asperipunctella*

Fig. 5-141. Schreckensteiniidae: *Schreckensteinia festaliella*

Fig. 5-142. Epermeniidae: *Ochromolopis ramapoella*

Fig. 5-143. Alucitidae: *Alucita adriendenisi*

Fig. 5-144. Pterophoridae: *Oidaematophorus eupatorii*

Fig. 5-145. Copromorphidae: *Ellabella editha*

Fig. 5-146. Carposinidae: *Bondia crescentella*

Fig. 5-147. Pyralidae, Galleriinae: *Galleria mellonella*

Fig. 5-148. Pyralidae, Chrysauginae: *Galasa nigrinodis*

Fig. 5-149. Pyralidae, Pyralinae: *Hypsopygia costalis*

Fig. 5-150. Pyralidae, Epipaschiinae: *Pococera aplastella*

Fig. 5-151. Pyralidae, Phycitinae: *Dioryctria reniculelloides*

Fig. 5-152. Crambidae, Scopariinae: *Eudonia alpinus*

Fig. 5-153. Crambidae, Crambinae, Argyriini: *Urola nivalis*

Fig. 5-154. Crambidae, Crambinae, Crambini: *Crambus bidens*

Fig. 5-155. Crambidae, Crambinae, Haimbachiini: *Chilo plejadellus*

Fig. 5-156. Crambidae, Crambinae, Prionapterygini: *Pseudoschoenobius opalescalis*

Fig. 5-157. Crambidae, Schoenobiinae: *Donacaula amblyptepennis*

Fig. 5-158. Crambidae, Acentropiinae: *Elophila icciusalis*

Fig. 5-159. Crambidae, Odontiinae: *Mimoschinia rufofascialis*

Fig. 5-160. Crambidae, Evergestinae: *Evergestis pallidata*

Fig. 5-161. Crambidae, Glaphyriinae: *Xanthophysa psychialis*

Fig. 5-162. Crambidae, Pyraustinae: *Anania coronata*

Fig. 5-163. Crambidae, Spilomelinae: *Choristostigma plumbosignalis*

Fig. 5-164. Thyrididae: *Thyris maculata*

Fig. 5-165. Hesperiidae, Eudaminae: *Epargyreus clarus*

Fig. 5-166. Hesperiidae, Pyrginae: *Erynnis icelus*

Fig. 5-167. Hesperiidae, Heteropterinae: *Carterocephalus palaemon*

Fig. 5-168. Hesperiidae, Hesperiinae: *Hesperia assiniboia*

Fig. 5-169. Hesperiidae, Megathyminae: *Megathymus streckeri*

Fig. 5-170. Papilionidae, Parnassiinae: *Parnassius smintheus*

Fig. 5-171. Papilionidae, Papilioninae: *Papilio canadensis*

Fig. 5-172. Pieridae, Pierinae: *Pieris oleracea*

Fig. 5-173. Pieridae, Coliadinae: *Colias philodice*

Fig. 5-174. Lycaenidae, Miletinae: *Feniseca tarquinius*

Fig. 5-175. Lycaenidae, Lycaeninae: *Lycaena hyllus*

Fig. 5-176. Lycaenidae, Theclinae: *Callophrys polia*

Fig. 5-177. Lycaenidae, Polyommatinae: *Glaucopsyche lygdamus*

Fig. 5-178. Riodinidae: *Apodemia mormo*

Fig. 5-179. Nymphalidae, Libytheinae: *Libytheana carinenta*

Fig. 5-180. Nymphalidae, Danainae: *Danaus plexippus*

Fig. 5-181. Nymphalidae, Limenitidinae:
Limenitis arthemis

Fig. 5-182. Nymphalidae, Heliconiinae:
Argynnis aphrodite

Fig. 5-183. Nymphalidae, Apaturinae:
Asterocampa celtis

Fig. 5-184. Nymphalidae, Nymphalinae:
Aglais milberti

Fig. 5-185. Nymphalidae, Satyrinae:
Cercyonis pegala

Fig. 5-186. Drepanidae, Thyatirinae:
Pseudothyatira cymatophoroides

Fig. 5-187. Drepanidae, Drepaninae: *Drepana arcuata*

Fig. 5-188. Uraniidae, Epipleminae: *Callizia amorata*

Fig. 5-189. Geometridae, Larentiinae, Cidariini: *Dysstroma hersiliata*

Fig. 5-190. Geometridae, Larentiinae, Hydriomenini: *Rheumaptera subhastata*

Fig. 5-191. Geometridae, Larentiinae, Stamnodini: *Stamnodes topazata*

Fig. 5-192. Geometridae, Larentiinae, Xanthorhoini: *Xanthorhoe ferrugata*

Fig. 5-193. Geometridae, Larentiinae, Asthenini: *Venusia cambrica*

Fig. 5-194. Geometridae, Larentiinae, Operophterini: *Operophtera bruceata*

Fig. 5-195. Geometridae, Larentiinae, Euduliini: *Eubaphe mendica*

Fig. 5-196. Geometridae, Larentiinae, Eupithecini: *Eupithecia annulata*

Fig. 5-197. Geometridae, Larentiinae, Lobophorini: *Lobophora nivigerata*

Fig. 5-198. Geometridae, Sterrhinae: *Cyclophora pendulinaria*

Fig. 5-199. Geometridae, Geometrinae: *Synchlora aerata*

Fig. 5-200. Geometridae, Archiearinae: *Archiearis infans*

Fig. 5-201. Geometridae, Ennominae, Alsophilini: *Alsophila pometaria*

Fig. 5-202. Geometridae, Ennominae, Cassymini: *Nematocampa resistaria*

Fig. 5-203. Geometridae, Ennominae, Macariini: *Macaria sexmaculata*

Fig. 5-204. Geometridae, Ennominae, Boarmini: *Ectropis crepuscularia*

Fig. 5-205. Geometridae, Ennominae, Melanolophini: *Eufidonia convergaria*

Fig. 5-206. Geometridae, Ennominae, Bistonini: *Biston betularia*

Fig. 5-207. Geometridae, Ennominae, Baptini: *Lomographa semiclarata*

Fig. 5-208. Geometridae, Ennominae, Caberini: *Cabera exanthemata*

Fig. 5-209. Geometridae, Ennominae, Angeronini: *Xanthotype urticaria*

Fig. 5-210. Geometridae, Ennominae, Azelini: *Pero honestaria*

Fig. 5-211. Geometridae, Ennominae, Nacophorini: *Phaeoura quernaria*

Fig. 5-212. Geometridae, Ennominae, Campaeini: *Campaea perlata*

Fig. 5-213. Geometridae, Ennominae, Ennomini: *Ennomos magnaria*

Fig. 5-214. Geometridae, Ennominae, Epiranthidini: *Spodolepis substriataria*

Fig. 5-215. Geometridae, Ennominae, Lithinini: *Petrophora subaequaria*

Fig. 5-216. Geometridae, Ennominae, Anagogini: *Probole amicaria*

Fig. 5-217. Geometridae, Ennominae, Ourapterygini: *Caripeta angustiorata*

Fig. 5-218. Lasiocampidae, Macromphaliinae: *Tolype velleda*

Fig. 5-219. Lasiocampidae, Lasiocampinae: *Malacosoma disstria*

Fig. 5-220. Mimallonidae: *Cicinnus melsheimeri*

Fig. 5-221. Bombycidae, Apatelodinae: *Apatelodes torrefacta*

Fig. 5-222. Bombycidae, Bombycinae: *Bombyx mori*

Fig. 5-223. Saturniidae, Ceratocampinae:
Anisota virginiensis

Fig. 5-224. Saturniidae, Hemileucinae:
Hemileuca nevadensis

Fig. 5-225. Saturniidae, Saturniinae:
Callosamia promethea

Fig. 5-226. Sphingidae, Sphinginae:
Ceratomia amyntor

Fig. 5-227. Sphingidae, Smerinthinae:
Smerinthus jamaicensis

Fig. 5-228. Sphingidae, Macroglossinae:
Amphion floridensis

Fig. 5-229. Notodontidae, Pygaerinae: *Clostera strigosa*

Fig. 5-230. Notodontidae, Notodontinae: *Gluphisia lintneri*

Fig. 5-231. Notodontidae, Phalerinae: *Datana ministra*

Fig. 5-232. Notodontidae, Heterocampinae: *Schizura ipomoea*

Fig. 5-233. Notodontidae, Nystaleinae: *Symmerista leucitys*

Fig. 5-234. Erebidae, Lymantriinae: *Orgyia antiqua* male

Fig. 5-235. Erebidae, Lymantriinae: *Orgyia antiqua* female

Fig. 5-236. Erebidae, Arctiinae, Lithosiini: *Hypoprepia miniata*

Fig. 5-237. Erebidae, Arctiinae, Arctiini: *Grammia parthenice*

Fig. 5-238. Erebidae, Herminiinae: *Phalaenostola hanhami*

Fig. 5-239. Erebidae, Pangraptinae: *Pangrapta decoralis*

Fig. 5-240. Erebidae, Hypeninae: *Hypena bijugalis*

Fig. 5-241. Erebidae, Rivulinae: *Rivula propinqualis*

Fig. 5-242. Erebidae, Scoliopteryginae: *Scoliopteryx libatrix*

Fig. 5-243. Erebidae, Calpinae: *Calyptra canadensis*

Fig. 5-244. Erebidae, Hypocalinae: *Hypocala andremona*

Fig. 5-245. Erebidae, Scolecocampinae: *Phobolosia anfracta*

Fig. 5-246. Erebidae, Hypenodinae: *Hypenodes palustris*

Fig. 5-247. Erebidae, Boletobiinae:
Metalectra discalis

Fig. 5-248. Erebidae, Phytometrinae:
Spargaloma sexpunctata

Fig. 5-249. Erebidae, Erebinae, Toxocampini:
Lygephila victoria

Fig. 5-250. Erebidae, Erebinae, Thermesiini:
Ascalapha odorata

Fig. 5-251. Erebidae, Erebinae, Catocalini:
Catocala concumbens

Fig. 5-252. Erebidae, Erebinae, Melipotini:
Drasteria adumbrata

Fig. 5-253. Erebidae, Erebinae, Euclidiini: *Caenurgina erechtea*

Fig. 5-254. Erebidae, Erebinae, Poaphilini: *Parallelia bistriaris*

Fig. 5-255. Erebidae, Erebinae, Ophiusini: *Zale lunata*

Fig. 5-256. Erebidae, Eulepidotinae: *Panopoda rufimargo*

Fig. 5-257. Euteliidae: *Marathyssa inficita*

Fig. 5-258. Nolidae: *Baileya dormitans*

Fig. 5-259. Noctuidae, Plusiinae: *Autographa mappa*

Fig. 5-260. Noctuidae, Bagisarinae: *Bagisara rectifascia*

Fig. 5-261. Noctuidae, Eustrotiinae: *Maliattha concinnimacula*

Fig. 5-262. Noctuidae, Acontiinae: *Ponometia candefacta*

Fig. 5-263. Noctuidae, Pantheinae: *Panthea furcilla*

Fig. 5-264. Noctuidae, Dilobinae: *Raphia frater*

Fig. 5-265. Noctuidae, Balsinae: *Balsa tristrigella*

Fig. 5-266. Noctuidae, Acronictinae: *Acronicta superans*

Fig. 5-267. Noctuidae, Cuculliinae: *Cucullia convexipennis*

Fig. 5-268. Noctuidae, Amphipyrinae, Amphipyrini: *Amphipyra pyramidoides*

Fig. 5-269. Noctuidae, Amphipyrinae, Psaphidini: *Feralia jocosa*

Fig. 5-270. Noctuidae, Amphipyrinae, Stiriini: *Stiria rugifrons*

Fig. 5-271. Noctuidae, Oncocnemidinae: *Sympistis piffardi*

Fig. 5-272. Noctuidae, Agaristinae: *Alypia langtoni*

Fig. 5-273. Noctuidae, Condicinae: *Leuconycta lepidula*

Fig. 5-274. Noctuidae, Heliothinae: *Schinia florida*

Fig. 5-275. Noctuidae, Eriopinae: *Callopistria cordata*

Fig. 5-276. Noctuidae, Bryophilinae: *Cryphia cuerva*

Fig. 5-277. Noctuidae, Noctuinae, Pseudeustrotiini: *Pseudeustrotia carneola*

Fig. 5-278. Noctuidae, Noctuinae, Phosphilini: *Phosphila miselioides*

Fig. 5-279. Noctuidae, Noctuinae, Prodenini: *Spodoptera frugiperda*

Fig. 5-280. Noctuidae, Noctuinae, Elaphriini: *Elaphria alapallida*

Fig. 5-281. Noctuidae, Noctuinae, Caradrinini: *Protoperigea posticata*

Fig. 5-282. Noctuidae, Noctuinae, Dypterygini: *Trachea delicata*

Fig. 5-283. Noctuidae, Noctuinae, Actinotiini: *Nedra ramosula*

Fig. 5-284. Noctuidae, Noctuinae, Phlogophorini: *Phlogophora periculosa*

Fig. 5-285. Noctuidae, Noctuinae, Apameini: *Apamea amputatrix*

Fig. 5-286. Noctuidae, Noctuinae, Arzamini: *Bellura obliqua*

Fig. 5-287. Noctuidae, Noctuinae, Xylenini: *Xylena thoracica*

Fig. 5-288. Noctuidae, Noctuinae, Orthosiini: *Orthosia revicta*

Fig. 5-289. Noctuidae, Noctuinae, Tholerini: *Nephelodes minians*

Fig. 5-290. Noctuidae, Noctuinae, Hadenini: *Polia propodea*

Fig. 5-291. Noctuidae, Noctuinae, Leucaniini: *Leucania lapidaria*

Fig. 5-292. Noctuidae, Noctuinae, Eriopygini: *Ulolonche modesta*

Fig. 5-293. Noctuidae, Noctuinae, Noctuinae: *Feltia herilis*

Appendix 5-1: Summary of specimens examined for the key to the Lepidoptera of Canada. One specimen was examined per species except when indicated otherwise in brackets.

Micropterigidae
Epimartyria auricrinella (4)
Epimartyria n. sp.
Eriocraniidae
Dyseriocrania griseocapitella
Eriocrania semipurpurella pacifica (2)
Eriocrania semipurpurella semipurpurella (2)
Acanthopteroctetidae
Acanthopteroctetes bimaculata (3)
Hepialidae
Gazorycta noviganus
Korscheltellus gracilis
Korscheltellus lupulinus
Sthenopis auratus
Sthenopis purpurascens
Nepticulidae
Ectoedemia lindquisti
Obrussa sericopeza
Stigmella corylifoliella
Stigmella slingerlandella
Trifurcula saccharella
Opostegidae
Pseudopostega albogaleriella
Pseudopostega cretea
Pseudopostega quadristrigella
Pseudopostega sp. (2)
Heliozelidae
Antispila ampelopsifoliella
Antispila freemani
Antispila nysaefoliella
Coptodisca kalmiella
Coptodisca splendoriferella
Adelidae
Adela purpurea
Adela ridingsella
Cauchas dietziella
Cauchas n. sp.
Elasmion bellella
Prodoxidae, Lamproniinae
Lampronia corticella
Lampronia oregonella
Lampronia russatella
Lampronia sublustris
Tetragma gei
Prodoxidae, Prodoxinae
Greya humilis
Greya variabilis
Prodoxus decipiens
Prodoxus quinquepunctellus
Tegeticula yuccasella
Incurvariidae
Paraclemensia acerifoliella (3)
Phylloporia bistrigella (2)
Tischeriidae
Coptotriche admirabilis
Coptotriche citrinipennella
Coptotriche crataegifoliae
Coptotriche malifoliella
Coptotriche zelleriella
Tineidae
Dryadaula visaliella
Eccritothrix trimaculella
Elatobia carbonella
Haplotinea insectella
Homosetia bifasciella
Homosetia costisignella
Isocorypha mediostriatella
Monopis dorsistrigatella
Monopis spilotella
Morophagoides burkerella
Nemapogon auropulvella
Nemapogon roburella
Niditinea orleansella
Niditinea spretella
Scardia anatomella
Scardiella approximatella
Tinea columbariella
Tineola bisselliella
Xylesthia pruniramiella
Acrolophidae
Acrolophus morus (2)
Amydria effrentella (3)
Psychidae
Astala confederata ♂
Dahlica triquetrella ♀
Hyaloscotes pithopoera ♂
Kearfottia albifasciella
Psyche casta ♂
Taleporia walshella ♂
Douglasiidae
Tinagma giganteum
Tinagma leucaspis
Tinagma obscurofasciella (3)
Bucculatricidae
Bucculatrix canadensisella
Bucculatrix eupatoriella
Bucculatrix montana
Bucculatrix sexnotata
Bucculatrix solidaginiella
Gracillariidae, Gracillariinae
Acrocercops astericola
Caloptilia fraxinella
Leucanthiza dircella
Marmara fraxinicola
Micrurapteryx salicifoliella
Parectopa pennsylvaniella
Parornix conspicuella
Gracillariidae, Lithocolletinae
Cameraria aceriella
Chrysaster ostensackenella
Cremastobombycia solidaginis
Phyllonorycter apparella
Phyllonorycter sp.
Porphyrosela desmodiella
Prolithocolletis lathyri
Gracillariidae, Phyllocnistinae
Phyllocnistis ampelopsifoliella
Phyllocnistis populiella (2)
Phyllocnistis vitegenella
Phyllocnistis sp.
Yponomeutidae, Yponomeutinae
Euhyponomeutoides gracilariella
Kessleria parnassiae
Ocnerostoma piniariella
Paraswammerdamia lutarea
Swammerdamia caesiella
Yponomeuta multipunctella
Zelleria haimbachi
Yponomeutidae, Attevinae
Atteva aurea (5)
Yponomeutidae, Argyresthiinae
Argyresthia goedartella
Argyresthia conjugella
Argyresthia oreasella
Argyresthia pygmaeela
Argyresthia sp.
Ypsolophidae, Ypsolophinae
Euceratia castella
Ypsolopha canariella
Ypsolopha cervella
Ypsolopha dentella
Ypsolopha falciferella
Ypsolophidae, Oschenheimeriinae
Oschenheimeria vacculella
Plutellidae
Plutella notabilis
Plutella porrectella
Plutella vanella
Plutella xylostella
Rhigognostis interrupta
Acrolepiidae
Acrolepiopsis assectella
Acrolepiopsis californica
Acrolepiopsis incertella
Glyphipterigidae
Diploschizia impigritella
Glyphipterix bifasciata
Glyphipterix circumscriptella
Glyphipterix haworthana
Glyphipterix saurodonta
Heliodinidae
Neoheliodines nyctaginella (2)
Bedelliidae
Bedellia somnulentella (5)
Lyonetiidae
Leucoptera laburnella
Lyonetia alniella
Lyonetia prunifoliella
Paraleucoptera albella
Proleucoptera smilaciella
Elachistidae, Stenomatinae
Antaeotricha humilis
Antaeotricha leucillana
Antaeotricha schlaegeri
Gonioterma mistrella
Menesta tortriciformella
Elachistidae, Ethmiinae
Ethmia albistrigella
Ethmia bipunctella
Ethmia longimaculella
Ethmia monticola
Pyramidobela quinquecristata
Elachistidae, Depressariinae
Agonopterix gelidella
Bibarrambla allenella
Depressaria alienella

Depressariodes canella
Nites betulae
Semioscopis inornata
Elachistidae, Elachistinae
Elachista orestella
Elachista spp. (3)
Perittia herrichiella
Elachistidae, Agonoxeninae
Blastodacna bicristatella
Blastodacna curvilineella
Blastodacna sp.
Chrysoclista cambiella
Chrysoclista lineella
Xyloryctidae
Landryia impositella
Rhamphura n. sp.
Scythris eboracensis
Scythris mixaula (2)
Chimbachidae
Dasytroma salicella ♀ (2)
Dasytroma salicella ♂ (3)
Glyphidoceridae
Glyphidocera hurlberti (2)
Glyphidocera lithodoxica (2)
Glyphidocera septentrionella
Oecophoridae
Batia lunaris
Brymblia quadrimaculella
Carcina quercana
Carolana ascriptella
Decantha tistra
Denisia haydenella
Eido trimaculella
Endrosis sarcitrella
Epicallima argenticinctella
Fabiola shalleriella
Hofmannophila pseudospretella
Mathildana newmanella
Oecophora bractella
Pleurota albistrigulella
Polix coloradella
Schiffermuelleria sp.
Batrachedridae
Batrachedra praeangusta (4)
Duospina trichella
Coleophoridae, Coleophorinae
Coleophora eleagnisella
Coleophora acutipennella
Coleophora crinita
Coleophora brunneipennis
Coleophora trifolii
Coleophoridae, Momphinae
Mompha claudiella
Mompha eloisella
Mompha stellella
Mompha unifasciella (2)
Coleophoridae, Blastobasinae
Asaphocrita sp.
Blastobasis glandulella
Calosima sp.
Holcocera immaculella
Hypatopa sp.
Pigritia sp.
Coleophoridae, Pterolonchinae
Pterolonche inspersa (3)
Autostichidae
Gerdana caritella (2)
Oegoconia deauratella (2)
Oegoconia sp.
Amphisbatidae
Machimia tentoriferella (2)
Psilocorsis fletcherella
Psilocorsis querciella
Psilocorsis reflexella
Cosmopterigidae
Chrysopeleia purpuriella
Cosmopterix fernaldella
Euclemensia bassettella
Limnaecia phragmitella
Perimede erransella
Periploca laeta
Sorhagenia nimbosa
Stagmatophora sexnotella
Stilbosis ostryaeella
Walshia miscecolorella
Gelechiidae, Gelechiinae
Agonochaetia conspersa
Anacampsis niveopulvella
Anarsia lineatella
Aristotelia fungivorella
Aroga trialbamaculella
Bryotropha similis
Caryocolum cassella
Chionodes lugubrella
Coleotechnites blastivora
Evippe prunifoliella
Filatima abactella
Gelechia lynceella
Gnorimoschema
gallaesolidaginis
Metzneria lappella
Neotelphusa praefix
Prolita sexpunctella
Pseudotelphusa belangerella
Ptycerata petrella
Scrobipalpa atriplicella
Teleiodes proximella
Xenolechia velatella
Gelechiidae, Dichomeridinae
Dichomeris leuconotella
Dichomeris levisella
Dichomeris setosella
Dichomeris simpliciella
Helcystgramma fernaldella
Limacodidae
Apoda biguttata
Euclea delphinii
Heterogenea shurtleffi
Lithacodes fasciola
Packardia geminata
Parasa chloris
Prolimacodes badia
Tortricidia testacea
Zygaenidae
Harrisina americana (5)
Sesiidae, Sesiinae, Tinthiinae
Pennisetia marginata (4)
Zenodoxus canescens
Sesiidae, Sesiinae, Sesiinae
Albuna pyramidalis
Carmenta giliae
Euhagena nebraskae
Paranthrene robiniae
Podosesia syringae
Sesia tibialis
Synanthedon novaroensis
Synanthedon proxima
Synanthedon saxifragae
Cossidae
Acossus centerensis
Acossus populi
Prionoxystus robiniae ♀
Prionoxystus robiniae ♂
Zeuzera pyrina ♀
Zeuzera pyrina ♂
Choreutidae
Anthophila alpinella
Caloreas occidentalis
Choreutis diana
Prochoreutis pernivalis
Tebenna onustana
Tortricidae, Tortricinae, Archipini
Adoxophyes furcatana
Aphelia koebelei
Archips alberta
Argyrotaenia velutinana
Choristoneura conflictana
Clepsis melaleucana
Clepsis peritana
Clepsis persicana
Lozotaenia rindgei
Pandemis limitata
Pandemis pyrusana
Syndemis afflictana
Xenotemna pallorana
Tortricidae, Tortricinae, Cnephasiini
Cnephasia sp.
Decodes fragrarianus
Eana argentana (2)
Eana osseana
Tortricidae, Tortricinae, Cochylini
Aethes deutschiana
Agapeta zoegana
Atroposia oenotherana
Cochylis dubitana
Recavicula hoffmannana
Saphenista felix
Thyralia bunteana
Trachysmia fulviplicana
Tortricidae, Tortricinae, Eulini
Anopina ednana
Apotomops wellingtoniana
Eulia ministrana (3)
Tortricidae, Tortricinae, Tortricini
Acleris albicomana
Acleris braunana
Acleris caliginosana
Acleris nigrolinea
Acleris nivisellana
Acleris obtusana
Acleris oxycoccana
Tortricidae, Tortricinae, Sparganothidini
Amorbia cuneana
Amorbia humerosana
Coelostathma discopunctana
Platynota idaeusalis
Sparganothis sulfureana
Sparganothis vocaridorsana
Sparganothis xanthoides
Tortricidae, Chlidanotinae
Thaumatographa youngiella (5)
Tortricidae, Olethreutinae, Bactrini
Bactra furfurana (2)
Bactra lancealana

Bactra maiorina
Bactra verutana (2)
Tortricidae, Olethreutinae, Enarmoniini
Ancylis metamelana
Ancylis unguicella
Enarmonia formosana
Hystrichophora stygiana
Tortricidae, Olethreutinae, Endothenini
Endothenia heinrichi
Endothenia montanana
Hulda impudens
Taniva albolineana
Tia enervana
Tortricidae, Olethreutinae, Eucosmini
Barbara colfaxiana
Epiblema benignatum
Epinotia medioplagata
Eucosma fandana
Eucosma fernaldana
Gypsonoma adjuncta
Notocelia culminana
Pelochrista scintillana
Phaneta tarandana
Proteoteras aesculana
Pseudexentera oregonana
Retinia pallidipennis
Sonia constrictana
Tortricidae, Olethreutinae, Grapholitini
Corticivora clarki
Cydia ingrata
Dichrorampha sedatana
Grapholita lunatana
Ecdytolopha insiticiana
Gymnandrosoma punctidiscanum
Pseudogalleria inimicella
Sereda tautana
Tortricidae, Olethreutinae, Olethreutini
Ahmosia aspasiana
Apotomis capreana
Celypha cespitana
Episimus argutanus
Eumarozia malachitana
Hedya ochroleucana
Olethreutes buckellana
Orthotaenia undulana
Paralobesia aemulana
Phaecasiophora niveiguttana
Pseudosciaphila duplex
Zomaria interruptolinea
Urodidae
Wockia asperipunctella (5)
Schreckensteiniidae
Schreckensteinia erythriella
Schreckensteinia festaliella (4)
Epermeniidae
Epermenia albapunctella
Epermenia cicutaella
Epermenia infracta
Ochromolopis ramapoella (2)
Alucitidae
Alucita adriendenisi (2)
Alucita lalannei
Alucita montana (2)
Pterophoridae
Adaina montanus
Amblyptilia pica
Capperia ningornis
Dejongia lobidactylus
Gillmeria pallidactyla
Hellinsia homodactylus
Oidaematophorus phaceliae
Paraplatyptilia albiciliata
Platyptilia percnodactyla
Stenoptilia coloradensis
Copromorphidae
Ellabella editha (2)
Lotisma trigonana (3)
Carposinidae
Bondia comonana
Bondia crescentella (2)
Carposina fernaldana
Carposina niponensis
Pyralidae, Galleriinae
Achroia grisella
Aphomia sociella
Corcyra cephalonica
Galleria mellonella
Paralipsa fulminalis
Pyralidae, Chrysauginae
Acallis gripalis
Arta statalis
Condylolomia participalis
Galasa nigrinodis
Tosale oviplagalis
Pyralidae, Pyralinae
Aglossa pinguinalis
Dolichomia olinalis
Herculia thymetusalis
Hypsopygia costalis
Pseudasopia intermedialis
Pyralis farinalis
Pyralidae, Epipaschiinae
Epipaschia superatalis
Macalla zelleri
Oneida lunulalis
Pococera aplastella
Toripalpus trabalis
Pyralidae, Phycitinae
Acrobasis tricolorella
Ambesa laetella
Anerastia lotella
Apomyelois bistriatella
Catastia actualis
Caudellia nigrella
Coenochroa californiella
Dioryctria cambiicola
Ephestia kuehniella
Etiella zinckenella
Eulogia ochrifrontella
Homeosoma stypticellum
Hulstia undulatella
Interjectio niviella
Melitara dentata
Meroptera pravella
Myelopsis subtetricella
Ortholepis pasadamia
Peoria approximella
Phycitodes mucidellus
Pima vividella
Polopeustis arctiella
Pyla fusca
Sarata caudellella
Sciota basilaris
Staudingeria albipennella
Telethusia ovalis
Zophodia grossulariella
Crambidae, Scopariinae
Cosipara tricoloralis
Eudonia spaldingalis
Gesneria centuriella
Scoparia biplagialis (2)
Crambidae, Crambinae, Argyrini
Argyria auratella
Argyria critica
Argyria rufisignella
Urola nivalis
Crambidae, Crambinae, Crambini
Agriphila attenuata
Agriphila vulgivagella
Catoptria oregonica
Chrysoteuchia topiaria
Crambus ainslellus or C. leachellus
Crambus unistriatellus
Euchromius ocellus
Microcrambus biguttellus
Neodactria caliginosellus
Pediasia trisecta
Raphiptera argillaceella
Tehama bonifatella
Thaumatopsis pexella
Crambidae, Crambinae, Haimbachiini
Chilo plejadellus
Eoreuma densella
Occidentalia compulatalis
Thopeutis forbesellus
Xubida panalope
Crambidae, Crambinae, Prionapterygini
Pseudoschoenobius opalescalis (3)
Prionaptryx nebulifera (2)
Crambidae, Schoenobiinae
Donacaula amplyptepennis
Donacaula aquilella
Donacaula mellinella (2)
Crambidae, Acentropiinae
Acentria ephemerella
Elophila ekthlipsis
Elophila icciusalis
Elophila obliteralis
Eoparargyractis plevie
Neocataclysta magnificalis
Parapoynx allionealis
Parapoynx maculalis
Petrophila kearfottalis
Crambidae, Odontiinae
Anatralata versicolor
Eustixia pupula
Frechinia criddlealis
Metrea ostreonalis
Microtheoris ophionalis
Mimoschinia rufofascialis
Crambidae, Evergestinae
Cylindrifrons succandidalis
Evergestis pallidata
Evergestis subterminalis
Orenaia arcticallis
Prorasea simalis
Crambidae, Glaphyriinae
Chalcoela iphitalis
Dicymolomia julianalis

Glaphyria sequistrialis
Lipocosma sicalis
Lipocosmodes fuliginosalis
Stegea eripalis
Xanthophysa psychialis
Crambidae, Pyraustinae
Anania coronata
Anania extricalis
Anania funebris
Anania mysippusalis
Fumibotys fumalis
Loxostege cereralis
Loxostege lepidalis
Ostrinia marginalis
Perispasta caeculalis
Pyrausta borealis
Saucrobotys fumoferalis
Sitochroa chortalis
Crambidae, Spilomelinae
Anageshna primordialis
Choristostigma plumbosignalis
Desmia funeralis
Diacme elealis
Framinghamia helvalis
Herpetogramma pertextalis
Mecyna mustelinalis
Nomophila nearctica
Udea rubigalis
Thyrididae
Thyris maculata (4)
Pseudothyris sepulchralis
Hesperiidae, Eudaminae
Epargyreus clarus
Thorybes pylades
Hesperiidae, Pyrginae
Erynnis icelus
Pholisora catullus
Pyrgus communis
Hesperiidae, Heteropterinae
Carterocephalus palaemon (5)
Hesperiidae, Hesperiinae
Amblyscirtes vialis
Anatrytone logan
Euphyes vestris
Hesperia assiniboia
Oarisma garita
Ochlodes sylvanoides
Poanes hobomok
Polites mystic
Thymelicus lineola
Hesperiidae, Megathyminae
Megathymus streckeri (2)
Papilionidae, Parnassiinae
Parnassius eversmanni
Parnassius smintheus (4)
Papilionidae, Papilioninae
Battus philenor
Eurytides marcellus
Papilio canadensis
Papilio machaon
Papilio polyxenes
Pieridae, Pierinae
Anthocaris sara
Euchloe olympia
Neophasia menapia
Pieris rapae
Pontia protodice
Pieridae, Coliadinae
Colias philodice
Eurema nicippe
Nathalis iole
Phoebis sennae
Zerene cesonia
Lycaenidae, Riodininae
Apodemia mormo (5)
Lycaenidae, Miletinae
Feniseca tarquinius (5)
Lycaenidae, Lycaeninae
Lycaena cuprea
Lycaena dione
Lycaena heteronea
Lycaena phlaeas
Lycaena rubida
Lycaenidae, Theclinae
Callophrys eryphon
Satyrium acadicum
Satyrium liparops
Satyrium titus
Strymon melinus
Lycaenidae, Polyommatinae
Celastrina ladon
Cupido amyntula
Glaucopsyche lygdamus
Lycaeides idas
Plebejus glandon
Plebejus optilete
Plebejus saepiolus
Nymphalidae, Libytheaninae
Libytheana carinenta (5)
Nymphalidae, Heliconiinae
Agraulis vanillae
Argynnis aphrodite
Argynnis cybele
Boloria selene
Euptoieta claudia
Nymphalidae, Nymphalinae
Chlosyne gorgone
Euphydryas phaeton
Junonia coenia
Nymphalis antiopa
Nymphalis californica
Nymphalis l-album
Phyciodes tharos
Polygonia comma
Vanessa atalanta
Nymphalidae, Limenitidinae
Limenitis archippus
Limenitis arthemis arthemis
Limenitis arthemis astyanax
Limenitis lorquini
Limenitis wedemeyeri
Nymphalidae, Apaturinae
Asterocampa celtis (3)
Asterocampa clyton (2)
Nymphalidae, Satyrinae
Cercyonis pegala
Coenonympha tullia
Erebia mancinus
Lethe anthedon
Lethe eurydice
Megisto cymelo
Neominois ridingsii
Oeneis macounii
Nymphalidae, Danainae
Danaus plexippus (5)
Bombycidae, Apatelodinae
Apatelodes torrefacta (3)
Olceclostera angelica (2)
Bombycidae, Bombycinae
Bombyx mori (5)
Saturniidae, Ceratocampinae
Anisota virginiensis (2)
Dryocampa rubicunda
Eacles imperalis
Sphingicampa bicolor
Saturniidae, Hemileucinae
Automeris io ♂
Hemileuca eglanterina
Hemileuca hera
Hemileuca nevadensis
Hemileuca sp.
Saturniidae, Saturniinae
Actias luna
Antheraea polyphemus
Callosamia promethea
Hyalophora cecropia
Sphingidae, Macroglossinae
Amphion floridensis
Darapsa choerilus
Eumorpha pandorus
Hemaris diffinis
Hyles gallii
Proserpinus flavofasciata
Sphecodina abbotti
Xylophanes tersa
Sphingidae, Smerinthinae
Amorpha juglandis
Pachysphinx modesta
Paonias excaecatus
Smerinthus cerisyi
Smerinthus jamaicensis
Sphingidae, Sphinginae
Agrius cingulatus
Ceratomia undulosa
Dolba hyloeus
Lapara bombycoides
Manduca sexta
Paratrea plebejus
Sphinx vashti
Drepanidae, Drepaninae
Drepana arcuata (2)
Drepana bilineata
Eudeilina herminiata
Oreta rosea
Drepanidae, Thyatirinae
Ceranemota albertae
Ceranemota fasciata
Euthyatira pudens
Habrosyne scripta
Pseudothyatira cymatophoroides
Lasiocampidae, Lasiocampinae
Phyllodesma americanum
Malacosoma sp. ♂ (2)
Malacosoma sp. ♀
Heteropacha rileyana
Lasiocampidae, Macromphaliinae
Tolype dayi (2)
Tolype laricis
Tolype velleda (2)
Mimallonidae
Cicinnus melsheimeri (3)
Lacosoma chiridota (2)
Geometridae, Archiearinae
Archiearis infans (3)
Leucobrephos brephoides (2)
Geometridae, Ennominae, Alsophilini
Alsophila pometaria ♀ (2)
Alsophila pometaria ♂ (3)

Geometridae, Ennominae, Anagogini
Cepphis armataria
Metanema inatomaria
Metarranthis duaria
Plagodis phlogosaria
Probole amicaria
Selenia kentaria
Geometridae, Ennominae, Angeronini
Aspitates aberratus
Euchlaena johnsonaria
Euchlaena tigrinaria
Lytrosis unitaria
Xanthotype sospeta
Geometridae, Ennominae, Azelini
Pero behrensaria
Pero honestaria
Pero mizon
Pero morrisonaria
Pero occidentalis
Geometridae, Ennominae, Baptini
Lomographa glomerata (2)
Lomographa semiclarata (2)
Lomographa vestaliata
Geometridae, Ennominae, Bistonini
Biston betularia
Erannis tiliaria ♀
Erannis tiliaria ♂
Hypagyrtis piniata
Lycia rachelae ♀
Lycia rachelae ♂
Paleacrita vernata
Phigalia titea
Geometridae, Ennominae, Boarmini
Aethalura intertexta
Anavitrinellia pampinaria
Dasyfidonia avuncularia
Ectropis crepuscularia
Ematurga amitaria
Epimecis hortaria
Hesperumia sulphuraria
Iridopsis larvaria
Orthofidonia exornata
Protoboarmia porcelaria
Stenoporpia pulmonaria
Geometridae, Ennominae, Caberini
Apodrepanulatrix litaria
Cabera erythemaria
Drepanulatrix falcataria
Eudrepanulatrix rectifascia
Sericosema juturnaria
Geometridae, Ennominae, Campaeini
Campaea perlata (5)
Geometridae, Ennominae, Cassymini
Protitame virginaria (4)
Nematocampa resistaria ♀
Geometridae, Ennominae, Ennomini
Ennomos alniaria
Ennomos magnaria (2)
Ennomos subsignaria (2)
Geometridae, Ennominae, Epirranthini
Spodolepis substriataria (5)
Geometridae, Ennominae, Lithinini
Gueneria similaria
Homochlodes
Petrophora subaequaria
Philedia punctomacularia
Tacparia detersata
Thallophaga taylorata
Geometridae, Ennominae, Macariini
Digrammia neptaria
Epelis truncataria
Eumacaria madopata
Fernaldella fimetaria
Heliomata cycladata
Melilla xanthometata
Speranza ribearia
Geometridae, Ennominae, Melanolophini
Eufidonia convergaria (2)
Eufidonia discospilata
Melanolophia imata
Melanolophia signataria
Geometridae, Ennominae, Nacophorini
Gabriola dyari
Phaeoura quernaria (4)
Geometridae, Ennominae, Ourapterygini
Besma quercivoraria
Caripeta divisata
Cingilia catenaria
Enypia venata
Lambdina fiscellaria
Neoterpes triangulifera
Nepytia canosaria
Plataea trilinearia
Prochoerodes lineola
Sicya macularia
Synaxis jubararia
Tetracis crocallata
Geometridae, Geometrinae
Mesothea incertata
Nemoria unitaria
Synchlora aerata
Chlorochlamys chloraleucaria
Hemithea aestivaria
Hethemia pistaciaria
Chlorosea nevadaria
Dichorda iridaria
Geometridae, Larentiinae, Asthenini
Hydrelia albifera
Trichodezia albovittata
Venusia cambrica
Venusia pearsalli (2)
Geometridae, Larentiinae, Cidariini
Colostygia turbata
Dysstroma hersiliata
Ecliptoptera silaceata
Eulithis explanata
Eustroma semiatrata
Plemyria georgii
Thera juniperata
Geometridae, Larentiinae, Euduliini
Eubaphe mendica (4)
Eubaphe unicolor
Geometridae, Larentiinae, Eupitheciini
Eupithecia bowmani
Eupithecia lariciata
Horisme intestinata
Pasiphila rectangulata
Prorella melissa
Geometridae, Larentiinae, Hydriomenini
Anticlea vasiliata
Entephria mutivagata
Hydriomena perfracta
Mesoleuca ruficillata
Perizoma basaliata
Rheumaptera hastata
Spargania magnoliata
Triphosa haesitata
Geometridae, Larentiinae, Lobophorini
Acasis viridata
Aplocera plagiata
Carsia sororiata
Cladara limitaria
Dyspteris abortivaria
Heterophleps triguttaria
Lobophora nivigerata
Geometridae, Larentiinae, Operophterini
Epirrita autumnata (2)
Operophtera bruceata ♀
Operophtera bruceata ♂ (2)
Geometridae, Larentiinae, Stamnodini
Stamnoctenis morrisata
Stamnodes topazata (4)
Geometridae, Larentiinae, Xanthorhoini
Epirrhoe sperryi
Euphyia intermedia
Orthonama obstipata
Psychophora suttoni
Xanthorhoe ferrugata
Zenophleps lignicolorata
Geometridae, Sterrhinae
Cyclophora pendulinaria
Haematopis grataria
Idaea demissaria
Leptostales ferruminaria
Scopula limboundata
Uraniidae, Epipleminae
Calledapteryx dryopterata (2)
Callizia amorata (3)
Notodontidae, Pygaerinae
Clostera albosigma (2)
Clostera apicalis
Clostera brucei
Clostera strigosa
Notodontidae, Notodontinae
Cerura scitiscripta
Furcula occidentalis
Gluphisia lintneri
Hyperaeschra georgica
Nerice bidentata
Notodonta scitipennis
Odontosia elegans
Pheosia rimosa
Notodontidae, Phalerinae
Datana angusii

Datana ministra
Ellida caniplaga
Nadata gibbosa
Peridea ferruginea
Notodontidae, Heterocampinae
Heterocampa biundata
Hyparpax aurora
Lochmaeus bilineata
Macrurocampa marthesia
Misogada unicolor
Oligiocentria lignicolor
Schizura badia
Notodontidae, Nystaleinae
Dasylophia anguina
Dasylophia thyatiroides
Symmerista canicosta (2)
Symmerista leucitys
Erebidae, Lymantriinae
Dasychira plagiata ♂
Gynaephora rossii (2)
Leucoma salicis
Lymantria dispar (2)
Orgyia pseudotsugata
Erebidae, Arctiinae, Lithosiini
Ascala anomala
Bruceia pulverina
Clemensia albata
Crambidia impura
Eilema bicolor
Hypoprepia miniata
Lycomorpha pholus
Erebidae, Arctiinae, Arctiini
Arctia caja
Cisseps fulvicollis
Ctenucha virginica
Cycnia tenera
Estigmene acrea
Euchaetes egle
Gnophaela vermiculata
Grammia obliterata
Grammia williamsii
Halysidota tesselaris
Haploa lecontei
Holarctia sordida
Hyphantria cunea
Lophocampa maculata
Neoarctia beanii
Pararctia yarrowi
Parasemia plantaginis
Phragmatobia fuliginosa
Platarctia parthenos
Platyprepia virginalis
Pyrrharctia isabella
Spilosoma dubia
Turuptiana permaculata
Tyria jacobeae
Virbia aurantiaca
Erebidae, Herminiinae
Chytolita petrealis
Idia americalis
Lascoria ambigualis
Macrochilo absorptalis
Palthis angulalis
Phalaenophana pyramusalis
Phalaenostola larentioides
Reabotis immaculalis
Renia discoloralis
Zanclognatha inconspicualis
Erebidae, Pangraptinae
Ledaea perditalis
Pangrapta decoralis (2)
Erebidae, Hypeninae
Colobochyla interpuncta
Hypena californica
Hypena humuli
Hypena palparia
Hypena scabra
Lomanaltes eductalis
Melanomma auricinctaria
Erebidae, Rivulinae
Oxycilla malaca
Rivula propinqualis (5)
Erebidae, Scoliopteryginae
Alabama argillacea
Scoliopteryx libatrix
Erebidae, Calpinae
Calyptra canadensis
Plusiodonta compressipalpis
Eudocima apta
Erebidae, Hypocalinae
Hypocala andremona (5)
Erebidae, Scolecocampinae
Gabara subnivosella
Nigetia formosalis
Phobolosia anfracta
Scolecocampa liburna
Erebidae, Hypenodinae
Dyspyralis illocata
Hypenodes caducus
Hypenodes fractilinea (2)
Hypenodes palustris
Parahypenodes quadralis
Erebidae, Boletobiinae
Metalectra quadrisignata (2)
Mycterophora inexplicata
Mycterophora longipalpata
Parascotia fuliginaria
Erebidae, Phytometrinae
Isogona tenuis
Phytometra ernestinana
Phytometra rhodarialis
Spargaloma sexpunctata
Erebidae, Erebinae, Toxocampini
Lygephila victoria (5)
Erebidae, Erebinae, Thermesiini
Ascalapha odorata (3)
Thysania zenobia (2)
Erebidae, Erebinae, Catocalini
Catocala antinympha
Catocala retecta
Catocala sordida
Catocala subnata
Catocala unijuga
Erebidae, Erebinae, Melipotini
Bulia deducta
Cissusa indiscreta
Drasteria petricola
Melipotis jucunda
Phoberia atomaris
Erebidae, Erebinae, Euclidiini
Caenurgina crassiuscula
Caenurgina erechtea
Doryodes grandipennis
Euclidia cuspidea
Erebidae, Erebinae, Poaphilini
Argyrostrotis anilis
Parallelia bistriaris
Erebidae, Erebinae, Ophiusini
Amolita fessa
Euparthenos nubilis
Zale duplicata
Zale helata
Zale minerea
Erebidae, Eulepidotinae
Anticarsia gemmatalis
Panopoda carneicosta
Panopoda rufimargo (3)
Euteliidae
Eutelia pulcherrimus
Marathyssa basalis
Marathyssa inficita
Paectes abrostoloides
Paectes oculatrix
Nolidae
Baileya dormitans
Baileya opthalmica
Garella nilotica
Meganola minuscula
Meganola spodia
Nola cilicoides (2)
Nola minna
Nycteola frigidana
Nycteola sp.
Noctuidae, Plusiinae
Abrostola urentis
Allagrapha aerea
Anagrapha falcifera
Autographa mappa
Chrysanympha formosa
Ctenoplusia oxygramma
Diachrysia balluca
Eosphoropteryx thyatiroides
Exyra fax
Megalographa biloba
Plusia putnami
Polychrysia esmeralda
Pseudeva purpurigera
Pseudoplusia includens
Syngrapha ignea
Trichoplusia ni
Noctuidae, Bagisarinae
Bagisara rectifascia (5)
Noctuidae, Eustrotiinae
Capis archaica
Capis curvata
Deltote bellicula
Protodeltote albidula
Maliattha concinnimacula
Noctuidae, Acontiinae
Ponometia candefacta
Ponometia elegantula
Ponometia sutrix
Tarache augustipennis
Tarache terminimacula
Noctuidae, Pantheinae
Charadra deridens
Colocasia flavicornis
Colocasia propinquilinea
Panthea acronyctoides
Panthea gigantea
Noctuidae, Dilobinae
Raphia frater (5)
Noctuidae, Balsinae
Balsa labecula
Balsa malana (3)
Balsa tristrigana (2)
Noctuidae, Acronictinae
Acronicta americana

Acronicta funeralis
Acronicta impressa
Acronicta lupini
Acronicta retardata
Agriopodes fallax
Cerma cerintha
Harrisimemna trisignata
Simyra insularis
Noctuidae, Cuculliinae
Cucullia eulepis
Cucullia luna
Cucullia mcdunnoughi
Cucullia omissa
Cucullia speyeri
Noctuidae, Amphipyrinae, Amphipyrini
Amphipyra glabella
Amphipyra pyramidoides (2)
Amphipyra tragopoginis (2)
Noctuidae, Amphipyrinae, Psaphidini
Acopa perpallida
Brachionycha borealis
Copivaleria grotei
Feralia comstocki
Psaphida rolandi
Noctuidae, Amphipyrinae, Stiriini
Annaphila diva
Azenia obtusa
Plagiomimicus spumosum
Stiria rugifrons (3)
Noctuidae, Oncocnemidinae
Behrensia conchiformis
Calophasia lunula
Catabena lineolata
Pleromelloida conserta
Pseudacontia crustaria
Sympistis badistriga
Sympistis chionanthi
Sympistis dentata
Sympistis nigrita
Sympistis parvonigra
Sympistis piffardi
Noctuidae, Agaristinae
Alypia langtoni (2)
Androloma macculochii
Eudryas grata
Psychomorpha epimenis
Noctuidae, Condicinae
Condica discistriga
Condica videns
Crambodes talidiformis
Leuconycta diptheroides
Ogdoconta cinereola
Noctuidae, Heliothinae
Eutricopis nexilis
Helicoverpa zea
Heliothis phloxiphaga
Melaporphyria immortua
Pyrrhia exprimens
Schinia walsinghami
Noctuidae, Eriopinae
Callopistria cordata (3)
Callopistria mollissima (2)
Noctuidae, Bryophilinae
"Cryphia" cuerva (3)
"Cryphia" olivacea (2)
Noctuidae, Noctuinae, Pseudeustrotiini
Pseudeustrotia carneola (5)
Anterastria teratophora
Noctuidae, Noctuinae, Phosphilini
Phosphila miselioides (5)
Noctuidae, Noctuinae, Prodenini
Spodoptera frugiperda (3)
Spodoptera ornithogallii
Spodoptera praefica
Noctuidae, Noctuinae, Elaphriini
Elaphria alapallida (2)
Elaphria versicolor (2)
Galgula partita
Noctuidae, Noctuinae, Caradrinini
Caradrina camina
Caradrina morpheus
Protoperigea posticata (2)
Proxenus miranda
Noctuidae, Noctuinae, Dypterygiini
Dypterygia rozmani
Magusa orbifera
Trachea delicata (4)
Noctuidae, Noctuinae, Actinotiini
Alastria chico
Iodopepla u-album
Nedra ramosula (3)
Noctuidae, Noctuinae, Phlogophorini
Conservula anodonta
Euplexia benesimilis
Phlogophora iris
Phlogophora periculosa (2)
Noctuidae, Noctuinae, Apameini
Achatodes zeae
Amphipoea americana
Apamea amputatrix
Benjaminiola colorada
Capsula subflava
Chortodes basistriga
Eremobina claudens
Helotropha reniformis
Hydraecia pallescens
Lateroligia ophiogramma
Lemmeria digitalis
Macronoctua onusta
Meropleon diversicolor
Neoligia exhausta
"Oligia" bridghami
"Oligia" divesta
Papaipema arctivorens
Resapamea passer
Rhizedra lutosa
Spartiniphaga inops
Xylomoia chagnoni
Noctuidae, Noctuinae, Arzamini
Bellura gortynoides (2)
Bellura obliqua (3)
Noctuidae, Noctuinae, Xylenini
Agrochola purpurea
Anathix ralla
Andropolia theodori
Aseptis binotata
Brachylomia populi
Cerapoda stylata
Chaetaglaea sericea
Chytonix palliatricula
Cosmia calami
Dryotype opina
Enargia decolor
Epidemas melanographa
Epiglaea apiata
Eucirroedia pampina
Eupsilia vinulenta
Fishia discors
Fishia illocata
Hillia iris
Homoglaea hircina
Hyppa brunneicrista
Hyppa contrasta
Hyppa indistincta
Ipimorpha pleonectusa
Litholomia napaea
Lithomoia germana
Lithophane innominata
Mesogona subcuprea
Metaxaglaea inulta
Parastichtis discivaria
Platypolia anceps
"Platypolia" mactata
Properigea albimacula
Psectraglaea carnosa
Pseudanarta crocea
Pseudobryomima muscosa
Pyreferra pettiti
Rhizagrotis cloanthoides
Sutyna privata
Ufeus satyricus
Xanthia tatago
Xylena thoracica
Xylotype arcadia
Zotheca tranquila
Noctuidae, Noctuinae, Orthosiini
Acerra normalis
Achatia distincta
Admetovis oxymorus
Crocigrapha normani
Egira dolosa
Morrisonia evicta
Orthosia rubescens
Stretchia muricina
Noctuidae, Noctuinae, Tholerini
Cerapteryx graminis
Nephelodes minians (2)
Tholera americana (3)
Noctuidae, Noctuinae, Hadenini
Afotella cylindrica
Anarta farnhami
Coranarta luteola
Dargida diffusa
Dargida procinctus
Escaria homogena
Hada sutrina
Hadena variolata
Hadenella pergentilis
Lacanobia nevadae
Mamestra configurata
Melanchra adjuncta
Papestra quadrata
Polia nugatis
Scotogramma submarina

Sideridis u-scripta
Spiramater lutra
Trichordestra legitima
Noctuidae, Noctuinae, Leucaniini
Leucania commoides
Leucania insueta
Leucania pseudargyria
Mythimna unipuncta
Noctuidae, Noctuinae, Eriopygini
Anhimella contrahens
Homorthodes furfurata
Hydroeciodes serrata
Lacinipolia anguina
Lasionycta secedens
Neleucania bicolorata
Orthodes cynica
"Orthodes" detracta
Protorthodes oviduca
Pseudorthodes vecors
Trichocerapoda oblita
Tricholita signata
Ulolonche modesta
Zosteropoda hirtipes
Noctuidae, Noctuinae, Noctuini
Abagrotis vittifrons
Actebia fennica
Adelphagrotis stellaris
Agnorisma bugrai
Agrotis venerabilis
Anaplectoides prasina
Anicla illapsa
Aplectoides condita
Cerastis tenebrifera
Chersotis juncta
Choephora fungorum
Coenophila opacifrons
Copablepharon longipenne
Cryptocala acadiensis
Diarsia dislocata
Dichagyris variabilis
Eueretagrotis perattenta
Eurois occultus
Euxoa obeliscoides
Feltia jaculifera
Graphiphora augur
Hemipachnobia monochromatea
Lycophotia phyllophora
Noctua pronuba
Ochropleura implecta
Parabagrotis insularis
Paradiarsia littoralis
Peridroma saucia
Prognorisma substrigata
Pronoctua peabodyae
Protogygia alberta
Protolampra rufipectus
Pseudohermonassa bicarnea
Rhyacia quadrangula
Setagrotis pallidicollis
Spaelotis bicava
Tesagrotis atrifrons
Xestia c-nigrum

Appendix 5-2: Characters and states used in the key.

Head

Vertex - The vertex is the top part of the head between the compound eyes. (Fig. 5-1)

Rough Scaled - Scales on the dorsal part of the head are rough or erect. (Fig. 5-2)

Smooth Scaled - Scales on the dorsal part of the head are flattened or smooth looking. (Fig. 5-3)

Frons - The frons is the front part of the head between the compound eyes. (Fig. 5-4)

Rough Scaled - Scales on the front part of the head are rough or erect. (Fig. 5-2)

Smooth Scaled - Scales on the front part of the head are flattened or smooth looking. (Fig. 5-3)

Compound Eye - The compound eyes are the large eyes visible and are made of many tiny lenses called ommatidia. (Fig. 5-5)

Hairy - Fine hairs are present between the individual facets of the compound eye and are noticeably long, at least ten times the width of an individual ommatidia. (Fig. 5-6)

Hairless - Fine hairs are absent between the individual facets of the compound eye or are not noticeably long or are not easily visible. (Fig. 5-5)

Ocelli - Ocelli are two very small, single lensed eyes that are situated just dorsal to the compound eyes when present. When in doubt, check the other side of the head since debris can occasionally take on the appearance of ocelli and they can be obscured by scales. (Fig. 5-7)

Present - Ocelli are present.

Absent - No ocelli are present. When the ocelli are completely concealed by long scales, they count as absent.

Antennae

Eye Cap - A broadening of the antennal base that can partially or fully cover the compound eye. (Fig. 5-8)

Present - A broadening of the antennal base that can partially or fully cover the compound eye is present. This character is only present in some tiny microlepidoptera.

Absent - A broadening of the antennal base that can partially or fully cover the compound eye is absent. This character is only present in some tiny microlepidoptera.

Number of Scale Rows per Antennal Segment - The antenna often has scales on each segment that may be arranged in rows. These are often only on the dorsal part of the antenna. Always check the middle of the antenna since the very base and very tip can be different than the remainder of the antenna. In cases where the segments are not apparent, try looking in lateral or ventral view for unscaled areas, or look for repeated patterns (eg. scale colours, distinct distal sensillae).

0 - There are no scales on the antenna, or they are present only at the very base or apex. When in doubt scan the entire antenna. (Fig. 5-9)

1 - There is one row of scales per antennal segment. In cases where the segments are not apparent, try looking in lateral or ventral view for unscaled areas, or look for repeated patterns (eg. scale colours, distinct distal sensillae). (Fig. 5-10)

2 - There are two rows of scales per antennal segment. In cases where the segments are not apparent, try looking in lateral or ventral view for unscaled areas, or look for repeated patterns (eg. scale colours, distinct distal sensillae). (Fig. 5-11)

3+ or Not in Rows - There are three or more rows of scales per antennal segment or the scales are not in apparent rows. In cases where the segments are not apparent, try looking in lateral or ventral view for unscaled areas, or look for repeated patterns (eg. scale colours, distinct distal sensillae). (Fig. 5-12)

Antennal Length - The approximate length of the antennae compared to the FW length.

<1/2 Forewing Length - The antenna is less than 1/2 the length of the forewing measured from the wing base along the costa to the apex. If the antenna is roughly 1/2 the length, mark both <1/2 and >1/2 as `OR`. (Fig. 5-13)

>1/2 Forewing Length - The antenna is greater than 1/2 the length of the forewing measured from the wing base along the costa to the apex, but less than the forewing length. If the antenna is roughly 1/2 the length, mark both <1/2 and >1/2 as `OR`. (Fig. 5-14)

> 1 Forewing Length - The antenna is greater than the length of the forewing measured from the wing base along the costa to the apex, but less than twice its length. If the antenna is roughly the length of the forewing, mark both >1/2 and >1 as `OR`. (Fig. 5-15)

> 2 Forewing Lengths - The antenna is greater than twice the length of the forewing measured from the wing base along the costa to the apex. Only Adelidae should have this character state which normally have iridescent forewings. If your specimen is dull-looking, check the wing. If it is covered in hairs and not scales, you have a caddisfly (Order Trichoptera). (Fig. 5-16)

Antennal Sensillae Length - These are fine hairs that are present ventrally on the antenna. For the purposes of this key, all hair-like structures that are visible are considered sensillae. (Fig. 5-17)

> Half Shaft Width - Fine hairs are present on the ventral surface of the antenna and they are longer than 1/2 the width of the antennal shaft. These hairs may be sparse (including a single one at the distal end of each antennal segment) or dense. They need to be throughout the antenna, not just at the base or tip.

< Half Shaft Width or Absent - Fine hairs are absent from the ventral surface of the antenna or they are shorter than 1/2 the width of the antennal shaft. These hairs may be sparse (including a single one at the distal end of each antennal segment) or dense. They need to be throughout the antenna, not just at the base or tip.

Antennal Type - The type of antenna the specimen has.

Filiform - A simple thread-like antenna or weakly pectinate with the pectinations less than twice the antennal shaft width. (Fig. 5-18)

Pectinate - The antennal segments have projections (pectinations) diverging off of them that are longer than twice the shaft width. Not all segments need to have pectinations, they are often absent from some of the antennal segments, especially apically. (Fig. 5-19)

Elongate Club - Roughly the distal quarter or more of the antenna is thicker than the basal part. Most commonly seen in some diurnal moths. (Fig. 5-20)

Hooked - The antennal tip is hooked. This is often in combination with an abrupt club, in these cases mark both. The hooked antenna is most common in skippers, but can be found in some moths. (Fig. 5-21)

Abrupt Club - The very tip of the antenna is thickened or it is thickened just before, and the apex is hooked. When it is also hooked, mark both. The abrupt club is characteristic of most butterflies, but a few moths have it as well. (Fig. 5-22)

Labial Palps - The labial palps are normally the most prominent palps. In some microleps the maxillary palps can be long as well, but in these cases the maxillary palps are very slender and have more than 3 visible segments while the labial palps have only 3 visible segments and may or may not be slender.

Orientation of Labial Palps - The orientation of the labial palps.

Ascending - Ascending palps point upwards, often following the contour of the head, and when really long can project backwards as well. (Fig. 5-23)

Porrect - Porrect palps point forwards, though they may have an upward inflection near their base. (Fig. 5-24)

Descending - Descending palps curl downwards or less commonly point downwards, and are normally parallel. Sometimes during the preparation of specimens, ascending palps can be artificially bent downwards, though these usually appear to be spread apart. (Fig. 5-25)

Labial Palp Length - The length of the labial palps relative to the compound eye.

> 2X Length of Compound Eye - The length of the labial palp (measured from the base to tip and following any contour) is greater than twice the greatest length of the compound eye. (Fig. 5-23)

< 2X Length of Compound Eye - The length of the labial palp (measured from the base to tip and following any contour) is less than twice the greatest length of the compound eye. (Fig. 5-5)

Labial Palp Vestiture - The presence or absence of erect scales or scale tufts on the labial palps.

Palps Tufted - Erect scales are present throughout or in tufts on the labial palp giving it a roughened appearance. (Fig. 5-5)

Palps Smooth - The scales on the labial palp are closely appressed to it. The palp may be expanded, especially on the second segment, but even here the scales will be appressed. (Fig. 5-26)

Maxillary Palps - The maxillary palps tend to be slender and with more than three segments when visible. Only some microleps have maxillary palps longer than half the length of the labial palps (measured from the base to tip and following any contour). A few macroleps that have very short labial palps will fall under this, but the maxillary palps in most leps are very short or not visible.

>1/2 Length Labial Palps - The maxillary palps are greater than half the length of the labial palps. (Fig. 5-27)

<1/2 Length Labial Palps - The maxillary palps are less than half the length of the labial palps. (Fig. 5-28)

Proboscis - The proboscis is located on the lower front part of the head when present and is often coiled. When coiled, the proboscis may be hidden between the labial palps, but can still be seen from a ventral view with good lighting. It can be absent or reduced.

Naked - The proboscis is completely shiny and naked, lacking appressed scales. Sometimes loose scales can adhere to the proboscis, but they are always arranged haphazardly and not overlapping each other. (Fig. 5-29)

Scaled - The proboscis has appressed scales on it at least near the base, but they can continue for more than half the length. (Fig. 5-30)

Absent - The proboscis is either absent or not visible. When coiled, the proboscis can be hidden between the labial palps, but can still be seen from a ventral view with good lighting. When it is very short and not visible at all due to dense erect scales, it is marked as absent. (Fig. 5-31)

Thorax

Dorsal Thoracic Scale Tuft - A tuft of erect scales is raised dorsally above the rest of the thoracic scales. This is typically mid-dorsal, though there may be smaller paired tufts. Tegulae which are triangular tufts of scales that spread out laterally from the thorax around the base of the forewing do not count as scale tufts. (Fig. 5-32)

Present - A dorsal thoracic scale tuft is present.

Absent - All scales on the dorsal surface of the thorax are uniform in height.

Wings

Wings Reduced - The wings are reduced or absent. Reduced wings are not functional and do not extend to the middle part of the abdomen. This is found only in the females of a few groups.

Reduced - The wings are reduced or absent. Reduced wings are not functional and do not extend to the middle part of the abdomen. This is found only in the females of a few groups. (Fig. 5-33)

Normal Size - Wings are present and normally fully functional. They extend beyond the middle of the abdomen. (Fig. 5-34)

Forewing

Raised Scales on Forewing (Fig. 5-35)

Present - Tufts of scales are present on the forewing that are raised above the surface. The tufts are often composed of modified scent scales that look different than the other wing scales. Damaged specimens can have the appearance of raised scales, but these are usually in a line and composed of scales similar to those of the rest of the wing.

Absent - All scales on the forewing are appressed to the surface.

Costal Fold in Male - The basal portion of the costa is folded back over itself. This is present in males of certain groups and they usually have modified scales tucked in underneath the fold. (Fig. 5-36)

Present - The costal fold is present in males.

Absent - The costal fold is absent in males.

Forewing Notch - There are one or more deep notches in the outer margin. (Fig. 5-37)

Present - A forewing notch or notches are present.

Absent - A forewing notch or notches are absent.

Forewing Pattern - The pattern refers to those on the dorsal surface of the wing only.

Number of Forewing Colours

Single Colour - The forewing is one solid colour with no pattern or variation in colour. (Fig. 5-38)

At Least 2 Colours - The forewing has at least a faint pattern or is speckled or graded in other colours. (Fig. 5-39)

Forewing Spots

Forewing Reniform Spot - The true reniform spot is found just beyond the middle of the forewing towards the costa, and just inside the postmedian line when present. This is typical of noctuids and other macroleps. When a spot is indicated in a similar location in microleps, it is marked as present. (Fig. 5-40)

Present - The reniform spot is present.

Absent - The reniform spot is absent.

Forewing Orbicular Spot - The true orbicular spot is found just before the middle of the forewing towards the costa, and just beyond the antemedian line when present. This is typical of noctuids and other macroleps. When a spot is indicated in a similar location in microleps, it is marked as present. (Fig. 5-41)

Present - The orbicular spot is present.

Absent - The orbicular spot is absent.

Forewing Claviform Spot - The true claviform spot is found just before the middle of the forewing towards the inner margin, just below the orbicular spot when present. This is typical of noctuids and other macroleps. When a spot is indicated in a similar location in microleps, it is marked as present. (Fig. 5-42)

Present - The claviform spot is present.

Absent - The claviform spot is absent.

Forewing Discal Spot / Dot - The discal spot is usually small and located close to the center of the median area of the forewing. It is rarely present when the reniform, orbicular, or claviform spots are present. (Fig. 5-43)

Present - A discal spot or dot is present.

Absent - A discal spot or dot is absent.

Forewing Lines - These characters refer to the dorsal surface of the wing only

Forewing Antemedian Line - The antemedian line is located roughly one third of the way from the forewing base and before the orbicular spot when present. This line may be incomplete and even a strong indication of this line at only the costa or inner margin or a series of dots should be marked as present. It is also marked as present when it forms the edge of a basal patch or median band. (Fig. 5-44)

Present - The antemedian line is present.

Absent - The antemedian line is absent.

Forewing Median Line - The median line is located roughly at the center of the forewing and between the orbicular and reniform spots when present. This line may be incomplete and even a strong indication of this line at only the costa or inner margin or a series of dots should be marked as present. It is also marked as present when it forms the edge of a patch or band. (Fig. 5-45)

Present - The median line is present.

Absent - The median line is absent.

Forewing Postmedian Line - The postmedian line is located roughly two thirds of the way from the forewing base and after the reniform spot when present. This line may be incomplete and even a strong indication of this line at only the costa or inner margin or a series of dots should be marked as present. It is also marked as present when it forms the edge of a median or terminal band. (Fig. 5-46)

Present - The postmedian line is present.

Absent - The postmedian line is absent.

Forewing Subterminal Line - The subterminal line is located just before the outer margin of the forewing and after the post median line when present. This line may be incomplete and even a strong indication of this line at only the costa or inner margin or a series of dots should be marked as present. It is also marked as present when it forms the edge of a median or terminal band. (Fig. 5-47)

Present - The subterminal line is present.

Absent - The subterminal line is absent.

Forewing Dashes or Streaks - Obvious dashes or streaks run through the forewing. They can be single or multiple. Sometimes the wing veins will be traced with paler scales, when these form a broad streak mark them as present, otherwise mark them as absent. (Fig. 5-48)

Present - Dashes or streaks are present.

Absent - Dashes or streaks are absent.

Forewing Colour - The colour refers strictly to the upper surface of the wing.

Forewing Iridescent / Shiny - At least some of the scales on the forewing appear reflective or change colour when the viewing angle of the wing is changed. Typically these are iridescent or excessively shiny. This is slightly subjective since all scales have some shininess to them.

Present - There are at least some iridescent or metallic scales, or overall looks very shiny.

Absent - There are no iridescent or metallic scales and overall does not look very shiny.

Forewing Transparent - There are at least small patches on the forewing that are transparent and lacking scales. Very translucent wings like those found in Cossidae can be marked either way. Excessive wear of specimens can cause extensive denuding of the wing scales, leaving it transparent. These should not be considered transparent.

Present - There are transparent patches on the wing.

Absent - The wing is fully scaled.

Forewing Black - At least some of the scales on the dorsal surface of the forewing are black. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some black scales are present on the forewing.

Absent - There are no black scales on the forewing.

Forewing Grey - At least some of the scales on the dorsal surface of the forewing are grey. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some grey scales are present on the forewing.

Absent - There are no grey scales on the forewing.

Forewing Brown - At least some of the scales on the dorsal surface of the forewing are brown. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some brown scales are present on the forewing.

Absent - There are no brown scales on the forewing.

Forewing Yellow - At least some of the scales on the dorsal surface of the forewing are yellow. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some yellow scales are present on the forewing.

Absent - There are no yellow scales on the forewing.

Forewing White - At least some of the scales on the dorsal surface of the forewing are white. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some white scales are present on the forewing.

Absent - There are no white scales on the forewing.

Forewing Orange - At least some of the scales on the dorsal surface of the forewing are orange. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some orange scales are present on the forewing.

Absent - There are no orange scales on the forewing.

Forewing Red - At least some of the scales on the dorsal surface of the forewing are red. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some red scales are present on the forewing.

Absent - There are no red scales on the forewing.

Forewing Purple - At least some of the scales on the dorsal surface of the forewing are purple. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some purple scales are present on the forewing.

Absent - There are no purple scales on the forewing.

Forewing Green - At least some of the scales on the dorsal surface of the forewing are green. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some green scales are present on the forewing.

Absent - There are no green scales on the forewing.

Forewing Blue - At least some of the scales on the dorsal surface of the forewing are blue. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some blue scales are present on the forewing.

Absent - There are no blue scales on the forewing.

Forewing Pink - At least some of the scales on the dorsal surface of the forewing are pink. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some pink scales are present on the forewing.

Absent - There are no pink scales on the forewing.

Hindwing - All of these characters refer to the dorsal surface of the wing.

Hindwing Fringe Length - The fringe is the elongated scales that border the outer margin of the hindwing.

> Hindwing Width - The length of the fringe is longer than the hindwing width (measured perpendicularly from the inner margin of the hindwing for the greatest distance to near the anal angle). This is present in small microleps. (Fig. 5-49)

< Hindwing Width - The length of the fringe is shorter than the hindwing width (measured perpendicularly from the inner margin of the hindwing for the greatest distance to near the anal angle). This is the state in larger microleps and macroleps. (Fig. 5-50)

Hindwing Tail - The hindwings are projected into tails. These can be subtle points. (Fig. 5-51)

Present - Tails are present.

Absent - Tails are absent.

Hindwing Notch - There are one or more deep notches in the outer margin. (Fig. 5-37)

Present - A hindwing notch or notches are present.

Absent - A hindwing notch or notches are absent.

Hindwing Pattern - All of these characters refer to the dorsal surface of the wing.

Hindwing Boldly Patterned - The hindwing has a bold pattern of contrasting colours. This can be as simple as the outer part of the wing being distinctly darker than the inner part.

Boldly Patterned - The hindwing is boldly patterned. (Fig. 5-52)

Not Boldly Patterned - The hindwing is not boldly patterned. It can grade subtly from one shade to another, but never distinctly so. (Fig. 5-53)

Hindwing Similar to Forewing in Pattern - The hindwing pattern is a continuation of the forewing pattern. This is most common in leps that rest with their wings open and hindwings exposed.

Forewing and Hindwing Pattern Similar - The forewing and hindwing are similar in pattern. (Fig. 5-52)

Forewing and Hindwing Pattern Different - The forewing and hindwing are not similar in pattern. (Fig. 5-53)

Hindwing Discal Spot / Lunule - A spot is often present in the middle of the hindwing which can sometimes be crescent-shaped (lunule). (Fig. 5-54)

Present - A discal spot or lunule is present.

Absent - A discal spot or lunule is absent.

Hindwing Colour

Hindwing Iridescent / Shiny - At least some of the scales on the hindwing appear reflective or change colour when the viewing angle of the wing is changed. Typically these are iridescent or excessively shiny. This is slightly subjective since all scales have some shininess to them.

Present - There are at least some iridescent or metallic scales, or overall looks very shiny.

Absent - There are no iridescent or metallic scales and overall does not look very shiny.

Hindwing Black - At least some of the scales on the dorsal surface of the hindwing are black. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some black scales are present on the hindwing.

Absent - There are no black scales on the hindwing.

Hindwing Grey - At least some of the scales on the dorsal surface of the hindwing are grey. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some grey scales are present on the hindwing.

Absent - There are no grey scales on the hindwing.

Hindwing Brown - At least some of the scales on the dorsal surface of the hindwing are brown. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some brown scales are present on the hindwing.

Absent - There are no brown scales on the hindwing.

Hindwing Yellow - At least some of the scales on the dorsal surface of the hindwing are yellow. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some yellow scales are present on the hindwing.

Absent - There are no yellow scales on the hindwing.

Hindwing White - At least some of the scales on the dorsal surface of the hindwing are white. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some white scales are present on the hindwing.

Absent - There are no white scales on the hindwing.

Hindwing Orange - At least some of the scales on the dorsal surface of the hindwing are orange. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some orange scales are present on the hindwing.

Absent - There are no orange scales on the hindwing.

Hindwing Red - At least some of the scales on the dorsal surface of the hindwing are red. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some red scales are present on the hindwing.

Absent - There are no red scales on the hindwing.

Hindwing Green - At least some of the scales on the dorsal surface of the hindwing are green. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some green scales are present on the hindwing.

Absent - There are no green scales on the hindwing.

Hindwing Blue - At least some of the scales on the dorsal surface of the hindwing are blue. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some blue scales are present on the hindwing.

Absent - There are no blue scales on the hindwing.

Hindwing Pink - At least some of the scales on the dorsal surface of the hindwing are pink. When it grades into another colour or if in doubt, mark more than one colour.

Present - At least some pink scales are present on the hindwing.

Absent - There are no pink scales on the hindwing.

Legs

Hind Tibial Spur Length - The hind tibia usually has two sets of movable spurs, one set near the apex, and one near the middle. Spurs when they are visible usually are situated in closely set pairs that spread outwards in a `V`. The spurs are often covered in scales and are usually prominent except when the tibiae are excessively hairy. (Fig. 5-55)

> 1/2 Length of 1st Tarsomere - At least one of the apical pair of tibial spurs is longer than half of the length of the first tarsomere.

< 1/2 Length of 1st Tarsomere - The apical pair of tibial spurs are both shorter than half of the length of the first tarsomere.

Hind Tibial Spines - Spines are present that protrude from the scaly covering. These spines are usually much darker than the surrounding scales so they are apparent; however, in some small microleps they can be concolourous, but they are excessively long. In specimens where the scales of the tibia are excessively long and dense, these spines will be very difficult to see. In these cases mark the spines as absent. (Fig. 5-56)

Present - Hind tibial spines are visible.

Absent - Hind tibial spines are not visible.

Hind Tarsal Spines - Darkly pigmented spines are present on the ventral surface of the tarsomeres. These do not include paired spines at the apical end of each tarsomere since these are present in most Lepidoptera. Only count spines that are not apical in position.

Present - Spines are present on the tarsomeres in addition to apical paired spines. (Fig. 5-57)

Absent - There are no spines on the tarsomeres in addition to apical paired spines. (Fig. 5-58)

Measurements & Ratios

Thorax Width - The thorax width is measured as the distance between the base of both forewings at the costa. Do not include the tegulae (triangular scaled projections extending from the thorax at the wing bases) in measurements. (Fig. 5-59)

Forewing Length - The forewing length is measured from the base at the costa in a straight line to the apex. Ignore this if the wings are reduced or absent. (Fig. 5-60)

Forewing Width - The forewing width is measured in a straight line from the apex to the anal angle. In smaller microleps with lanceolate wings, measure the broadest part of the wing, usually around the middle of the forewing. Ignore this if the wings are reduced or absent. (Fig. 5-61)

Hindwing Width - The hindwing width is measured as the greatest distance measured from the costa perpendicularly to the anal angle. Ignore this if the wings are reduced or absent. (Fig. 5-62)

Ratio Forewing Length : Thorax Width - Forewing length (measured from the base at the costa in a straight line to the apex) divided by thorax width (measured as the distance between the base of both forewings at the costa). Ignore this if the wings are reduced or absent. (Fig. 5-63)

Ratio Forewing Length : Forewing Width - Forewing length (measured from the base at the costa in a straight line to the apex) divided by forewing width (measured in a straight line from the apex to the anal angle). Ignore this if the wings are reduced or absent. (Fig. 5-64)

Ratio Forewing Width : Hindwing Width - Forewing width (measured in a straight line from the apex to the anal angle) divided by hindwing width (measured as the greatest distance measured from the costa perpendicularly to the anal angle). Ignore this if the wings are reduced or absent. (Fig. 5-65)

Abdomen

Ovipositor - The abdominal tip of most female Lepidoptera is fleshy; however, in some taxa there is a sclerotized and elongated ovipostitor. If a sclerotized-looking ovipositor extends beyond the abdominal scales, mark the ovipositor as sclerotized.

Sclerotized - A sclerotized and elongate ovipositor is present. (Fig. 5-66)

Non-sclerotized - A sclerotized and elongate ovipositor is absent.

Abdominal Dorsal Scale Tuft - A tuft of erect scales is raised dorsally above the rest of the abdominal scales. Do not include anal scale tufts at the tip of the abdomen. (Fig. 5-67)

Present - A dorsal abdominal scale tuft is present.

Absent - A dorsal abdominal scale tuft is absent.

Abdominal Pattern - The abdomen has a contrasting pattern on it.

Boldly Patterned - The abdomen is boldly patterned. (Fig. 5-68)

Not Boldly Patterned - The abdomen is not boldly patterned. (Fig. 5-69)

Geography

Nunavut

Northwest Territories - The Lepidoptera fauna is not very well known here so marking this may eliminate taxa that are present.

Yukon Territory - The Lepidoptera fauna is not very well known here so marking this may eliminate taxa that are present.

British Columbia

Alberta

Saskatchewan - The Lepidoptera fauna is not very well known here so marking this may eliminate taxa that are present.

Manitoba

Ontario

Quebec

New Brunswick - The Lepidoptera fauna is not very well known here so marking this may eliminate taxa that are present.

Prince Edward Island - The Lepidoptera fauna is not very well known here so marking this may eliminate taxa that are present.

Nova Scotia

Newfoundland and Labrador - The Lepidoptera fauna is not very well known here so marking this may eliminate taxa that are present.

Appendix 5-3: Taxon writeups used in the key.

Micropterigidae (Fig. 5-70)

Superfamily: Micropterigoidea

Number of Canadian Species: 1 mostly eastern sp. (*Epimartyria auricrinella*) + 1 undescribed sp. in BC

Genera: *Epimartyria*

Abundance: Very localized to wet areas where the larval host liverwort occurs, diurnal and rarely collected unless specifically targeted.

Quick Recognition: The combination of the metallic wings, forewing and hindwing similar in shape and proboscis being absent will separate this from other similar-looking families. The two species are easily separated by wing pattern.

Diagnosis: HEAD: ocelli prominent; compound eyes small; chaetosemata present; head scales sparse and rough; functional mandibles present though difficult to see; proboscis absent; labial palps slender and relatively short; maxillary palps prominent; antenna filiform, with one scale row per segment, though often completely worn off, greater than half the length of the forewing, with prominent sensillae surrounding each flagellomere. THORAX: wings homoneurous, with a jugum; forewing dark metallic with a purplish sheen, unicolourous in *Epimartyria auricrinella*, with a broad yellow postmedian blotch in the undescribed species; hindwing lighter though still with a metallic sheen; legs with tibial spur formula of 0-0-4, hind tibial spurs short, hind tarsal spines present though not always obvious. ABDOMEN: entirely smooth, dark.

Similar Taxa: Eriocraniidae (forewing patterned, small proboscis present)

Taxonomic References: Covell 1984

Eriocraniidae (Fig. 5-71)

Superfamily: Eriocranioidea

Number of Canadian Species: 2 spp. (*Dyseriocrania griseocapitella* in the east and *Eriocrania semipurpurella* across the boreal)

Genera: *Dyseriocrania, Eriocrania*

Abundance: Rarely collected, but can be locally common, comes to light.

Quick Recognition: The metallic sheen to the wings with fine strigulated pattern, forewing and hindwing similar in shape, small proboscis, and bulging vertex of the head will separate this from other similar-looking families. The two species can be separated by wing pattern.

Diagnosis: HEAD: ocelli prominent; compound eyes small; chaetosemata present; head scales sparse and rough; mandibles present though difficult to see; very small proboscis present; labial palps slender and relatively short; maxillary palps prominent; antenna filiform, with one scale row per segment, about half the length of the forewing. THORAX: wings homoneurous, with a jugum; forewing somewhat translucent with a metallic sheen, often with fine lines or spots; hindwing slightly translucent grey; legs with tibial spur formula of 0-1-4, hind tibial spurs of normal length, hind tarsal spines present though not usually obvious. ABDOMEN: entirely smooth; female with a prominent ovipositor.

Similar Taxa: Micropterigidae (forewing unpatterned, no proboscis)

Taxonomic References: Davis 1978

Acanthopteroctetidae (Fig. 5-72)

Superfamily: Acanthopteroctetoidea

Number of Canadian Species: 1 sp. *Acanthopteroctetes bimaculata* in Canada only known from Manitoba to Alberta in boreal and mountain habitats; another species will likely be found in southern Alberta.

Genera: *Acanthopteroctetes*

Abundance: Very rarely collected probably due to its diurnal or crepuscular habits.

Quick Recognition: The homoneurous wings, lack of iridescence on the wings and lack of ocelli are characteristic.

Diagnosis: HEAD: ocelli absent; compound eyes relatively larger than other related families; head scales rough; mandibles present though difficult to see; small proboscis present but often difficult to see; labial palps minute and descending; maxillary palps prominent, longer than proboscis; antenna filiform, with one or two scale rows per segment, greater than half the length of the forewing. THORAX: wings homoneurous, with a small jugum; forewing dull greyish, often with the indication of two darker spots along the inner margin; hindwing greyish; legs with tibial spur formula of 0-1-4, hind tibial spurs just less than half length of first tarsomere, hind tibial and tarsal spines obvious. ABDOMEN: entirely smooth.

Similar Taxa: Most similar to Eriocraniidae and Micropterigidae, but both of these have prominent ocelli.

Taxonomic References: Davis 1978

Hepialidae (Fig. 5-73)

Superfamily: Hepialoidea

Number of Canadian Species: 12 spp. found throughout Canada south of the tundra.

Genera: *Gazorycta, Korscheltellus, Paraphymatopus, Sthenopis*

Abundance: Uncommon to locally common, some species frequent lights, many are most frequently found in mating swarms in the evening.

Quick Recognition: Large to huge thick-bodied micromoths with relatively small heads, short antennae, and homoneurous wings. Most species are easy to recognize by wing pattern, though there is no modern literature on *Paraphymatopus*.

Diagnosis: HEAD: tiny relative to thorax; ocelli absent; head scales rough; proboscis absent; both labial and maxillary palps tiny; antenna filiform, scale-less, very short. THORAX: wings homoneurous, with a jugum; forewing usually marked with broad bands or blotches, sometimes metallic; hindwing usually mostly unpatterned; legs with without tibial spurs, hind tibial and tarsal spines not obvious except in *Gazorycta*. ABDOMEN: entirely smooth, and relatively long.

Similar Taxa: No other family of homoneurous moths approaches the size of a ghost moth.

Taxonomic References: Barnes & Benjamin 1925 (*Gazorycta* spp.); Powell & Opler 2009 (*Paraphymatopus* spp. and some others); Handfield 1999 (eastern spp.)

Nepticulidae (Fig. 5-74)

Superfamily: Nepticuloidea

Number of Canadian Species: 37 spp. found across Canada

Genera: *Stigmella, Ectoedemia, Trifurcula, Obrussa*

Abundance: uncommon, some species come to lights

Quick Recognition: The minute size (forewing length 3 mm or less) combined with the large eye-caps and darkly patterned forewings make it easily recognizable. Most species need to be dissected for positive identification.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough, rarely smooth on the frons; proboscis very short and can be difficult to see; labial palps small and descending; maxillary palps prominent; antenna filiform, with one scale row per segment, half length of the forewing or shorter, with a very large rounded eye-cap at the base. THORAX: wings heteroneurous and lanceolate, with a frenulum, jugum sometimes present; forewing dark and usually metallic, often with a pale band; hindwing usually pale grey; legs with tibial spur formula of 0-2-4, hind tibial spurs prominent, very large hind tibial spines present though sometimes obscured. ABDOMEN: entirely smooth, dark.

Similar Taxa: Opostegidae (forewing mostly white)

Taxonomic References: Wilkinson & Scoble 1979

Opostegidae (Fig. 5-75)

Superfamily: Nepticuloidea

Number of Canadian Species: at least 4 spp. found across Canada

Genera: *Opostegoides, Pseudopostega*

Abundance: rare, some species come to lights

Quick Recognition: The minute size (forewing length 5 mm or less) combined with the large eye-caps and mostly white forewings make it easily recognizable. Most species need to be dissected for positive identification.

Diagnosis: HEAD: ocelli absent; head scales smooth or rough; proboscis very short and difficult to see; labial palps small and descending; maxillary palps often prominent; antenna filiform, with one scale row per segment, half length of the forewing or more, with a very large eye-cap at the base. THORAX: wings heteroneurous and lanceolate, without a frenulum though with a row of curved scales that serves the same function; forewing always predominantly white, often with some darker markings; hindwing usually pale brownish grey; legs with tibial spur formula of 0-2-4, hind tibial spurs variably prominent, very large hind tibial spines present, tibial spines often present. ABDOMEN: entirely smooth.

Similar Taxa: Nepticulidae (forewing mostly darkly patterned)

Taxonomic References: Davis & Stonis 2007

Heliozelidae (Fig. 5-76)

Superfamily: Incurvarioidea

Number of Canadian Species: at least 13 spp. sporadic across Canada, most spp. in the east.

Genera: *Antispila, Coptodisca*

Abundance: Rare, typically collected diurnally.

Quick Recognition: Very small, metallic forewing, scaled proboscis, descending labial palps, ocelli absent, sclerotized ovipositor. Difficult to identify due to lack of literature.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis present and scaled at base, scaling can be difficult to see; labial palps descending; maxillary palps visible; antenna filiform, with two scale rows per segment, that rarely appears as one scale row per segment, half the length of the forewing or less. THORAX: wings heteroneurous and lanceolate, with a frenulum; forewing metallic usually with broad antemedian or postmedian bands; hindwing grey; legs with tibial spur formula of 0-2-4, hind tibial spurs large. ABDOMEN: entirely smooth, with a sclerotized ovipositor.

Similar Taxa: Elachistidae, Elachistinae are similar, but the forewing pattern is never as bold and metallic and the ovipositor is not sclerotized.

Taxonomic References: Lafontaine 1973 (some *Antispila*), Forbes 1923 (a few)

Adelidae (Fig. 5-77)

Superfamily: Incurvarioidea

Number of Canadian Species: 13 spp. across Canada but most diverse in the west, some undescribed.

Genera: *Adela*, *Cauchas, Elasmion*

Abundance: Common, most species encountered diurnally, especially in mating swarms or at flowers.

Quick Recognition: Usually metallic, often with antennae much longer than the forewing length, with two scale rows per antennal segment, rough scaling on the head, with a scaled proboscis and lacking ocelli. Generally easy to identify though there are a few undescribed species in the west.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough, occasionally smooth on the frons; proboscis present and scaled at base, scaling can be difficult to see; labial palps descending or porrect; maxillary palps small; antenna filiform, sometimes thickened on shaft or at base, with two scale rows per segment, greater than half the length of the forewing in *Cauchas*, much longer than the forewing in other genera. THORAX: wings heteroneurous and rounded, with a frenulum; forewing often metallic and often with prominent lines; hindwing usually grey; legs with tibial spur formula of 0-2-4, hind tibial spurs variable; tarsal spines prominent. ABDOMEN: entirely smooth, with a sclerotized ovipositor.

Similar Taxa: Prodoxidae are similar but can be separated by the typically less metallic wing markings, longer maxillary palps, and most genera do not have two distinct scale rows per antennal segment; if with two scale rows, they lack a scaled proboscis. Incurvariidae can be separated since they have one scale row per antennal segment. Tineidae are less commonly metallic and rarely have a scaled proboscis.

Taxonomic References: Powell 1969 (most spp.); Handfield 1999 (most eastern spp.)

Prodoxidae, Lamproniinae (Fig. 5-78)

Superfamily: Incurvarioidea

Number of Canadian Species: at least 7 spp. across Canada but most diverse in the west.

Genera: *Lampronia*, *Tetragma*

Abundance: Uncommon to locally common, encountered diurnally or nocturnally.

Quick Recognition: Most *Lampronia* have a bold blotchy pattern or are metallic on the forewing, *Tetragma* is uniformly creamy. The combination of sclerotized ovipositor, lack of ocelli, scaled proboscis, long maxillary palps, and forewing pattern will help seperate it from most similar taxa. Some species are easy to identify, though there is a lack of comprehensive literature.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually rough; proboscis usually short and usually scaled at base; labial palps ascending or porrect; maxillary palps quite long; antenna filiform, with one scale row per segment or unscaled, about half the length of the forewing or less. THORAX: wings heteroneurous and rounded, with a frenulum; forewing with a bold blotchy pattern, metallic, or uniformly grey; hindwing usually whitish brown, can be metallic; legs with tibial spur formula of 0-2-4, hind tibial spurs prominent; tarsal spines usually absent. ABDOMEN: entirely smooth, with a sclerotized ovipositor.

Similar Taxa: Adelidae usually have much longer antennae, are usually metallic, and always have two rows of scales per antennal segment. Prodoxinae typically have more distinctive tarsal spines, often lack bold blotchy markings on the forewing, and never have a scaled proboscis. Incurvariidae can be separated by forewing pattern. Tineidae rarely have a scaled proboscis.

Taxonomic References: Dietz 1905 (some *Lampronia*); Davis, *et al.* 1992 (*Tetragma*)

Prodoxidae, Prodoxinae (Fig. 5-79)

Superfamily: Incurvarioidea

Number of Canadian Species: at least 12 spp. in western Canada and in extreme southern Ontario.

Genera: *Greya, Prodoxus, Tegeticula*

Abundance: Rare to locally uncommon, *Prodoxus* and *Tegeticula* are found in close association with yucca flowers.

Quick Recognition: *Greya* is either uniformly greyish or has a blotchy forewing pattern; The other genera are closely associated with yucca and are white, sometimes with black markings on the forewing. The very long labial palps are characteristic in most species. Fairly easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis present and unscaled; labial palps ascending or porrect; maxillary palps normally quite long and sometimes form flexible tentacles; antenna filiform, with variable scaling, usually less than half the length of the forewing. THORAX: wings heteroneurous and rounded, with a frenulum; forewing with a bold blotchy pattern, uniformly greyish, or white, sometimes with black spots; hindwing usually white, sometimes greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs variable, tarsal spines usually present. ABDOMEN: entirely smooth, with a sclerotized ovipositor.

Similar Taxa: Adelidae usually have much longer antennae and are usually metallic, and always have two rows of scales per antennal segment. Lamproniinae typically have less distinctive tarsal spines, usually have a scaled proboscis, and have a different forewing pattern. Incurvariidae can be separated by forewing pattern. Tineidae usually have shorter maxillary palps.

Taxonomic References: Davis, *et al.* 1992 (*Greya*); Powell & Opler 2009 (*Prodoxus*); Pellmyr 1999 (*Tegeticula*)

Incurvariidae (Fig. 5-80)

Superfamily: Incurvarioidea

Number of Canadian Species: at least 2 spp. across southern Canada.

Genera: *Paraclemensia, Phylloporia*

Abundance: Rare to locally abundant, *Paraclemensia acerifoliella* can outbreak in Sugar Maple forests, regularly taken at lights.

Quick Recognition: *Paraclemensia acerifoliella* is easily recognized by the metallic blue forewings and orange head. *Phylloporia bistrigella* is brownish with pale white antemedian and postmedian lines like many other small microleps, but the large maxillary palps, scaled proboscis, and rough orange head scales will distinguish it.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough and orange on the vertex, sometimes partially appressed on the frons; proboscis short and scaled; labial palps variable in orientation; maxillary palps long; antenna filiform, with variable scaling, usually around half the length of the forewing. THORAX: wings heteroneurous and rounded to nearly lanceolate, with a frenulum; forewing metallic blue or brown with white lines; hindwing greyish and translucent; legs with tibial spur formula of 0-2-4, hind tibial spurs long, tarsal spines sometimes present. ABDOMEN: entirely smooth, with a sclerotized ovipositor.

Similar Taxa: The two species can be separated from other similar microleps as outlined above.

Taxonomic References: Covell 1984 (*Paraclemensia*); Dietz 1905 (*Phylloporia*)

Tischeriidae (Fig. 5-81)

Superfamily: Tischerioidea

Number of Canadian Species: at least 9 spp. across Canada, most diverse in the southeast.

Genera: *Coptotriche*

Abundance: Rare, rarely comes to light.

Quick Recognition: Very small often pale coloured microleps, head tapering towards the proboscis which is scaled, prominent rough `mushroom` of scales on the vertex with smoothly scaled frons, and very long antennal sensillae. Specimens must be dissected for specific identification.

Diagnosis: HEAD: ocelli absent; head scales prominent and forming a mushroom-like appearance on the vertex, scales appressed on the frons; proboscis scaled; labial palps short and descending; maxillary palps small; antenna filiform, with a broadened scape, normally with two scale rows per segment, with prominent long sensillae on the underside, usually longer than half the length of the forewing. THORAX: wings heteroneurous and lanceolate, with a frenulum; forewing usually drab and unicolourous, sometimes metallic; hindwing pale; legs with tibial spur formula of 0-2-4, hind tibial spurs long. ABDOMEN: entirely smooth.

Similar Taxa: The characters of the head are diagnostic.

Taxonomic References: Braun 1972

Tineidae (Fig. 5-82)

Superfamily: Tineoidea

Number of Canadian Species: well over 40 spp. across Canada.

Genera: *Dryadaula, Eccritothrix, Elatobia, Haplotinea, Homosetia, Isocorypha, Monopis, Morophagoides, Nemapogon, Niditinea, Scardia, Scardiella, Tinea, Tineola*, *Trichophaga*, *Xylesthia*, and others.

Abundance: Common, most species come to light.

Quick Recognition: Difficult to characterize; usually small microleps, sometimes moderate sized, head scales rough and usually most prominent on the vertex, ocelli absent, proboscis reduced or lost, distinct bristles are usually present on the second segment of the labial palps, most species drab in colour. Many are difficult to identify to species due to an abundance of undescribed species and outdated literature.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough and usually prominent on vertex; proboscis reduced or absent, rarely scaled; labial palps usually long and tufted, typically with prominent bristles on the second segment; maxillary palps variable; antenna filiform, with one scale row per segment that often appears as two rows, usually longer than half the length of the forewing. THORAX: wings heteroneurous and often lanceolate, with a frenulum; forewing usually drab, sometimes boldly patterned; hindwing also drab; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long. ABDOMEN: entirely smooth.

Similar Taxa: The distinct bristles on the labial palps are normally present and will separate tineids from all other microleps except Acrolophidae and Psychidae. Both of the latter families have few Canadian species and are best separated by wing pattern.

Taxonomic References: Dietz 1905 (many species); Powell & Opler 2009 (many western species); Robinson 1986 (Scardiinae)

Acrolophidae (Fig. 5-83)

Superfamily: Tineoidea

Number of Canadian Species: 4 spp. across Canada including 1 undescribed sp.

Genera: *Acrolophus, Amydria*

Abundance: Rare to uncommon, can be found at light.

Quick Recognition: *Acrolophus* is rather large and has very long and sparse scales on the head and thorax. *Amydria* looks like a typical tineid and is best identified by the forewing pattern. They are relatively easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough and often sparse and hair-like; proboscis absent; labial palps ascending, variable in length and always tufted, with prominent spines laterally; maxillary palps small; antenna filiform, with one or two scale rows per segment, longer than half the length of the forewing in *Amydria*, much shorter in *Acrolophus*. THORAX: wings heteroneurous and rounded, with a frenulum; forewing usually drab and brownish, with fine darker markings; hindwing paler; legs with tibial spur formula of 0-2-4, hind tibial spurs variable. ABDOMEN: entirely smooth.

Similar Taxa: The distinct bristles on the labial palps are normally present and will separate acrolophids from all other microleps except Tineidae and Psychidae. The last two familes are best separated by wing pattern.

Taxonomic References: Dietz 1905 (*Amydria*); Hasbrouck 1964 (*Acrolophus*)

Psychidae (Fig. 5-84)

Superfamily: Tineoidea

Number of Canadian Species: 9 spp. across Canada

Genera: *Apterona, Astala, Dahlica, Hyaloscotes, Kearfottia, Psyche, Taleporia*

Abundance: Uncommon to locally common, most commonly seen as larval cases, some species come to light.

Quick Recognition: Easiest to recognize when associated with larval cases. Otherwise adults are quite variable in appearance. The most widespread species appear similar to a typical tineid with relatively slender wings, while some of the rarer species have very broad wings, or sharply pointed ones that are translucent. Most are easy to identify to species, especially when associated with a larval case, but a few require dissection.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually rough, occasionally smooth; proboscis absent; labial palps variable in orientation, short, and usually tufted; maxillary palps small; antenna filiform or pectinate, with variable scaling, usually less than half the length of the forewing. THORAX: wings heteroneurous and rounded, sometimes pointed, usually fairly slender though very broad in a few species, absent to greatly reduced in the females of most species, with a frenulum; forewing variable in pattern from drab and brownish, with fine darker markings, to translucent, to unicolourous, to having a broad white band; hindwing paler or similar to the forewing; legs with tibial spur formula of 0-2-4, hind tibial spurs variable. ABDOMEN: smooth to hairy.

Similar Taxa: Most flightless females of other families will have at least small wing pads present, while in Psychidae they are usually not visible. The smaller species look just like tineids and are best separated by wing pattern.

Taxonomic References: Davis 1964 (all but *Dahlica* and *Kearfottia*); Handfield 1999 (most eastern spp.)

Douglasiidae (Fig. 5-85)

Superfamily: Gracillarioidea

Number of Canadian Species: 4 described spp. and at least one undescribed spp.; in western Canada with only one of these found in the east.

Genera: *Tinagma*

Abundance: Rare to locally common, diurnal on their host plants or at light.

Quick Recognition: The brown and white dusted forewing with two brown bands coupled with the distinctly narrower hindwing is distinctive.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales smooth; proboscis present; labial palps usually descending, moderately long, tufted, maxillary palps small; antenna filiform, with one scale row per segment, about half the length of the forewing. THORAX: wings heteroneurous and lanceolate, with a frenulum; forewing consistent in pattern, brown and white dusted with two broad brown bands; hindwing much narrower than the forewing, evenly brown; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long. ABDOMEN: smooth.

Similar Taxa: The wing pattern and difference in size between the fore and hindwings are diagnostic.

Taxonomic References: Gaedike 1990

Bucculatricidae (Fig. 5-86)

Superfamily: Gracillarioidea

Number of Canadian Species: At least 32 spp. across Canada.

Genera: *Bucculatrix*

Abundance: uncommon to locally abundant, diurnal or at light.

Quick Recognition: The elongate pointed face, naked proboscis, rough-scaled vertex and smooth scaled frons, small eye-cap, and in the male a notched basal segment of the antenna is distinctive. Reared specimens are easily recognized by the characteristic ribbed cocoon of this family. Many specimens need dissection for specific identification.

Diagnosis: HEAD: ocelli absent; head with a distinct tuft of scales on the vertex, scales smooth on the elongate pointed frons; proboscis small; all palps tiny; antenna filiform, with two scale rows per segment, longer than half the length of the forewing. THORAX: wings heteroneurous and lanceolate, with a frenulum; forewing often boldly patterned, usually with oblique bands, spots, or streaks, sometimes with metallic markings; hindwing evenly grey or brown; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long, hind tibiae with long hair-like scales. ABDOMEN: smooth.

Similar Taxa: The head characters described above are diagnostic.

Taxonomic References: Braun 1963 (nearly all species)

Gracillariidae, Gracillariinae (Fig. 5-87)

Superfamily: Gracillarioidea

Number of Canadian Species: At least 65 spp. across Canada.

Genera: *Acrocercops*, *Callisto, Caloptilia, Leucanthiza, Marmara, Micrurapteryx, Parectopa, Parornix*

Abundance: common to locally abundant, most come to light, some commonly hibernating under bark.

Quick Recognition: Slender microleps that typically rest in a `push-up` position with the front of the body elevated; antennae with a single scale row and quite long; proboscis naked. Most species difficult to identify due to a lack of literature.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth, sometimes rough on the vertex; proboscis present, but sometimes difficult to see; labial palps usually ascending, usually long, usually slender; antenna filiform, with one scale row per segment, about the length of the forewing. THORAX: wings heteroneurous and lanceolate, with a frenulum; forewing pattern variable, often boldly patterned, sometimes metallic; hindwing evenly grey or brown; legs with tibial spur formula of 0-2-4, hind tibial spurs usually short, rarely with hind tibial spines. ABDOMEN: smooth.

Similar Taxa: The most similar taxa are the other subfamilies of Gracillariidae. Both Phyllocnistinae and Lithocolletinae are usually smaller (forewing length 1.5-3.9 mm), while in Gracillariinae the forewing length is 2.5-5.0 mm. The easiest way to separate the subfamilies is to key specimens out.

Taxonomic References: Forbes 1923 (key to genera & some spp.); Powell & Opler 2009 (some western spp.)

Gracillariidae, Lithocolletinae (Fig. 5-88)

Superfamily: Gracillarioidea

Number of Canadian Species: At least 65 spp. across Canada.

Genera: *Cameraria*, *Chrysaster*, *Cremastobombycia*, *Phyllonorycter*, *Porphyrosela*, *Prolithocolletis*

Abundance: uncommon to common, most come to light.

Quick Recognition: Tiny microleps, typically with boldly patterned forewings, with a single scale row per antennal segment and a naked proboscis. Most need dissection for specific identification.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually rough on the vertex, smooth on the frons; proboscis present; labial palps descending, variable in length, slender; antenna filiform, with one scale row per segment, about the length of the forewing. THORAX: wings heteroneurous and lanceolate, with a frenulum; forewing usually boldly patterned with oblique lines or triangles, sometimes metallic; hindwing usually evenly grey; legs with tibial spur formula of 0-2-4, hind tibial spurs variable in length. ABDOMEN: smooth.

Similar Taxa: The most similar taxa are the other subfamilies of Gracillariidae. Gracillariinae are typically larger (forewing length 2.5-5.0 mm, in Lithocolletinae 1.8-3.9 mm) and have usually ascending labial palps and a smoothly scaled vertex. Phyllocnistinae usually have prominent hind tibial and tarsal spines and have the bold markings on the forewing mostly near the apex. Other tiny microleps of similar pattern typically have a scaled proboscis. The easiest way to separate the subfamilies is to key specimens out.

Taxonomic References: Braun 1908 (most spp.); Forbes 1923 (key to most genera & some spp.); Powell & Opler 2009 (some western spp.)

Gracillariidae, Phyllocnistinae (Fig. 5-89)

Superfamily: Gracillarioidea

Number of Canadian Species: At least 3 spp. across Canada, with at least 1 undescribed species.

Genera: *Phyllocnistis*

Abundance: uncommon to common, at light or hibernating under bark.

Quick Recognition: Tiny microleps, the forewing is white with a complex pattern on the outer two-fifths of the wing, with a single scale row per segment on the antenna and a naked proboscis. They are most easily identified to species when associated with a larval leafmine.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis present, though can be difficult to see; labial palps descending, fairly long, slender; antenna filiform, with one scale row per segment, shorter than the length of the forewing. THORAX: wings heteroneurous and lanceolate, with a frenulum; forewing white with a complex pattern on the outer two-fifths, occasionally with a dark blotch along the inner margin near the base; hindwing very slender, evenly grey; legs with tibial spur formula of 0-2-4, hind tibial spurs usually fairly long, hind tibial and tarsal spines present. ABDOMEN: smooth.

Similar Taxa: The forewing pattern, spined hind tibiae and tarsi, and tiny size (forewing length 1.5-2.8 mm) will separate it from other Gracillariidae. Other tiny microleps of similar pattern typically have a scaled proboscis or lack spines on the hind tibiae and tarsi.

Taxonomic References: Forbes 1923; Powell & Opler 2009 (some spp.)

Yponomeutidae, Attevinae (Fig. 5-90)

Superfamily: Yponomeutoidea

Number of Canadian Species: 1 species (*Atteva aurea*) in southern ON and PQ.

Genera: *Atteva*

Abundance: uncommon at lights.

Quick Recognition: The forewing pattern, with clusters of pale spots, is unmistakeable.

Diagnosis: HEAD: ocelli absent; head scales smooth, slightly roughened on the vertex; proboscis present; labial palps ascending, two times as long as the compound eye, slender; antenna filiform, with one scale row per segment, shorter than the length of the forewing. THORAX: wings heteroneurous and broad, with a frenulum; forewing orange with clusters of yellow spots surrounded by metallic blue; hindwing grey and very translucent towards the center; legs with tibial spur formula of 0-2-4, hind tibial spurs short. ABDOMEN: smooth.

Similar Taxa: None

Taxonomic References: Wilson, *et al*. 2010

Yponomeutidae, Yponomeutinae (Fig. 5-91)

Superfamily: Yponomeutoidea

Number of Canadian Species: 15 species across Canada.

Genera: *Eucalantica, Euhyponomeutoides, Kessleria, Ocnerostoma, Paraswammerdamia, Swammerdamia, Yponomeuta, Zelleria*

Abundance: uncommon, most come to light.

Quick Recognition: Quite variable on the generic level and difficult to characterize overall. Some species easily recognized by the broad white forewing with fine black spots. Others tend to be much more slender. Species identification can be challenging.

Diagnosis: HEAD: ocelli absent; head scales rough, often smooth on the frons; proboscis present; labial palps porrect or descending, usually fairly long, slender, rarely tufted; antenna filiform, with two scale rows per segment, usually longer than half the length of the forewing. THORAX: wings heteroneurous and either broad or lanceolate, sometimes very slender, with a frenulum; forewing pattern variable, sometimes white with black spots, often streaky, sometimes unpatterned; hindwing usually grey or brown; legs with tibial spur formula 0-2-4, hind tibial spurs variable, hind tarsal spines sometimes present. ABDOMEN: smooth.

Similar Taxa: Argyresthiinae are closely related and similar, most species have bold patterns that will immediately distinguish them and they never have tarsal spines. Plutellidae can be separated by the distinctive forward projecting triangular scale tuft on the labial palps. Bedelliidae can be separated by forewing pattern. Bucculatricidae typically have a very boldly patterned wing and have a characteristic elongate and smooth scaled frons combined with a distinct scale tuft on the vertex. Urodidae can be separated by the pattern and distinct raised scales of the forewing. Tineidae typically have a less prominent proboscis and much rougher looking scales on the vertex. Copromorphidae can be separated on wing pattern.

Taxonomic References: Freeman 1960 (*Ocnerostoma*, *Zelleria*); Powell & Opler 2009 (*Eucalantica*, *Zelleria*); Duckworth 1965 (most *Swammerdamia*); Sperling, *et al.* 1995 (*Yponomeuta*); Braun 1940 (*Kessleria*)

Yponomeutidae, Argyresthiinae (Fig. 5-92)

Superfamily: Yponomeutoidea

Number of Canadian Species: at least 22 species across Canada.

Genera: *Argyresthia*

Abundance: common at light.

Quick Recognition: Live specimens are easily recognized by the characteristic head-standing pose. Slender lanceolate wings, forewing often with distinctive blotches of various colours or pure gold, coupled with no ocelli, naked proboscis, and rough vertex with smooth frons will help distinguish this from most other taxa. Species identification is easy for most boldly-patterned species, but more challenging for others.

Diagnosis: HEAD: ocelli absent; head scales rough on the vertex and smooth on the frons; proboscis naked; labial palps variable in orientation, fairly long, slender; antenna filiform, with one or two scale rows per segment, longer than half the length of the forewing. THORAX: wings heteroneurous and lanceolate; forewing pattern often with a complex pattern of blotches or strigulae, sometimes unicolourous, shiny to metallic; hindwing usually grey or brown; legs with tibial spur formula 0-2-4, hind tibial spurs long; ABDOMEN: smooth.

Similar Taxa: Some Yponomeutinae are similar, but they typically have tarsal spines, otherwise they are difficult to separate. Bedelliidae can be separated by forewing pattern. Tineidae typically have a less prominent proboscis. Gracillariidae can be similar, but always have 1 scale row per antennal segment and often have shorter hind tibial spurs.

Taxonomic References: Busck 1907; Freeman 1972 (some species)

Ypsolophidae, Ypsolophinae (Fig. 5-93)

Superfamily: Yponomeutoidea

Number of Canadian Species: at least 13 species across Canada, most diverse in the west.

Genera: *Euceratia, Ypsolopha*

Abundance: rare to uncommon at light.

Quick Recognition: Most species have a prominent curved tip to the forewing, if not then they usually have a bulge at both the apex and anal angle of the forewing. Most species also have very long porrect labial palps. Species identifications are challenging in the west due to the lack of literature.

Diagnosis: HEAD: ocelli usually absent; head scales rough; proboscis present; labial palps variable in orientation but usually porrect, long, usually tufted; antenna filiform, with two scale rows per segment, usually longer than half the length of the forewing, usually with fairly prominent sensillae. THORAX: wings heteroneurous and broadly lanceolate, forewing often with a prominent hook at the apex, otherwise usually with prominent bulges at the apex and anal angle; forewing pattern variable, most often yellow and brown; hindwing usually grey or brown; legs with tibial spur formula 0-2-4, hind tibial spurs variable, hind tarsal spines present; ABDOMEN: smooth, sometimes with a prominent ovipositor.

Similar Taxa: A few ypsolophines lack the peculiar shaped forewings and are similar to Yponomeutinae, which never have the massive porrect labial palps.

Taxonomic References: Aurelian 2008 (most species east of BC); Powell & Opler 2009 (some western species)

Ypsolophidae, Ochsenheimeriinae (Fig. 5-94)

Superfamily: Yponomeutoidea

Number of Canadian Species: A single species *Ochsenheimeria vaculella* has been introduced from Europe and can be found in ON and PQ.

Genera: *Ochsenheimeria*

Abundance: rare at light.

Quick Recognition: The vertex and antennal base with long scales, smoothly scaled frons, tibial spines, and yellow band on the abdomen will identify this species.

Diagnosis: HEAD: ocelli present; head scales rough and long on the vertex, smooth on the frons; proboscis present; labial palps ascending, long, tufted; antenna filiform, with long dense scales at base, with two scale rows per segment, less than half the length of the forewing. THORAX: wings heteroneurous and broadly lanceolate; forewing usually dull, brown; hindwing greyish brown, very pale at base; legs with tibial spur formula 0-2-4, hind tibial spurs long, hind tibial and tarsal spines present; ABDOMEN: smooth and brown with a yellow band distally.

Similar Taxa: The quick recognition characters will separate it from other taxa.

Taxonomic References: Covell 1984

Plutellidae (Fig. 5-95)

Superfamily: Yponomeutoidea

Number of Canadian Species: At least 6 spp. nearly everywhere in Canada, most diverse in the west.

Genera: *Plutella*, *Rhigognostis*

Abundance: common at light.

Quick Recognition: The forward-pointing scale tuft on the second segment of the labial palps is distinctive. Species are generally easy to identify, but the literature is lacking for most.

Diagnosis: HEAD: ocelli present; head scales rough, rarely smooth on the frons; proboscis present; labial palps ascending, usually long, with a prominent triangular scale tuft on the second segment; antenna filiform, with two scale rows per segment, greater than half the length of the forewing. THORAX: wings heteroneurous and broadly lanceolate; forewing usually with markings elongate; hindwing greyish; legs with tibial spur formula 0-2-4, hind tibial spurs usually short, hind tarsal spines usually present; ABDOMEN: smooth.

Similar Taxa: None, the triangular scale tufts on the labial palps are distinctive.

Taxonomic References: Covell 1984 (*Plutella xylostella*); Forbes 1923 (eastern *Plutella*); Powell & Opler 2009; Baraniak 2007 (some western spp.)

Acrolepiidae (Fig. 5-96)

Superfamily: Yponomeutoidea

Number of Canadian Species: 3 spp., 1 probably widespread in the west and 2 in southern ON & PQ.

Genera: *Acrolepiopsis*

Abundance: rare, though one is a pest on leeks in ON & PQ, rarely come to light.

Quick Recognition: Labial palps ascending and un-tufted, proboscis naked, ocelli present. Identification to species may require dissection.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough on vertex, smooth on frons; proboscis present; labial palps ascending, long, slender without tufts; antenna filiform, with two scale rows per segment, greater than half the length of the forewing. THORAX: wings heteroneurous and broadly lanceolate; forewing brown to grey with the most prominent marking a white triangular spot on the inner margin in the antemedian area, other markings variably present; hindwing greyish; legs with tibial spur formula 0-2-4, hind tibial spurs long, hind tarsal spines sometimes present; ABDOMEN: smooth.

Similar Taxa: Plutellidae have a prominent triangular tuft of scales on the labial palps.

Taxonomic References: Landry 2007

Glyphipterigidae (Fig. 5-97)

Superfamily: Yponomeutoidea

Number of Canadian Species: 9 spp. across Canada.

Genera: *Diploschizia, Glyphipterix*

Abundance: rare to uncommon, diurnal.

Quick Recognition: The prominent curved metallic wing markings, naked proboscis, and large ocelli are characteristic. Identification to species is usually not too difficult.

Diagnosis: HEAD: ocelli large; chaetosemata absent; head scales smooth; proboscis present; labial palps usually ascending, long, usually slender; antenna filiform, often with prominent sensillae, with two scale rows per segment, about half the length of the forewing or less. THORAX: wings heteroneurous and fairly broad, hindwing sometimes lanceolate; forewing variable in pattern, markings typically curved and metallic; hindwing brown; legs with tibial spur formula 0-2-4, hind tibial spurs long; ABDOMEN: smooth, sometimes boldly patterned.

Similar Taxa: Choreutidae have a scaled proboscis.

Taxonomic References: Heppner 1985

Heliodinidae (Fig. 5-98)

Superfamily: Yponomeutoidea

Number of Canadian Species: 1 sp., *Neoheliodines nyctaginella* in southern MB and BC.

Genera: *Neoheliodines*

Abundance: very rare, diurnal.

Quick Recognition: The distinctive forewing markings coupled with smoothly-scaled head, naked proboscis, and drooping labial palps will identify it.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales smooth; proboscis present; labial palps descending, short, slender; antenna filiform, with two scale rows per segment, longer than half the length of the forewing. THORAX: wings heteroneurous and lanceolate; forewing metallic, orange with black borders and metallic spots; hindwing greyish brown; legs with tibial spur formula 0-2-4, hind tibial spurs long; ABDOMEN: smooth.

Similar Taxa: Several other microleps have a similar forewing pattern but these all have a scaled proboscis.

Taxonomic References: Covell 1984

Bedelliidae (Fig. 5-99)

Superfamily: Yponomeutoidea

Number of Canadian Species: 1 sp., *Bedellia somnulenta* across southern Canada.

Genera: *Bedellia*

Abundance: rare to uncommon at light.

Quick Recognition: The naked proboscis, roughly scaled vertex, lack of ocelli, expanded antennal base, and drooping labial palps will help identify it.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough on the vertex, smooth on the frons; proboscis present; labial palps descending, usually short, slender; antenna filiform, with two scale rows per segment, usually longer than the length of the forewing. THORAX: wings heteroneurous and lanceolate; forewing drab greyish to brownish and finely speckled, sometimes with more distinctive cream markings along inner margin; hindwing greyish brown; legs with tibial spur formula 0-2-4, hind tibial spurs long; ABDOMEN: smooth.

Similar Taxa: Both Lyonetiidae and Argyresthiinae are similar. The easiest way to separate Bedelliidae from these taxa is by the forewing pattern. Superficially they are similar to Coleophoridae, but can be separated by the naked proboscis, drooping labial palps, and lack of spine patches on top of the abdomen.

Taxonomic References: Powell & Opler 2009

Lyonetiidae (Fig. 5-100)

Superfamily: Yponomeutoidea

Number of Canadian Species: 6 spp., across Canada.

Genera: *Leucoptera, Lyonetia, Paraleucoptera, Proleucoptera*

Abundance: rare to locally uncommon, most come to light.

Quick Recognition: The naked proboscis, roughly scaled vertex, lack of ocelli, expanded antennal base, and drooping labial palps will help identify the family.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually rough on the vertex, smooth on the frons; proboscis present; labial palps descending, usually short, slender; antenna filiform, with two scale rows per segment, usually longer than the length of the forewing. THORAX: wings heteroneurous and lanceolate; forewing variable in pattern and colour; hindwing usually greyish brown; legs with tibial spur formula 0-2-4, hind tibial spurs variable in length; ABDOMEN: smooth.

Similar Taxa: Both Bedelliidae and Argyresthiinae are similar. Bedelliidae are best separated by forewing pattern. Argyresthiinae usually have a slightly broader forewing and often have a more blotchy pattern compared to the finer markings typical of Lyonetiidae.

Taxonomic References: Forbes 1923 (*Paraleucoptera, Proleucoptera*, some *Lyonetia*)

Elachistidae, Stenomatinae (Fig. 5-101)

Superfamily: Gelechioidea

Number of Canadian Species: 5 spp., in eastern Canada and 1 sp. in southern BC.

Genera: *Antaeotricha, Gonioterma, Menesta*

Abundance: rare to common at light.

Quick Recognition: Scaled proboscis, elongate squared forewings, broader hindwings, large size. Most are easy to identify to species, dissection is often necessary for *Antaeotricha*.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales often rough on the vertex, usually smooth on the frons; proboscis scaled; labial palps ascending, long, slender; antenna filiform, with two scale rows per segment, with prominent sensillae, usually longer than half the length of the forewing. THORAX: sometimes tufted; wings heteroneurous, forewing elongate and squared, hindwing broader; forewing usually mottled in colour, sometimes with raised scales, sometimes iridescent, hindwing grey, brown, or white; legs with tibial spur formula 0-2-4, hind tibial spurs usually long, hind tibial spines rarely present; ABDOMEN: smooth.

Similar Taxa: Ethmiinae, Oecophoridae, and Gelechiinae are most easily separated by forewing pattern. Phycitinae can be separated by forewing pattern as well, and typically have the antennae tucked straight backwards, whereas in Stenomatinae the antennae usually point forwards or out to the sides.

Taxonomic References: Duckworth 1964 (*Antaeotricha*, *Gonioterma*)

Elachistidae, Ethmiinae (Fig. 5-102)

Superfamily: Gelechioidea

Number of Canadian Species: 7 spp., across southern Canada.

Genera: *Ethmia*, *Pyramidobela*

Abundance: uncommon to common at light.

Quick Recognition: Scaled proboscis, elongate squared forewings, broader hindwings, large size, in *Ethmia* the forewing is boldly patterned with black and grey or white, and has a brightly coloured abdomen; in *Pyramidobela* the forewing pattern is mostly brown with prominent raised scales. They are easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales at least partially smooth on the vertex, smooth on the frons; proboscis scaled; labial palps usually ascending, long, usually slender; antenna filiform, with one or two scale rows per segment, rarely with prominent sensillae, variable in length but usually around half the forewing length. THORAX: wings heteroneurous, forewing elongate and squared to rounded, hindwing broader; forewing usually boldly patterned with black and white or grey, the black spots often as a broad streak along the inner margin and often as elongate spots, sometimes mostly brownish with raised scales, hindwing usually grey; legs with tibial spur formula 0-2-4, hind tibial spurs variable in length, hind tarsal spines present, though may be difficult to see; ABDOMEN: smooth, boldly patterned or brightly coloured in most species.

Similar Taxa: The combination of size, forewing pattern, boldly coloured abdomen, and scaled proboscis will separate *Ethmia* from all others. The combination of size, forewing pattern, raised scales on the forewing, and scaled proboscis will separate *Pyramidobela* from all others.

Taxonomic References: Powell 1973

Elachistidae, Depressariinae (Fig. 5-103)

Superfamily: Gelechioidea

Number of Canadian Species: 49 spp., throughout Canada.

Genera: *Agonopterix, Bibarrambla, Depressaria, Depressariodes, Nites, Semioscopis*

Abundance: common at light or hibernating under bark

Quick Recognition: Scaled proboscis, usually squared forewings, overall very flattened body, most species common from fall to spring. Some are easy to identify to species by forewing pattern, others require dissection, especially in the west.

Diagnosis: HEAD: ocelli present or absent; chaetosemata absent; head scales rough on vertex, smooth on frons; proboscis scaled; labial palps curved up and back over the head, long, usually slender, sometimes tufted; antenna filiform, with two scale rows per segment, usually around half the forewing length. THORAX: wings heteroneurous, forewing squared, sometimes acutely pointed, hindwing broad; forewing variable in pattern, usually brown or grey, hindwing usually grey; legs with tibial spur formula 0-2-4, hind tibial spurs variable in length, hind tarsal spines often present; ABDOMEN: smooth.

Similar Taxa: Superficially depressariines are similar to some tortricids in the tribe Tortricini, but can be easily separated by the scaled proboscis and recurved labial palps. Amphisbatidae are also flattened but can be separated by forewing pattern. Oecophoridae and Ethmiinae usually have a narrower forewing, otherwise they can be separated by forewing pattern. Phycitinae tends to have much narrower forewings relative to the broad hindwings, and the antennae typically rest tightly backwards. Crambidae usually have a more triangular forewing and a very different forewing pattern.

Taxonomic References: Hodges 1974; Clarke 1941

Elachistidae, Elachistinae (Fig. 5-104)

Superfamily: Gelechioidea

Number of Canadian Species: At least 54 spp., throughout Canada, more probably undescribed.

Genera: *Coelopoeta, Elachista, Perittia*

Abundance: uncommon to common, many come to light.

Quick Recognition: Scaled proboscis, curved labial palps, smooth head scaling, small size, relatively stubby lanceolate wings. Most require dissection for specific identification.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis scaled; labial palps ascending, long, slender; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, lanceolate; forewing variable in pattern and colour, hindwing usually grey; legs with tibial spur formula 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: Many other Gelechioidea like Oecophoridae, Batrachedridae, Coleophoridae, Cosmopterigidae, and Gelechiinae can look very similar. They can be tricky to separate externally, but Elachistinae tend to have stouter looking wings.

Taxonomic References: Kaila 1995a; 1995b; 1996; 1997; 1999

Elachistidae, Agonoxeninae (Fig. 5-105)

Superfamily: Gelechioidea

Number of Canadian Species: At least 3 spp., across southern Canada.

Genera: *Blastodacna, Chrysoclista*

Abundance: rare to locally uncommon, diurnal or at light.

Quick Recognition: Scaled proboscis, long labial palps, smooth head scaling, raised scales on forewing. Fairly easy to identify to species in the east using a reference collection, in the west there may be undescribed species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth, rarely roughened on vertex; proboscis scaled; labial palps ascending or porrect, long, slender; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, lanceolate; forewing with tufts of raised scales, either greyish or black with a large orange blotch and silvery spots, hindwing usually grey; legs with tibial spur formula 0-2-4, hind tibial spurs usually long. ABDOMEN: smooth.

Similar Taxa: A few other Gelechioidea like Momphinae, Cosmopterigidae, and Gelechiinae can look similar. These are best separated by forewing pattern.

Taxonomic References: *Blastodacna curvilineela* is in Forbes 1923, *Chrysoclista lineella* is in Covell 1984

Xyloryctidae, Scythridinae (Fig. 5-106)

Superfamily: Gelechioidea

Number of Canadian Species: At least 13 spp., throughout Canada, many undescribed.

Genera: *Landryia, Rhamphura, Scythris*

Abundance: rare to uncommon, usually diurnal.

Quick Recognition: Scaled proboscis, long labial palps, usually drably patterned. Many require dissection for specific identification, though many species are undescribed.

Diagnosis: HEAD: ocelli present or absent; chaetosemata absent; head scales smooth, sometimes roughened; proboscis scaled; labial palps ascending or porrect, long, slender; antenna filiform, with two scale rows per segment, usually longer than half the forewing length. THORAX: wings heteroneurous, lanceolate; forewing variable though usually subdued, hindwing usually greyish; legs with tibial spur formula 0-2-4, hind tibial spurs short. ABDOMEN: smooth.

Similar Taxa: A few other Gelechioidea like Gelechiinae and Oecophoridae can look similar and are often difficult to separate.

Taxonomic References: Landry 1991

Chimbachidae (Fig. 5-107, 5-108)

Superfamily: Gelechioidea

Number of Canadian Species: A single introduced species *Dasytromma salicella* has been found in southern BC.

Genera: *Dasytromma*

Abundance: rarely collected due to its limited distribution and early spring adult emergence.

Quick Recognition: Scaled proboscis, broad greyish brown forewing with two indistinct bands in the male, wingless female.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales somewhat rough, smooth on the frons in males; proboscis scaled; labial palps porrect, slightly ascending in females, long, tufted; antenna filiform, with two scale rows per segment, longer than half the forewing length and with prominent sensillae in males. THORAX: wings heteroneurous, broad, forewing somewhat pointed, females brachypterous; forewing greyish brown with two dark partial bands, hindwing greyish brown; legs with tibial spur formula 0-2-4, hind tibial spurs long in males, short in females; hind tarsal spines present. ABDOMEN: with some rough scales.

Similar Taxa: Females can be separated from other apterous moths by the scaled proboscis. Males can be separated from all others by the combination of scaled proboscis, ocelli, and forewing pattern.

Taxonomic References: Hodges 1974

Glyphidoceridae (Fig. 5-109)

Superfamily: Gelechioidea

Number of Canadian Species: 3 spp., in BC, AB, ON, and PQ, probably more widespread.

Genera: *Glyphidocera*

Abundance: rare, comes to light

Quick Recognition: Scaled proboscis, elongate squared forewings with broader hindwings, somewhat difficult to instantly separate from other similar looking Gelechioidea. Identification to species is fairly easy from a reference collection, but the near lack of literature makes it difficult.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales somewhat rough or smooth on vertex, smooth on the frons; proboscis scaled; labial palps upcurved, long, slender; antenna filiform, with two scale rows per segment, usually longer than half the forewing length. THORAX: wings heteroneurous, forewing elongate and squared, hindwing broader; forewing typically brownish, sometimes with spots, hindwing brownish; legs with tibial spur formula 0-2-4, hind tibial spurs variable in length; hind tarsal spines rarely present. ABDOMEN: smooth.

Similar Taxa: Similar to Blastobasinae, Depressariinae, and Oecophoridae from which it usually can be separated by forewing pattern. Gelechiidae usually have a narrower hindwing that often has a distinctly projected apex. Several Pyralidae will key out with it, and they can be separated by the antennae tucking tightly back over the body and by the wing shape and pattern.

Taxonomic References: Adamski 2000 (western sp.)

Oecophoridae (Fig. 5-110)

Superfamily: Gelechioidea

Number of Canadian Species: 18 species across Canada.

Genera: *Batia, Brymblia, Carcina, Carolana, Decantha, Denisia, Eido, Endrosis, Epicallima, Fabiola, Hofmannophila, Mathildana, Oecophora, Pleurota, Polix, Schiffermuelleria, Stathmopoda*

Abundance: uncommon to common, most come to light.

Quick Recognition: Scaled proboscis, large recurved labial palps, no ocelli, often boldly patterned. Identification to species is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth, sometimes rough on vertex; proboscis scaled; labial palps recurved, long, slender, rarely tufted; antenna filiform, with two scale rows per segment, usually longer than half the forewing length, sensillae often prominent. THORAX: wings heteroneurous, usually lanceolate, sometimes more rounded in larger species; forewing highly variable in pattern and colour, often with bold patterns and bright colours, hindwing usually grey, brown, or white; legs with tibial spur formula 0-2-4, hind tibial spurs usually long; hind tarsal spines rarely present. ABDOMEN: smooth.

Similar Taxa: Depressariinae, Xyloryctidae, Coleophoridae, and Gelechiidae can be similar and are best separated by forewing pattern.

Taxonomic References: Hodges 1974 (all except *Oecophora, Schiffermuelleria, Stathmopoda*)

Batrachedridae (Fig. 5-111)

Superfamily: Gelechioidea

Number of Canadian Species: 3 species across Canada.

Genera: *Batrachedra, Duospina*

Abundance: rare to uncommon, at light.

Quick Recognition: Scaled proboscis, large recurved labial palps, no ocelli, slender wings, hindwing more slender than forewing, very similar to several other gelechioids. Identification to species is fairly easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis scaled; labial palps recurved, long, slender; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, slender lanceolate; forewing either greyish or yellowish, sometimes with distinctive ovate dark spots, hindwing usually greyish; legs with tibial spur formula 0-2-4, hind tibial spurs usually long. ABDOMEN: smooth.

Similar Taxa: Oecophoridae, Coleophoridae, Cosmopterigidae, and Gelechiidae can be similar and are best separated by forewing pattern.

Taxonomic References: Hodges 1966a

Coleophoridae, Coleophorinae (Fig. 5-112)

Superfamily: Gelechioidea

Number of Canadian Species: well over 74 species throughout Canada, many undescribed.

Genera: *Coleophora*

Abundance: common, at lights or diurnal.

Quick Recognition: Scaled proboscis, large labial palps, no ocelli, smoothly scaled head, slender wings, paired elongate patches of spines dorsally on abdominal segments; when alive, they typically hold their antennae forward in a

`V` shape. Identification to species is very difficult for most due to a large number of undescribed species and scarcity of literature.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis scaled; labial palps usually ascending or porrect, long, slender, rarely tufted; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, slender lanceolate; forewing variable in colour and pattern, often unicolourous, hindwing usually grey; legs with tibial spur formula 0-2-4, hind tibial spurs variable in length. ABDOMEN: smooth, with paired elongate dorsal patches of spines.

Similar Taxa: Various Gelechioidea, including other Coleophoridae and Cosmopterigidae, can be similar and can be separated by the dorsal abdominal patches of spines.

Taxonomic References: Landry & Wright 1993 (metallic green spp.); Landry 1998a (some spp.)

Coleophoridae, Momphinae (Fig. 5-113)

Superfamily: Gelechioidea

Number of Canadian Species: well over 15 species throughout Canada, many undescribed.

Genera: *Mompha*

Abundance: rare to uncommon, only a few regularly come to light, others active in early morning.

Quick Recognition: Scaled proboscis, large recurved labial palps, no ocelli, smoothly scaled head, wing may be boldly patterned, metallic, or tufted.

Identification to species is very difficult for some due to a large number of undescribed species and scarcity of literature.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis scaled; labial palps ascending, long, slender, sometimes tufted; antenna filiform, with one or two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, lanceolate; forewing variable in colour and pattern, often boldly patterned or metallic, often with raised scale tufts, hindwing usually grey or brown; legs with tibial spur formula 0-2-4, hind tibial spurs usually short. ABDOMEN: smooth.

Similar Taxa: Various Gelechioidea, including other Coleophoridae, Elachistinae, Agonoxeninae, Oecophoridae, Batrachedridae, Cosmopterigidae, and Gelechiinae can be similar and are best separated by forewing pattern.

Taxonomic References: Forbes 1923 (a few spp.)

Coleophoridae, Blastobasinae (Fig. 5-114)

Superfamily: Gelechioidea

Number of Canadian Species: well over 7 species throughout Canada, many undescribed.

Genera: *Asaphocrita, Blastobasis, Calosima, Holcocera, Hypatopa, Pigritia*

Abundance: uncommon, at light.

Quick Recognition: Scaled proboscis, large ascending labial palps, no ocelli, smoothly scaled head, forewing usually greyish, spines usually present on the tarsi, with a prominent ovipositor. In live specimens, they rest with the forewing apices separated forming a ‘V’-shaped end to the abdomen. Identification to species is difficult for many.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis scaled; labial palps usually ascending, usually long, slender; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, lanceolate to rounded; forewing usually grey with black and white markings, hindwing usually greyish or whitish; legs with tibial spur formula 0-2-4, hind tibial spurs usually long; hind tarsal spines usually present. ABDOMEN: smooth, with bands of spines, ovipositor usually prominent.

Similar Taxa: Various Gelechioidea like Oecophoridae, Autostichidae, and Gelechiinae can be similar and are best separated by forewing pattern and lack of abdominal spines.

Taxonomic References: Forbes 1923 (a few spp.)

Coleophoridae, Pterolonchinae (Fig. 5-115)

Superfamily: Gelechioidea

Number of Canadian Species: 1 introduced species (*Pterolonche inspersa*) in BC.

Genera: *Pterolonche*

Abundance: rare

Quick Recognition: Proboscis absent, descending labial palps, forewing white with brown streaks.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough, sometimes smooth on frons; proboscis absent; labial palps usually descending, long, usually tufted; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, lanceolate; forewing white with brown streaks; legs with tibial spur formula 0-2-4, hind tibial spurs short. ABDOMEN: smooth.

Similar Taxa: The quick recognition characters should separate it from all others.

Taxonomic References: none

Autostichidae (Fig. 5-116)

Superfamily: Gelechioidea

Number of Canadian Species: 3 or 4 species across southern Canada

Genera: *Gerdana, Oegoconia, Taygete*

Abundance: rare to uncommon, at light.

Quick Recognition: Proboscis scaled, ascending labial palps, most genera with a fairly distinctive forewing pattern. The genera are easy to separate by forewing pattern, but some may require dissection for positive identification.

Diagnosis: HEAD: ocelli absent, rarely present; chaetosemata absent; head scales smooth, sometimes rough on vertex; proboscis scaled; labial palps ascending, long, slender; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, lanceolate; forewing light brown with dark brown in the basal, postmedian, and terminal areas and discal dot, or black with white blotches in the antemedian and postmedian areas, hindwing greyish to brownish; legs with tibial spur formula 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: Autostichids can be separated from several other gelechioids like Elachistidae, Scythridinae, Oecophoridae, Coleophoridae, and Gelechiidae by the forewing pattern.

Taxonomic References: Clarke 1941 (*Gerdana*); Lee & Brown 2010; Huemer 1998 (*Oegoconia*)

Amphisbatidae (Fig. 5-117)

Superfamily: Gelechioidea

Number of Canadian Species: At least 7 spp. from SK to NS.

Genera: *Machimia*, *Psilocorsis*

Abundance: rare to uncommon, at light

Quick Recognition: Proboscis scaled, ascending labial palps, fairly distinctive forewing pattern. Some Psilocorsis can be difficult to identify to species, all others are easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually rough on vertex, smooth on frons; proboscis scaled; labial palps ascending, long, slender; antenna filiform, with two scale rows per segment, usually longer than half the forewing length. THORAX: wings heteroneurous, forewing broad and squared, usually brownish with fine dark strigulations throughout, or straw yellow with grey spots and lines, hindwing greyish; legs with tibial spur formula 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: Amphisbatids can be separated from several other gelechioids like Depressariinae, Oecophoridae, and Dichomeridinae by the forewing pattern.

Similar looking Pyralidae can be separated by the forewing pattern and by the antennae typically being tucked tightly backwards along the body.

Taxonomic References: Hodges 1974

Cosmopterigidae (Fig. 5-118)

Superfamily: Gelechioidea

Number of Canadian Species: 16 species across Canada.

Genera: *Chrysopeleia, Cosmopterix, Eteobalea, Euclemensia, Limnaecia, Perimede, Periploca, Sorhagenia, Stagmatophora, Stilbosis, Walshia*

Abundance: uncommon, most come to light.

Quick Recognition: Proboscis scaled, ascending labial palps, smoothly scaled head, hind tarsal spines often present. Many can be recognized by forewing pattern, others are more difficult.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis scaled; labial palps ascending, long, slender; antenna filiform, with two scale rows per segment, usually longer than half the forewing length. THORAX: wings heteroneurous, lanceolate, sometimes very slender, forewing variable in pattern and colour, sometimes boldly patterned, sometimes metallic, hindwing usually greyish; legs with tibial spur formula 0-2-4, hind tibial spurs usually long; hind tarsal spines often present. ABDOMEN: smooth.

Similar Taxa: Many other Gelechioidea like Elachistidae, Xyloryctidae, Batrachedridae, Coleophoridae, and Gelechiinae are similar and can be difficult to separate.

Taxonomic References: Hodges 1978

Gelechiidae, Gelechiinae (Fig. 5-119)

Superfamily: Gelechioidea

Number of Canadian Species: well over 200 species throughout Canada, many undescribed.

Genera: *Agonochaetia, Anacampsis, Anarsia, Aroga, Bryotropha, Caryocolum, Chionodes, Chrysoesthia, Coleotechnites, Deltophora, Enchrysa, Euscrobipalpa, Exoteleia, Filatima, Gelechia, Gnorimoschema, Isophrictis, Metzneria, Monochroa, Neotelphusa, Phthorimaea, Prolita, Pseudotelphusa, Ptycerata, Rifseria, Scrobipalpa, Scrobipalpula, Scrobipalpulopsis, Sitotroga, Xenolechia*, and others

Abundance: common, most come to light.

Quick Recognition: Proboscis scaled, ascending labial palps, smoothly scaled head, hind tarsal spines usually present, hindwing often broad with an apical projection. Most are difficult to identify to species.

Diagnosis: HEAD: ocelli present or absent; chaetosemata absent; head scales smooth; proboscis scaled; labial palps ascending, long, slender, sometimes tufted; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, forewing lanceolate to broad, hindwing often broad with an apical projection, forewing variable in pattern and colour, sometimes boldly patterned, rarely with raised scale tufts, hindwing usually greyish or brownish; legs with tibial spur formula 0-2-4, hind tibial spurs usually long; hind tarsal spines usually present. ABDOMEN: smooth.

Similar Taxa: Most Gelechiinae have a distinct projection at the apex of the hindwing that is lacking in most other Gelechioidea. When they lack this projection they can look like many other gelechioids like Xyloryctidae, Oecophoridae, Coleophoridae, Glyphidoceridae, and Cosmopterigidae and can be difficult to separate. Dichomeridinae can be separated by forewing pattern. Pyralidae can be separated by the often more triangular wings, antennae held tightly backwards, and by wing pattern.

Taxonomic References: Busck 1903 (some spp.); Powell & Opler 2009 (some western spp.); Forbes 1923 (some eastern spp.); Lee & Brown 2008 (key to Teleiodini); Rutten & Karsholt 2004 (*Bryotropha*); Huemer 1988 (*Caryocolum*); Hodges 1999 (*Chionodes*); Freeman 1960 (some *Coleotechnites*, some *Exoteleia*); Freeman 1965 (some *Coleotechnites*); Sattler 1979 (*Deltophora*); Povolny 1967 (some *Euscrobipalpa*, some *Gnorimoschema*, *Ptycerata*, some *Scrobipalpula*, *Scrobipalpulopsis*); Miller 2000, Povolny 1998, 2003 (some *Gnorimoschema*); Englert 1974 (*Metzneria*); Hodges 1966b (*Prolita, Rifseria*)

Gelechiidae, Dichomeridinae (Fig. 5-120)

Superfamily: Gelechioidea

Number of Canadian Species: 30 species across Canada.

Genera: *Dichomeris, Helcystogramma*

Abundance: uncommon, most come to light.

Quick Recognition: Proboscis scaled, ascending labial palps, smoothly scaled head, ocelli usually present, hind tarsal spines often present, forewing often divided into longitudinal dark and light areas, hindwing often broad with an apical projection. Most are fairly easy to identify to species.

Diagnosis: HEAD: ocelli usually present; chaetosemata absent; head scales smooth; proboscis scaled; labial palps ascending, long, slender, sometimes tufted on second segment; antenna filiform, with two scale rows per segment, longer than half the forewing length. THORAX: wings heteroneurous, forewing elongate and usually squared, sometimes rounded, sometimes with the apex acute, hindwing broad and typically squarish, forewing variable in pattern and colour, sometimes boldly patterned, hindwing unicolourous and variable in colour; legs with tibial spur formula 0-2-4, hind tibial spurs usually long; hind tarsal spines often present. ABDOMEN: smooth.

Similar Taxa: The squarish shape of the hindwing is fairly distinctive amongst the Gelechioidea. When the hindwing is more subtly squarish they can look like many other gelechioids like Elachistidae, Glyphidoceridae, Oecophoridae, and Gelechiinae and can be separated by forewing pattern. Pyralidae can be separated by the often more triangular forewing, antennae typically held tightly back over the body, and forewing pattern.

Taxonomic References: Hodges 1986

Limacodidae (Fig. 5-121)

Superfamily: Zygaenoidea

Number of Canadian Species: 15 across southern Canada, most species confined to the southeast.

Genera: *Apoda, Euclea, Heterogenea, Lithacodes, Packardia, Parasa, Prolimacodes, Tortricidia*

Abundance: common in south eastern Canada, rarer as you go north and west, at lights.

Quick Recognition: Broad wings on a relatively stout, hairy body, easily recognized by wing pattern. Most are easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough, sometimes smooth; proboscis small or absent; labial palps usually ascending, sometimes porrect, variable in length, usually slender, sometimes tufted; antenna filiform, rarely pectinate, with many scale rows per segment, usually less than half the forewing length. THORAX: wings heteroneurous, forewing broad and usually squared, sometimes rounded, sometimes with the apex acute, hindwing broad and usually rounded, forewing variable in pattern and colour, sometimes boldly patterned, sometimes unicolourous, sometimes with green patterns, hindwing unicolourous and usually brown; legs usually densely furry, with tibial spur formula of 0-2-2 or 0-2-4, hind tibial spurs often long. ABDOMEN: hairy, rarely with a dorsal scale tuft.

Similar Taxa: The quick recognition characters will easily separate most limacodids from other Lepidoptera.

Taxonomic References: Handfield 1999

Zygaenidae (Fig. 5-122)

Superfamily: Zygaenoidea

Number of Canadian Species: A single species, *Harrisina americana* can be found in southern MB and ON.

Genera: *Harrisina*

Abundance: Rare, uncommon in southernmost ON, diurnal or at lights.

Quick Recognition: Unmistakeable by the jet black slender wings and reddish collar.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales smooth, though somewhat roughened on frons; proboscis prominent; labial palps descending, small, slender; antenna pectinate, with many scale rows per segment, about half the forewing length. THORAX: wings heteroneurous, slender with an acute apex, both jet black and unicolourous, hindwing slightly translucent; legs with no apparent tibial spurs. ABDOMEN: smooth.

Similar Taxa: None.

Taxonomic References: Powell & Opler 2009

Sesiidae, Tinthiinae (Fig. 5-123)

Superfamily: Sesioidea

Number of Canadian Species: 3 spp. across Canada, 2 of which are found only in AB.

Genera: *Pennisetia, Zenodoxus*

Abundance: uncommon to rare, diurnal.

Quick Recognition: Very wasp-like, often with partially translucent wings and with colourful wings and body. Easy to identify to species.

Diagnosis: HEAD: ocelli large; chaetosemata present; head scales smooth, sometimes roughened on vertex; proboscis prominent or reduced; labial palps ascending, variable in length, often tufted; antenna pectinate or filiform, sometimes with long sensillae, with variable scaling, roughly half the forewing length. THORAX: wings heteroneurous, slender and rounded, often transparent centrally, often boldly patterned if not transparent; legs with tibial spur formula of 0-2-4; often with prominent scale tufts, especially on hind tibiae, tibial spurs long, sometimes with hind tarsal spines. ABDOMEN: smooth, often boldly patterned, sometimes with a dorsal scale tuft.

Similar Taxa: Sesiinae have an elongate club on the antenna.

Taxonomic References: Eichlin & Duckworth 1988

Sesiidae, Sesiinae (Fig. 5-124)

Superfamily: Sesioidea

Number of Canadian Species: 38 spp. across Canada.

Genera: *Albuna, Carmenta, Euhagena, Melitta, Paranthrene, Podosesia, Sesia, Synanthedon*

Abundance: uncommon to common, most diurnal, a few come to light.

Quick Recognition: Very wasp-like, often with partially translucent wings and with colourful wings and body. Most are fairly easy to identify to species.

Diagnosis: HEAD: ocelli large; chaetosemata present; head scales smooth, sometimes roughened on vertex, rarely rough on frons; proboscis prominent; labial palps usually ascending, long, usually tufted; antenna with an elongate club, sometimes with a slightly hooked tip, sometimes with long sensillae, with many scale rows per antennal segment, roughly half the forewing length. THORAX: wings heteroneurous, slender and rounded or acute, usually transparent centrally, often boldly patterned if not transparent; legs with tibial spur formula of 0-2-4; often with prominent scale tufts, especially on hind tibiae, tibial spurs variable in length, hind tarsal spines present. ABDOMEN: smooth, usually boldly patterned.

Similar Taxa: Tinthiinae have either pectinate or filiform antennae.

Taxonomic References: Eichlin & Duckworth 1988 (most spp.)

Cossidae (Fig. 5-125)

Superfamily: Cossoidea

Number of Canadian Species: 6 spp. across Canada.

Genera: *Acossus, Givira, Prionoxystus, Zeuzera*

Abundance: uncommon to common, at light.

Quick Recognition: Large, very stout, greasy-looking moths, often with translucent wings, forewing pattern usually consists of fine lines. Most are fairly easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis absent or very short; labial palps ascending, short, usually tufted; antenna usually pectinate, sometimes filiform, with many scale rows per antennal segment, less than half the forewing length. THORAX: wings heteroneurous, broad and rounded or acute, usually at least slightly translucent, typically greyish with darker grey or black fine lines throughout the forewing, hindwings sometimes with fine darker lines, sometimes boldly patterned; legs densely furry, tibial spurs usually not visible, hind tarsal spines present. ABDOMEN: furry and large.

Similar Taxa: There is a resemblance of some species to Sphingidae, though most sphingids lack a pectinate antenna, have a more prominent proboscis, and have different wing patterns.

Taxonomic References: Handfield 1999 (all but *Givira*)

Choreutidae (Fig. 5-126)

Superfamily: Choreutoidea

Number of Canadian Species: 17 spp. across Canada, several undescribed.

Genera: *Anthophila*, *Caloreas*, *Choreutis*, *Prochoreutis*, *Tebenna*

Abundance: uncommon to rare, diurnal, a few come to light.

Quick Recognition: Micros with stout, squared wings, often with metallic spots, scaled proboscis, large ocelli, live individuals hold the wings flared outwards, often with the apex drooping. Some are fairly easy to identify to species, but others are more difficult due to a lack of literature.

Diagnosis: HEAD: ocelli large; chaetosemata absent; head scales smooth; proboscis scaled; labial palps usually ascending, long, usually tufted; antenna filiform, usually with long sensillae, with two scale rows per antennal segment, roughly half the forewing length. THORAX: wings heteroneurous, broad, forewing squared, variable in colour and pattern, often with prominent lines, often with metallic spots near the anal angle; hindwing usually unpatterned, sometimes with bold markings; legs with tibial spur formula of 0-2-4, hind tibial spurs large. ABDOMEN: smooth, sometimes boldly patterned.

Similar Taxa: The scaled proboscis will separate them from Tortricidae. Pyralidae and Crambidae can be separated by the much smaller ocelli, frequent presence of chaetosemata, tympanum present ventrally on the first abdominal segment, and by wing pattern.

Taxonomic References: Dombroskie 2003 (most eastern spp.)

Tortricidae, Tortricinae, Tortricini (Fig. 5-127)

Superfamily: Tortricoidea

Number of Canadian Species: 57 spp. across Canada, several undescribed.

Genera: *Acleris*

Abundance: common, at lights, often active in winter.

Quick Recognition: Naked proboscis, ascending palps with small terminal segment, forewing generally flattened, squared-off, strongly arched basally, most species found during the colder months of the year. Some species are extremely variable and can be difficult to identify.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales usually rough on vertex and at least partially smooth on frons; proboscis naked; labial palps typically ascending, usually long, usually tufted; antenna filiform, with two scale rows per antennal segment, usually less than half the forewing length. THORAX: wings heteroneurous, broad, forewing squared, variable in colour and pattern, lines typically slanted, often a V-shaped marking prominent at middle of costa, usually greyish; hindwing usually unpatterned, sometimes with fine strigulations; legs with tibial spur formula of 0-2-4, hind tibial spurs often large. ABDOMEN: smooth.

Similar Taxa: Olethreutinae and Sparganothini can be separated by having only a single row of scales per antennal segment. Other Tortricinae are best separated by the wing pattern. Glyphipterigidae can be separated by the forewing pattern and larger ocelli. Some noctuoids are similar and can be separated by forewing pattern and by the presence of tympana laterally on the thorax.

Taxonomic References: Razowski 1966 (most spp.)

Tortricidae, Tortricinae, Cnephasiini (Fig. 5-128)

Superfamily: Tortricoidea

Number of Canadian Species: 11 spp. across Canada, some undescribed.

Genera: *Cnephasia, Decodes, Eana*

Abundance: uncommon to rare, at lights.

Quick Recognition: Naked proboscis, ascending palps with small terminal segment, generally with elongate wings that are fairly pointed at the apex. Some species can be difficult to identify and may require dissection.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales rough, sometimes partially smooth on frons; proboscis naked; labial palps typically ascending, sometimes descending, usually long, usually tufted; antenna filiform, with two scale rows per antennal segment, variable in length. THORAX: wings heteroneurous, fairly elongate, forewing with an acute apex, variable in colour and pattern, sometimes unicolourous, often with fine lines throughout, often greyish; hindwing usually unpatterned, often greyish or white; legs with tibial spur formula of 0-2-4, hind tibial spurs usually short, tarsal spines usually present. ABDOMEN: smooth.

Similar Taxa: Olethreutinae and Sparganothini can be separated by having only a single row of scales per antennal segment. Other Tortricinae are best separated by the wing pattern. Some noctuoids, especially Arctiinae are similar and can be separated by forewing pattern and by the presence of tympana laterally on the thorax.

Taxonomic References: Mutuura 1982 (*Cnephasia*); Obraztsov 1962 (*Eana*); Powell 1980 (*Decodes*)

Tortricidae, Tortricinae, Cochylini (Fig. 5-129)

Superfamily: Tortricoidea

Number of Canadian Species: At least 56 spp. across Canada, some undescribed.

Genera: *Aethes, Agapeta, Atroposia, Cochylidia, Cochylis, Gynidomorpha, Henricus, Phalonidia, Platphalonidia, Recavicula, Saphenista, Thyralia, Trachysmia*, and others

Abundance: uncommon to common, at lights.

Quick Recognition: Naked proboscis, palps with small terminal segment, generally with stubby squared or pointed wings, often brightly coloured. Many species can be difficult to identify and many require dissection.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales rough, sometimes smooth on frons; proboscis naked; labial palps variable in direction, long, usually tufted; antenna filiform, with two scale rows per antennal segment, usually with long sensillae, usually less than half the forewing length. THORAX: wings heteroneurous, variable in shape, typically stubby, variable in colour and pattern, usually with bright colours and contrasting patterns, males sometimes with costal fold; hindwing usually unpatterned, often greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long. ABDOMEN: smooth.

Similar Taxa: Olethreutinae and Sparganothini can be separated by having only a single row of scales per antennal segment. Other Tortricinae are best separated by the wing pattern. Glyphipterigidae can be separated by the forewing pattern and larger ocelli. Some noctuids are similar and can be separated by forewing pattern and by the presence of tympana laterally on the thorax.

Taxonomic References: Sabourin, *et al.* 2002 (some *Aethes*); Razowski 1997 (most spp.)

Tortricidae, Tortricinae, Euliini (Fig. 5-130)

Superfamily: Tortricoidea

Number of Canadian Species: 4 spp. across Canada.

Genera: *Anopina, Apotomops, Eulia*

Abundance: uncommon, some spp. at lights.

Quick Recognition: Naked proboscis, palps ascending with small terminal segment, generally with squared wings, greyish or brownish. Easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales usually rough on vertex, somewhat smooth on frons; proboscis naked; labial palps typically ascending, variable in length, usually slender; antenna filiform, with two scale rows per antennal segment, usually with long sensillae, usually less than half the forewing length. THORAX: wings heteroneurous, typically squared, usually grey and white, sometimes brownish orange; hindwing greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs variable in length. ABDOMEN: smooth.

Similar Taxa: Olethreutinae and Sparganothini can be separated by having only a single row of scales per antennal segment. Other Tortricinae are best separated by the wing pattern. Glyphipterigidae can be separated by the forewing pattern and larger ocelli. Some noctuoids are similar and can be separated by forewing pattern and by the presence of tympana laterally on the thorax.

Taxonomic References: Brown & Powell 2000 (*Anopina*); Powell 1986 (*Apotomops*); Razowski 2002 (*Eulia*)

Tortricidae, Tortricinae, Sparganothini (Fig. 5-131)

Superfamily: Tortricoidea

Number of Canadian Species: 33 spp. across Canada, some undescribed.

Genera: *Amorbia, Coelostathma, Platynota, Sparganothis*

Abundance: common to uncommon, at lights.

Quick Recognition: Naked proboscis, palps long and porrect, with squared wings, often yellow or brownish. Usually easy to identify to species.

Diagnosis: HEAD: ocelli usually present; chaetosemata present; head scales usually rough on vertex, sometimes smooth on frons; proboscis naked; labial palps usually porrect, long, sometimes tufted; antenna filiform, with one scale rows per antennal segment, rarely with two scale rows, with long sensillae, variable in length. THORAX: wings heteroneurous, forewing squared, often yellow or brown, usually with reticulate markings, males sometimes with costal fold; hindwing usually greyish or white; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long. ABDOMEN: smooth.

Similar Taxa: Other Tortricinae have two scale rows per antennal segment. Olethreutinae typically either lack porrect labial palps, or the palps are shorter. Glyphipterigidae can be separated by the forewing pattern and larger ocelli. Some noctuoids are similar and can be separated by forewing pattern and by the presence of tympana laterally on the thorax.

Taxonomic References: Phillips-Rodriguez & Powell 2007 (*Amorbia*); Lambert 1950 (most spp.)

Tortricidae, Tortricinae, Archipini (Fig. 5-132)

Superfamily: Tortricoidea

Number of Canadian Species: over 80 spp. across Canada.

Genera: *Adoxophyes*, *Aphelia*, *Archepandemis*, *Archips*, *Argyrotaenia, Choristoneura, Clepsis, Dichelia, Diedra, Ditula, Lozotaenia, Pandemis, Syndemis, Xenotemna*

Abundance: common, at lights.

Quick Recognition: Naked proboscis, palps ascending with small terminal segment, with squared wings, sometimes with a sinuous costa, often brown with darker brown oblique bands. Often easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales usually rough on vertex, usually smooth on frons; proboscis naked; labial palps usually ascending, variable in length, sometimes tufted; antenna filiform, with two scale rows per antennal segment, with long sensillae, less than half the forewing length. THORAX: wings heteroneurous, forewing squared, often brown with darker brown bands, males sometimes with a costal fold; hindwing usually greyish or white; legs with tibial spur formula of 0-2-4, hind tibial spurs variable in length, hind tarsal spines often present. ABDOMEN: smooth.

Similar Taxa: Olethreutinae and Sparganothini can be separated by having only a single row of scales per antennal segment. Other Tortricinae are best separated by the wing pattern. Glyphipterigidae can be separated by the forewing pattern and larger ocelli. Some noctuoids are similar and can be separated by forewing pattern and by the presence of tympana laterally on the thorax.

Taxonomic References: Mutuura 1978 (*Archepandemis*); Razowski 1977 (*Archips*); Razowski 1979a, 1979b (most *Clepsis*); Mutuura 1980 (some *Pandemis*); Freeman 1958 (most spp.)

Tortricidae, Chlidanotinae (Fig. 5-133)

Superfamily: Tortricoidea

Number of Canadian Species: a single species *Thaumatographa youngiella* is known from S. BC

Genera: *Thaumatographa*

Abundance: rare, at lights.

Quick Recognition: Naked proboscis, with squared wings, distinct complex forewing pattern.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales smooth, rarely roughened on vertex; proboscis naked; labial palps ascending or porrect, long, slender; antenna filiform, with one scale row per antennal segment, with long sensillae, less than half the forewing length. THORAX: wings heteroneurous, forewing squared, brown with many fine white lines, prominent black spots at anal angle; hindwing brown; legs with tibial spur formula of 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: The forewing pattern is distinctive, only a few Olethreutinae and Glyphipterigidae have vaguely similar patterns.

Taxonomic References: None

Tortricidae, Olethreutinae, Endotheniini (Fig. 5-134)

Superfamily: Tortricoidea

Number of Canadian Species: 10 spp. across Canada

Genera: *Endothenia, Hulda, Taniva, Tia*

Abundance: uncommon, at lights.

Quick Recognition: Naked proboscis, squared wings, labial palps with tiny third segment. Species are generally easy to identify but may require dissection.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales usually rough on vertex, usually smooth on frons; proboscis naked; labial palps usually porrect, usually short, tufted; antenna filiform, with one scale row per antennal segment, less than half the forewing length. THORAX: wings heteroneurous, forewing squared, usually with a complex pattern, grey brown and white; hindwing greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs long, hind tarsal spines rarely present. ABDOMEN: smooth.

Similar Taxa: The single row of scales per antennal segment will separate Endotheniini from similar looking Tortricinae. It is difficult to separate them from other Olethreutinae and best done by wing pattern or by dissection.

Taxonomic References: Gilligan, *et al.* 2008 (most spp.)

Tortricidae, Olethreutinae, Bactrini (Fig. 5-135)

Superfamily: Tortricoidea

Number of Canadian Species: 6 spp. across Canada

Genera: *Bactra*

Abundance: uncommon to rare, at lights.

Quick Recognition: Naked proboscis, elongate wings, forewing apex somewhat acute, usually streaked, labial palps descending. Most species require dissection for positive identification.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales usually rough on vertex, often smooth on frons; proboscis naked, rarely reduced; labial palps usually descending, variable in length, tufted; antenna filiform, with one scale row per antennal segment, greater than half the forewing length. THORAX: wings heteroneurous, forewing elongate, apex somewhat acute, sometimes with a complex pattern, often streaked, usually brownish; hindwing greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: The single row of scales per antennal segment will separate Bactrini from similar looking Tortricinae. It is difficult to separate them from other Olethreutinae and best done by wing pattern or by dissection.

Taxonomic References: Heinrich 1926; Gilligan, *et al.* 2008 (some spp.)

Tortricidae, Olethreutinae, Olethreutini (Fig. 5-136)

Superfamily: Tortricoidea

Number of Canadian Species: over 109 spp. across Canada, most diverse in the east, some undescribed

Genera: *Ahmosia, Apotomis, Argyroploce, Aterpia, Celypha, Episimus, Eumarozia, Evora, Hedya, Metendothenia, Olethreutes, Orthotaenia, Paralobesia, Phaecasiophora, Pristerognatha, Pseudosciaphila, Zomaria*

Abundance: common, at lights.

Quick Recognition: Naked proboscis, stout squared wings, labial palps usually ascending with small terminal segment, forewing pattern usually banded grey and white or dark and light brown. Many species require dissection for positive identification, some genera are difficult.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales rough on vertex, often smooth on frons; proboscis naked, rarely reduced; labial palps usually ascending, usually stout, usually tufted; antenna filiform, with one scale row per antennal segment, usually less than half the forewing length. THORAX: wings heteroneurous, forewing stout, squared, sometimes with a complex pattern, usually banded with grey and white or with dark and light grey; hindwing grey brown or white; legs with tibial spur formula of 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: The single row of scales per antennal segment will separate Olethreutini from similar looking Tortricinae. They can usually be separated from other Olethreutinae by wing pattern.

Taxonomic References: Adamski & Peters 1986 (*Apotomis*); Miller 1985, Jalava & Miller 1998 (some *Olethreutes*); Heinrich 1926 (most spp.); Gilligan, *et al.* 2008, Miller 1987 (many spp.)

Tortricidae, Olethreutinae, Enarmoniini (Fig. 5-137)

Superfamily: Tortricoidea

Number of Canadian Species: 39 spp. across Canada

Genera: *Ancylis, Enarmonia, Eucosmomorpha, Hystrichophora*

Abundance: common, at lights.

Quick Recognition: Naked proboscis, forewing usually with a falcate tip and often boldly patterned, labial palps with small terminal segment. Many are easy to identify to species by wing pattern, others are much more difficult, even with dissection.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales usually rough; proboscis naked, rarely reduced; labial palps porrect or descending, fairly long, usually tufted; antenna filiform, with one scale row per antennal segment, usually less than half the forewing length. THORAX: wings heteroneurous, forewing stout to slightly elongate, usually with a falcate tip, sometimes squared, usually with a bold complex pattern; hindwing greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs long, rarely with tarsal spines. ABDOMEN: smooth.

Similar Taxa: The single row of scales per antennal segment will separate Enarmoniini from similar looking Tortricinae. They can usually be separated from other Olethreutinae by wing pattern.

Taxonomic References: Heinrich 1923a (most spp.); Gilligan, *et al.* 2008, Miller 1987, McDunnough 1955 (some spp.)

Tortricidae, Olethreutinae, Eucosmini (Fig. 5-138)

Superfamily: Tortricoidea

Number of Canadian Species: over 308 spp. across Canada, most diverse in the west, many undescribed

Genera: *Barbara, Catastega, Epiblema, Epinotia, Eucosma, Gretchena, Griselda, Gypsonoma, Notocelia, Pelochrista, Phaneta, Proteoteras, Pseudexentera, Retinia, Rhopobota, Rhyacionia, Sonia, Spilonota, Suleima, Zeiraphera*

Abundance: common, at lights.

Quick Recognition: Naked proboscis, forewing usually elongate, labial palps with small terminal segment. Some are relatively easy to identify, most require dissection, some groups are very difficult.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales rough, often smooth on the frons; proboscis naked, rarely reduced; labial palps variable in direction, often short, usually tufted; antenna filiform, with one scale row per antennal segment, variable in length. THORAX: wings heteroneurous, forewing usually elongate, squared or acute, rarely falcate, pattern variable, often with metallic markings especially towards anal angle, males sometimes with a costal fold; hindwing usually greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long, rarely with tarsal spines. ABDOMEN: smooth.

Similar Taxa: The single row of scales per antennal segment will separate Eucosmiini from similar looking Tortricinae. They can often be separated from other Olethreutinae by wing pattern.

Taxonomic References: Brown 1992 (*Catastega*); Wright 2002 (some *Epiblema*); Brown 1980 (some *Epinotia*); Miller 1974, Powell 1968 (some *Eucosma*); Wright 2005, 2006, 2007a, 2007b, 2008 (some *Eucosma* and *Pelochrista*); McDunnough 1938a (some *Phaneta*); Miller 1986 (*Pseudexentera*); Powell & Miller 1978 (*Rhyacionia*); Mutuura & Freeman 1966 (*Zeiraphera*); Heinrich 1923a (most spp.); Gilligan, *et al.* 2008, Miller 1987, Powell & Opler 2009, Heinrich 1923b, 1924, 1929, McDunnough 1925, 1935, 1942 (some spp.)

Tortricidae, Olethreutinae, Grapholitini (Fig. 5-138)

Superfamily: Tortricoidea

Number of Canadian Species: 65 spp. across Canada

Genera: *Corticivora, Cydia, Dichrorampha, Grapholita, Ecdytolopha, Gymnandrosoma, Pammene, Pseudogalleria, Sereda*

Abundance: uncommon to common, at lights.

Quick Recognition: Naked proboscis, forewing stout, either squared or acute, labial palps with small terminal segment. Some are relatively easy to identify, most require dissection, some groups are very difficult.

Diagnosis: HEAD: ocelli usually present; chaetosemata present; head scales usually rough; proboscis naked, rarely reduced; labial palps variable in direction, short, usually tufted; antenna filiform, with one scale row per antennal segment, variable in length. THORAX: sometimes with a scale tuft; wings heteroneurous, forewing usually stout, squared or acute, pattern variable, usually dark, often with metallic markings; hindwing greyish brown or white; legs with tibial spur formula of 0-2-4, hind tibial spurs long, rarely with tarsal spines. ABDOMEN: smooth, rarely with a dorsal scale tuft.

Similar Taxa: The single row of scales per antennal segment will separate Grapholitini from similar looking Tortricinae. They can often be separated from other Olethreutinae by wing pattern.

Taxonomic References: Brown 1984 (*Corticivora*); Heinrich 1926 (most spp.); Gilligan, *et al.* 2008, Miller 1987, Powell & Opler 2009, McDunnough 1935 (some spp.)

Urodidae (Fig. 5-140)

Superfamily: Urodoidea

Number of Canadian Species: 1 sp. (*Wockia asperipunctella*) found sporadically across Canada

Genera: *Wockia*

Abundance: rare, does not frequent lights

Quick Recognition: Naked proboscis, forewing elongate and pointed, grey with a darker grey patch of scales in the antemedian area.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough on vertex, smooth on frons; proboscis naked; labial palps porrect, short, slender; antenna filiform, with two scale rows per antennal segment, about half the forewing length. THORAX: wings heteroneurous, forewing elongate, pointed, grey, with a dark grey patch of raised scales in the antemedian area; hindwing grey; legs with tibial spur formula of 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: The quick recognition characters will separate Urodidae from all others.

Taxonomic References: Landry 1998b

Schreckensteiniidae (Fig. 5-141)

Superfamily: Schreckensteinioidea

Number of Canadian Species: 2 spp. found sporadically across Canada

Genera: *Schreckensteinia*

Abundance: rare, not usually at lights

Quick Recognition: Naked proboscis, forewing slender, hind tibia with spines and huge spurs, in live specimens hind legs held out sideways at rest. The two species are usually easy to separate, though dissection is often necessary on worn specimens.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis naked; labial palps porrect, variable in length, slender; antenna filiform, with two scale rows per antennal segment, about half the forewing length. THORAX: wings heteroneurous, forewing slender, pointed, brownish, often with streaky markings; hindwing grey or brown; legs with tibial spur formula of 0-2-4, hind tibial spurs very long, hind tibial spines present. ABDOMEN: smooth.

Similar Taxa: The quick recognition characters will separate Schreckensteiniidae from all others.

Taxonomic References: Forbes 1923

Epermeniidae (Fig. 5-142)

Superfamily: Epermenioidea

Number of Canadian Species: 7 spp. across Canada

Genera: *Epermenia, Ochromolopis*

Abundance: rare, at lights

Quick Recognition: Naked proboscis, smoothly scaled head, no ocelli, forewing slender, usually with some raised scales along the inner margin, hind tibia and tarsi with spines. Some species are fairly easy to recognize by forewing pattern, others need dissection.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis naked, sometimes reduced; labial palps usually ascending, long, slender; antenna filiform, with one or two scale rows per antennal segment, greater than half the forewing length. THORAX: wings heteroneurous, forewing slender, pointed, usually with raised scales along the inner margin, pattern variable, greyish; hindwing grey; legs with tibial spur formula of 0-2-4, hind tibial spurs often long, hind tibial spines present, hind tarsal spines present. ABDOMEN: smooth, rarely boldly patterned.

Similar Taxa: The quick recognition characters will separate Epermeniidae from all others.

Taxonomic References: Gaedike 2008

Alucitidae (Fig. 5-143)

Superfamily: Alucitoidea

Number of Canadian Species: 3 spp. across Canada

Genera: *Alucita*

Abundance: common, rarer as you go east, at lights

Quick Recognition: Each wing is divided into six plumes and is banded light and dark grey. For specific identification dissection is usually necessary.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough on vertex, smooth on frons; proboscis naked; labial palps ascending, long, tufted; antenna filiform, with one scale row per antennal segment, greater than half the forewing length. THORAX: wings heteroneurous, divided into six plumes, banded light and dark grey or brown; legs with tibial spur formula of 0-2-4, hind tibial spurs long. ABDOMEN: smooth.

Similar Taxa: Pterophoridae have the forewing notched and the hindwing divided into three plumes.

Taxonomic References: Landry & Landry 2004

Pterophoridae (Fig. 5-144)

Superfamily: Pterophoroidea

Number of Canadian Species: 65 spp. across Canada, most diverse in the west

Genera: *Adaina, Amblyptilia, Capperia, Cnaemidophora, Dejongia, Emmelina, Geina, Gillmeria, Hellinsia, Oidaematophorus, Oxyptilus, Paraplatyptilia, Platyptilia, Spenarches, Stenoptilia, Trichoptilus*

Abundance: common, at lights

Quick Recognition: The forewing is notched and the hindwing is divided into three plumes, abdomen and legs are very long, live specimens hold the wings out to the sides in a T-shape. Specific identification is often challenging.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually smooth; proboscis naked; labial palps usually ascending, often short, usually slender; antenna filiform, with two scale rows per antennal segment, usually with long sensillae, usually less than half the forewing length. THORAX: rarely with a dorsal scale tuft; wings heteroneurous, forewing notched, usually with prominent lines in the postmedian area, typically brownish or white, hindwing divided into three plumes, sometimes boldly patterned; legs with tibial spur formula of 0-2-4, very long, hind tibial spurs short relative to the elongate legs. ABDOMEN: smooth, long, sometimes boldly patterned with chevrons.

Similar Taxa: Alucitidae have each wing divided by six plumes.

Taxonomic References: Cashatt 1972 (some *Hellinsia*); Lange 1950; Landry & Gielis 2008 (some *Paraplatyptilia*); Barnes & Lindsey 1921 (most spp.); Landry 1987; McDunnough 1923, 1927, 1938b, 1939 (some spp.)

Copromorphidae (Fig. 5-145)

Superfamily: Copromorphoidea

Number of Canadian Species: 2 spp. in BC and SW AB

Genera: *Ellabella*, *Lotisma*

Abundance: rare to uncommon, at lights

Quick Recognition: Naked proboscis, no ocelli, often with raised scales on the forewing. The two species are easy to separate.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth, sometimes partially roughened; proboscis naked; labial palps usually ascending, variable in length, slender; antenna filiform, with two scale rows per antennal segment, roughly half the forewing length. THORAX: wings heteroneurous, forewing fairly broad, apex pointed, pattern variable, greyish, hindwing broad, greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs variable in length. ABDOMEN: smooth.

Similar Taxa: Carposinidae typically have a prominent reniform spot on the forewing. Lithosiini and Hypenodinae can be also separated by forewing pattern and by the presence of tympana on the metathorax.

Taxonomic References: Heppner 1984 (*Ellabella*); Heppner 1986 (*Lotisma*)

Carposinidae (Fig. 5-146)

Superfamily: Copromorphoidea

Number of Canadian Species: 4 spp. across Canada

Genera: *Bondia, Carposina*

Abundance: uncommon, at lights

Quick Recognition: Naked proboscis, no ocelli, with raised scales on the forewing, reniform spot prominent. The species are usually easy to separate.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually smooth; proboscis naked; labial palps usually ascending, usually long, usually slender; antenna filiform, with two scale rows per antennal segment, sometimes with prominent sensillae, longer than half the forewing length. THORAX: wings heteroneurous, forewing fairly broad, apex pointed, pattern variable, with a prominent reniform spot, greyish, sometimes with metallic markings, with raised scales, hindwing broad, usually greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs variable in length. ABDOMEN: smooth.

Similar Taxa: Copromorphidae lack a prominent reniform spot. Sparganothini can be separated by forewing pattern. Lithosiini can be separated by forewing pattern and by the presence of tympana on the metathorax.

Taxonomic References: Davis 1968

Pyralidae, Galleriinae (Fig. 5-147)

Superfamily: Pyraloidea

Number of Canadian Species: 7 spp. sporadically across Canada

Genera: *Achroia*, *Aphomia*, *Cacotherapia*, *Corcyra*, *Galleria*, *Paralipsa*

Abundance: rare to locally common, at lights, some species associated with bee hives

Quick Recognition: Reduced scaled proboscis, no ocelli, typically greyish, sometimes quite large. The species are fairly easy to separate.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth, sometimes rough on frons; proboscis scaled, reduced; labial palps variable in orientation, usually small, usually slender; antenna filiform, with two scale rows per antennal segment, usually shorter than half the forewing length. THORAX: wings heteroneurous, forewing variable, apex rounded or squared, sometimes notched in middle of outer margin, pattern variable, greyish, hindwing broad, greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs variable in length; hind tarsal spines often present. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Phycitinae are quite variable and can look similar, but usually have a much broader hindwing compared to the forewing. To separate these two it is best to eliminate the few galleriines by forewing pattern.

Taxonomic References: Solis & Metz 2008 (*Aphomia, Paralipsa*); Powell & Opler 2009 (*Achroia, Galleria*)

Pyralidae, Chrysauginae (Fig. 5-148)

Superfamily: Pyraloidea

Number of Canadian Species: 7 spp. sporadically across Canada, most spp. restricted to SE Canada

Genera: *Acallis, Arta, Condylolomia, Galasa, Tosale*

Abundance: uncommon, at lights

Quick Recognition: Scaled proboscis, ocelli usually prominent, often boldly patterned, forewing sometimes with a large excavation in costa, legs often with large scale tufts, live specimens rest with body elevated and legs prominent. The species are fairly easy to separate.

Diagnosis: HEAD: ocelli usually present; chaetosemata usually present; head scales usually rough on vertex, usually smooth on frons; proboscis scaled; labial palps variable in orientation, usually small, usually slender; antenna filiform, with long sensillae, with two scale rows per antennal segment, variable in length. THORAX: wings heteroneurous, forewing usually boldly patterned, apex squared, sometimes excavated in middle of costa, pattern usually bold, usually brownish, hindwing broad, variable in colour, sometimes boldly patterned; legs with tibial spur formula of 0-2-4, hind tibial spurs usually short, legs often with distinct scale tufts. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Chrysauginae can be similar to Phycitinae and many Crambidae subfamilies, but can be separated by forewing pattern.

Taxonomic References: Cashatt 1968; Covell 1984 (some spp.)

Pyralidae, Pyralinae (Fig. 5-149)

Superfamily: Pyraloidea

Number of Canadian Species: 10 spp. across Canada

Genera: *Aglossa, Dolichomia, Herculia, Hypsopygia, Pseudasopia, Pyralis*

Abundance: uncommon, at lights, often indoors

Quick Recognition: Scaled proboscis, ocelli absent, forewing typically with distinct AM and PM lines, forewing often triangular in shape, live specimens sometimes curl abdomen upwards at rest. The species are usually easy to separate.

Diagnosis: HEAD: ocelli absent; chaetosemata usually present; head scales usually rough; proboscis scaled, sometimes absent; labial palps usually ascending, usually small, usually slender; antenna filiform, rarely pectinate in males, sometimes with long sensillae, with two scale rows per antennal segment, often less than half forewing length. THORAX: wings heteroneurous, forewing often triangular, sometimes more elongate, forewing usually boldly patterned, usually with prominent AM and PM lines, apex squared or pointed, often reddish or pinkish, hindwing broad, usually greyish, usually boldly patterned; legs with tibial spur formula of 0-2-4, hind tibial spurs usually short, hind tarsal spines sometimes present. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Pyralinae can be separated from Galleriinae and others by the forewing pattern.

Taxonomic References: Powell & Opler 2009, Covell 1984 (some spp.)

Pyralidae, Epipaschiinae (Fig. 5-150)

Superfamily: Pyraloidea

Number of Canadian Species: 15 spp. across Canada

Genera: *Epipaschia, Macalla, Oneida, Pococera, Toripalpus*

Abundance: uncommon, at lights

Quick Recognition: Scaled proboscis, ocelli present, labial palps prominent and curved upwards, forewing typically greyish with distinct AM and PM lines, forewing with raised scales usually present. They can be tricky to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata usually present; head scales rough on vertex, usually smooth on frons; proboscis scaled; labial palps ascending, long, slender; antenna filiform, sometimes with bizarre ornamentation, usually with long sensillae, with two scale rows per antennal segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing usually with prominent AM and PM lines, apex squared, greyish, hindwing broad, greyish; legs with tibial spur formula of 0-2-4, hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, sometimes boldly patterned, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Epipaschiinae can be separated from Phycitinae by forewing pattern.

Taxonomic References: Holland & Schaus 1925 (*Epipaschia*, *Macalla*, most *Pococera*, some *Toripalpus*); Solis 1991 (*Oneida*); Solis 1993 (some *Toripalpus*)

Pyralidae, Phycitinae (Fig. 5-151)

Superfamily: Pyraloidea

Number of Canadian Species: over 140 spp. across Canada

Genera: *Acrobasis, Ambesa, Anerastia, Apomyelois, Bandera, Cadra, Canarsia, Catastia, Caudellia, Coenochroa, Cuniberta, Dasypyga, Dioryctria, Ephestia, Ephestiodes, Erelieva, Etiella, Eulogia, Eumysia, Eurythmia, Euzophera, Homoeosoma, Honora, Hulstia, Interjectio, Lipographis, Macrorrhinia, Melitara, Meroptera, Moodna, Myelopsis, Oreana, Ortholepis, Peoria, Philodema, Phobus,* *Phycitodes, Pima, Plodia, Polopeustis, Promylea, Psorosina, Pyla, Ragonotia, Rhagea, Rostrolaetilia, Salebriaria, Sarata, Sciota, Staudingeria, Telethusia, Trachycera, Tulsa, Vitula, Zophodia*

Abundance: common, at lights, some spp. diurnal

Quick Recognition: Scaled proboscis, ocelli usually present, labial palps usually fairly long and curved upwards, forewing often with distinct AM and PM lines, usually greyish, forewing most often very narrow compared to broad hindwing, hind tarsal spines usually present. They are often very difficult to identify to species.

Diagnosis: HEAD: ocelli usually present; chaetosemata usually present; head scales often smooth; proboscis scaled; labial palps usually ascending, usually long, usually slender; antenna filiform, sometimes with long sensillae, with two scale rows per antennal segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing most often very slender compared to the hindwing, usually with prominent AM and PM lines, reniform spot often present, apex usually squared, usually greyish or brownish with white markings, hindwing broad, greyish, brownish, or whitish; legs with tibial spur formula of 0-2-4, hind tibial spurs short, hind tarsal spines usually present. ABDOMEN: smooth, rarely boldly patterned, rarely with dorsal scale tuft, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Phycitinae are best separated from other similar pyralids and crambids by eliminating the other taxa since phycitines are so polymorphic.

Taxonomic References: Neunzig 1986 (*Acrobasis, Trachycera*); Neunzig 2003 (*Ambesa, Canarsia, Catastia, Dioryctria, Interjectio, Lipographis, Meroptera, Oreana, Ortholepis, Philodema, Phobus, Pima, Polopeustis, Psorosina, Pyla, Salebriaria, Sarata, Sciota, Telethusia, Tulsa*); Shaffer 1968 (*Anerastia, Coenochroa, Peoria, Ragonotia*); Neunzig 1990 (*Apomyelois, Bandera, Cadra, Caudellia, Cuniberta, Ephestia, Ephestiodes, Erelieva, Eulogia, Eurythmia,* *Euzophera, Moodna, Myelopsis, Plodia, Vitula*); Neunzig 1997 (*Homoeosoma, Melitara, Phycitodes, Rhagea, Rostrolaetilia, Zophodia*); Heinrich 1956 (most spp.)

Crambidae, Scopariinae (Fig. 5-152)

Superfamily: Pyraloidea

Number of Canadian Species: 17 spp. across Canada

Genera: *Cosipara, Eudonia, Gesneria, Scoparia*

Abundance: common, at lights

Quick Recognition: Scaled proboscis, ocelli present, labial palps porrect or descending, forewing usually with distinct antemedian and postmedian lines, usually with distinct claviform, orbicular, or reniform spots, grey with black markings. Most are fairly easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales usually rough on vertex, smooth on frons; proboscis scaled; labial palps porrect or descending, usually long, usually tufted; antenna filiform, sometimes with long sensillae, with two scale rows per antennal segment, usually roughly half forewing length. THORAX: wings heteroneurous, forewing fairly slender, usually with prominent AM and PM lines, reniform, orbicular, and claviform spots usually present, apex usually squared or rounded, greyish with black and white markings, hindwing broad, greyish or whitish; legs with tibial spur formula of 0-2-4, hind tibial spurs usually short. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Scopariinae are easily separated from other crambids and pyralids by the characteristic forewing pattern.

Taxonomic References: Munroe 1972a, 1973

Crambidae, Crambinae, Argyriini (Fig. 5-153)

Superfamily: Pyraloidea

Number of Canadian Species: 4 spp. in eastern Canada as far west as MB

Genera: *Argyria, Urola*

Abundance: uncommon, at lights

Quick Recognition: Scaled proboscis, broad squared forewing, shining white, often with a distinct slanted orange or brown median line. Easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales rough, somewhat smoothened on frons; proboscis scaled; labial palps porrect or ascending, usually long, relatively short compared to other Crambinae, slender; antenna filiform, with two scale rows per antennal segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing broad, shining white, often with a distinct slanted orange or brown median line, apex squared, hindwing broad, white; legs with tibial spur formula of 0-2-4, hind tibial spurs often long. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Argyriini are easily separated from other crambids and pyralids by the characteristic forewing pattern.

Taxonomic References: Martinez & Brown 2007

Crambidae, Crambinae, Crambini (Fig. 5-154)

Superfamily: Pyraloidea

Number of Canadian Species: 57 spp. throughout Canada

Genera: *Agriphila, Arequipa, Catoptria, Chrysoteuchia, Crambus, Euchromius, Fissicrambus, Loxocrambus, Microcrambus, Neodactria, Parapediasia, Pediasia, Platytes, Raphiptera, Tehama, Thaumatopsis*

Abundance: common to abundant, at lights, often flushed from grasses

Quick Recognition: Scaled proboscis, very long porrect palps, elongate forewing with squared tip, usually streaky looking, often with silvery or golden streaks, broad hindwing. Some genera are challenging to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata present; head scales smooth, sometimes roughened on vertex; proboscis scaled; labial palps porrect or descending, very long, sometimes tufted; antenna filiform, rarely pectinate, with two scale rows per antennal segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing slender, often streaked with silver or gold, often with a complex pattern of lines in the subterminal area, usually brownish; hindwing broader, greyish brown or white; legs with tibial spur formula of 0-2-4, hind tibial spurs short. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Crambini are best separated from other crambids and pyralids by the forewing pattern.

Taxonomic References: Landry 1995 (key to genera, *Arequipa, Chrysoteuchia, Platytes, Raphiptera, Tehama*); Bird 2003-2006 (*Agriphila*); Bird 2003 (*Catoptria*); Klots 1940 (some *Crambus*); Kearfott 1908 (some *Crambus*, some *Neodactria*); Klots 1942 (some *Crambus*, some *Pediasia*); McDunnough 1921 (some *Crambus*); Fernald 1896 (some *Crambus, Fissicrambus*, most *Neodactria*, *Parapediasia*, some *Pediasia*, some *Thaumatopis*); Capps 1966 (*Euchromius*); McDunnough 1929 (*Loxocrambus*); Klots 1968 (*Microcrambus*); Bird 2003-2009 (most *Pediasia*)

Crambidae, Crambinae, Haimbachiini (Fig. 5-155)

Superfamily: Pyraloidea

Number of Canadian Species: 5 spp. across Canada

Genera: *Chilo, Eoreuma, Occidentalia, Thopeutis, Xubida*

Abundance: rare, at lights

Quick Recognition: Scaled proboscis, very long porrect palps, elongate forewing with squared tip, usually streaky looking, broad hindwing. Fairly easy to identify to species.

Diagnosis: HEAD: ocelli usually present; chaetosemata present; head scales smooth, sometimes roughened on vertex; proboscis scaled; labial palps porrect, very long, usually slender; antenna filiform, with two scale rows per antennal segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing slender, often streaked in pattern, usually brownish; hindwing usually broader, greyish or white; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Haimbachiini are best separated from other crambids and pyralids by the forewing pattern.

Taxonomic References: Fernald 1896 (*Chilo, Occidentalia*); Klots 1970 (*Eoreuma, Xubida*); Capps 1965 (*Haimbachia*)

Crambidae, Crambinae, Prionapterygini (Fig. 5-156)

Superfamily: Pyraloidea

Number of Canadian Species: 2 spp. *Pseudoschoenobius opalescalis* in S. AB, *Prionapteryx nebulifera* in S. MB & S. ON

Genera: *Prionapteryx*, *Pseudoschoenobius*

Abundance: very rare, at lights

Quick Recognition: Scaled proboscis, very long porrect or descending palps, elongate forewing with acute or falcate tip, broad hindwing. Easy to identify to species.

Diagnosis: HEAD: ocelli present or absent; chaetosemata present; head scales smooth, sometimes roughened on vertex; proboscis scaled; labial palps descending or porrect, long, slender; antenna filiform, with two scale rows per antennal segment, less than half forewing length. THORAX: wings heteroneurous, forewing slender to very slender, apex either acute or falcate, boldly patterned or subdued, brownish, sometimes with metallic markings; hindwing broader, whitish; legs with tibial spur formula of 0-2-4, hind tibial spurs short. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Prionapterygini are best separated from other crambids and pyralids by the forewing pattern.

Taxonomic References: Fernald 1896

Crambidae, Schoenobiinae (Fig. 5-157)

Superfamily: Pyraloidea

Number of Canadian Species: over 4 spp. across S. Canada

Genera: *Carectocultus, Donacaula*

Abundance: rare to common, at lights, associated with water

Quick Recognition: Scaled proboscis, forewing acutely pointed, extremely long porrect palps, yellow or brown forewing, often with streaky markings. Difficult to identify to species.

Diagnosis: HEAD: ocelli present or absent; chaetosemata usually present; head scales rough or smooth; proboscis scaled, reduced; labial palps porrect, extremely long, sometimes tufted; antenna filiform, with long sensillae, with two scale rows per antennal segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing slender, apex acute, typically streaked, yellow or brown; hindwing broad, whitish; legs with tibial spur formula of 0-2-4, hind tibial spurs short. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Schoenobiinae are best separated from others by the characteristic forewing shape and pattern.

Taxonomic References: none

Crambidae, Acentropiinae (Fig. 5-158)

Superfamily: Pyraloidea

Number of Canadian Species: 19 spp. across Canada

Genera: *Acentria, Elophila, Eoparargyractis, Neocataclysta, Parapoynx, Petrophila*

Abundance: common to uncommon, at lights, associated with water, often flushed during the day

Quick Recognition: Scaled proboscis, forewing elongate triangular, both wings usually boldly patterned. Usually easy to identify to species.

Diagnosis: HEAD: ocelli present, rarely absent; chaetosemata present; head scales smooth; proboscis scaled, rarely absent; labial palps ascending, rarely descending, short, sometimes tufted; antenna filiform, often with long sensillae, with one or two scale rows per antennal segment, often less than half forewing length. THORAX: wings heteroneurous, female rarely apterous, forewing elongate triangular, apex acute or square, typically boldly patterned with many fine lines, varying in colour, but usually pale; hindwing broad, usually boldly patterned, varying in colour, sometimes with gold spots on the outer margin; legs with tibial spur formula of 0-2-4, hind tibial spurs usually short. ABDOMEN: smooth, often boldly patterned, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Acentropiinae are easy to separate from other crambids and pyralids by the wing pattern.

Taxonomic References: Scholtens & Balogh 1996 (*Acentria*); Munroe 1972a, 1973 (most spp.)

Crambidae, Odontiinae (Fig. 5-159)

Superfamily: Pyraloidea

Number of Canadian Species: 6 spp. scattered across southern Canada

Genera: *Anatralata, Eustixia, Frechinia, Metrea, Microtheoris, Mimoschinia*

Abundance: rare to uncommon, at lights

Quick Recognition: Scaled proboscis, most spp. have distinct forewing patterns. Easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata usually present; head scales smooth, often rough on vertex; proboscis scaled; labial palps usually porrect, usually short, usually tufted; antenna filiform, often with long sensillae, with two scale rows per antennal segment, often less than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex acute or square, typically boldly patterned, varying in colour, usually pale, rarely with raised scales; hindwing broad, usually whitish; legs with tibial spur formula of 0-2-4, hind tibial spurs usually long. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Odontiinae are easy to separate from other crambids and pyralids by the wing pattern.

Taxonomic References: Munroe 1972b, 1973

Crambidae, Evergestinae (Fig. 5-160)

Superfamily: Pyraloidea

Number of Canadian Species: 13 spp. throughout Canada, most diverse in the west.

Genera: *Cylindrifrons, Evergestis, Orenaia, Prorasea*

Abundance: common to uncommon, at lights

Quick Recognition: Scaled proboscis, most spp. have distinct forewing patterns. Fairly easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough on vertex, smooth on frons; proboscis scaled; labial palps porrect or ascending, usually short, tufted; antenna filiform, with two scale rows per antennal segment, often greater than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex acute or square, typically boldly patterned with fine lines, varying in colour; hindwing broad, often slightly boldly patterned; legs with tibial spur formula of 0-2-4, hind tibial spurs often long. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Evergestinae are easy to separate from other crambids and pyralids by the wing pattern.

Taxonomic References: Munroe 1973

Crambidae, Glaphyriinae (Fig. 5-161)

Superfamily: Pyraloidea

Number of Canadian Species: 12 spp. mainly in southern ON and PQ, also in southern BC.

Genera: *Abegesta, Aethiophysa, Chalcoela, Dicymolomia, Glaphyria, Hellula, Lipocosma, Lipocosmodes, Nephrogramma, Stegea, Xanthophysa*

Abundance: rare to uncommon, at lights

Quick Recognition: Scaled proboscis, most spp. have distinct forewing and hindwing patterns. Fairly easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata absent, but scale tufts present in that location; head scales usually rough on vertex, smooth on frons; proboscis scaled; labial palps usually porrect, usually short, usually tufted; antenna filiform, with two scale rows per antennal segment, usually about half forewing length. THORAX: wings heteroneurous, forewing triangular, apex square, typically boldly patterned with fine antemedian and postmedian lines or blotches, varying in colour; hindwing broad, usually with a rough continuation of forewing pattern; legs with tibial spur formula of 0-2-4, hind tibial spurs long. ABDOMEN: smooth, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Glaphyriinae are easy to separate from other crambids and pyralids by the wing pattern.

Taxonomic References: Munroe 1972b, 1973

Crambidae, Pyraustinae (Fig. 5-162)

Superfamily: Pyraloidea

Number of Canadian Species: 52 spp. throughout Canada.

Genera: *Achyra, Anania, Crocidophora, Fumibotys, Hahncappsia, Loxostege, Nascia, Neohelvibotys, Ostrinia, Perispasta, Pyrausta, Saucrobotys, Sitochroa, Uresiphita*

Abundance: common, at lights

Quick Recognition: Scaled proboscis, most spp. have distinct forewing and hindwing patterns. Often easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough on vertex, smooth on frons; proboscis scaled; labial palps usually porrect, usually short, usually tufted; antenna filiform, usually with two scale rows per antennal segment, greater than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex square or acute, typically boldly patterned with spots and lines, often brownish, often with bright colours; hindwing broad, often boldly patterned, usually brownish; legs with tibial spur formula of 0-2-4, hind tibial spurs usually short. ABDOMEN: smooth, occasionally boldly patterned, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Pyraustinae are easy to separate from most other crambids and pyralids by the wing pattern. Spilomelinae are difficult to separate except by familiarity with the wing patterns of the various genera.

Taxonomic References: Munroe 1976a, 1976b

Crambidae, Spilomelinae (Fig. 5-163)

Superfamily: Pyraloidea

Number of Canadian Species: 47 spp. throughout Canada.

Genera: *Anageshna*, *Blepharomastix, Choristostigma, Desmia, Diacme, Diaphania, Diastictis, Diathrausta, Framinghamia, Herpetogramma, Hymenia, Lineodes, Loxostegopsis, Mecyna, Nomophila, Palpita, Pantographa, Polygrammodes, Spolodea, Udea*

Abundance: common, at lights

Quick Recognition: Scaled proboscis, most spp. have distinct forewing and hindwing patterns. Often easy to identify to species.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough on vertex, smooth on frons; proboscis scaled; labial palps usually porrect, usually short, often tufted; antenna filiform, often with long sensillae, usually with two scale rows per antennal segment, usually greater than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex square or acute, typically boldly patterned with spots and lines, often brownish, often with bright colours; hindwing broad, often boldly patterned, usually brownish; legs with tibial spur formula of 0-2-4, hind tibial spurs short. ABDOMEN: smooth, rarely boldly patterned, with paired tympanal organs ventrally on the first abdominal segment.

Similar Taxa: Spilomelinae are easy to separate from most other crambids and pyralids by the wing pattern. Pyraustinae are difficult to separate except by familiarity with the wing patterns of the various genera.

Taxonomic References: Munroe 1956a (*Anageshna*); Powell & Opler 2009 (*Choristostigma*, *Diaphania*, some *Diathrausta*, some *Herpetogramma*, *Lineodes*, *Mecyna*, *Nomophila*); Covell 1984 (*Desmia*, *Diacme*, *Diaphania*, some *Herpetogramma*, *Hymenia*, *Nomophila*, *Pantographa*, *Polygrammodes*, *Spolodea*); Munroe 1956b (*Diastictis*); Munroe 1956c (*Diathrausta*); Munroe 1952 (*Palpita*); Munroe 1966 (*Udea*)

Thyrididae (Fig. 5-164)

Superfamily: Thyridoidea

Number of Canadian Species: 2 spp. *Thyris maculata* across southern Canada, *Pseudothyris sepulchralis* in extreme southern ON.

Genera: *Pseudothyris, Thyris*

Abundance: rare to uncommon, diurnal

Quick Recognition: Naked proboscis, both wings dark with a distinct pale blotchy pattern. Easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis naked; labial palps usually ascending, long, tufted; antenna filiform, with two scale rows per antennal segment, greater than half forewing length. THORAX: stout, wings heteroneurous, forewing triangular, apex square, dark with pale blotches; hindwing broad, patterned like forewing; legs with tibial spur formula of 0-2-4, hind tibial spurs long, tarsal spines present. ABDOMEN: smooth, boldly patterned.

Similar Taxa: The naked proboscis, lack of ocelli, and characteristic wing pattern are distinctive.

Taxonomic References: Covell 1984

Hesperiidae, Eudaminae (Fig. 5-165)

Superfamily: Hesperioidea

Number of Canadian Species: 5 spp. through much of Canada, most diverse in extreme southern ON.

Genera: *Achalarus, Epargyreus, Thorybes, Urbanus*

Abundance: uncommon to common, diurnal

Quick Recognition: Hooked and clubbed antenna, broad dark or chocolate brown wings, stout body.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending, short, roughly scaled; antenna hooked and clubbed, far apart at base, with many rows of scales per antennal segment, varying in length. THORAX: stout, wings heteroneurous, forewing triangular, apex square, brown, often with paler markings in the median and post median areas; hindwing broad, brown, usually unicolourous, sometimes with tails; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Eudamines are easily separated from other skippers by the forewing pattern.

Taxonomic References: Layberry, *et al.* 1998

Hesperiidae, Pyrginae (Fig. 5-166)

Superfamily: Hesperioidea

Number of Canadian Species: 19 spp. throughout Canada.

Genera: *Erynnis, Pholisora, Pyrgus, Staphylus*

Abundance: common, diurnal

Quick Recognition: Clubbed and often hooked antenna, broad brown or grey wings with paler markings, stout body.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough, sometimes smooth; proboscis naked; labial palps ascending or porrect, variable in length, tufted; antenna clubbed, often hooked, far apart at base, with many scale rows per antennal segment, less than half forewing length. THORAX: stout, wings heteroneurous, forewing broad, apex square, brown or grey with paler markings, postmedian line always at least partially visible; hindwing broad, brown, often unicolourous; hind tibial spurs short, hind tarsal spines present. ABDOMEN: hairy.

Similar Taxa: Pyrgines are easily separated from other skippers by the forewing pattern.

Taxonomic References: Layberry, *et al.* 1998

Hesperiidae, Heteropterinae (Fig. 5-167)

Superfamily: Hesperioidea

Number of Canadian Species: 1 sp. (*Carterocephalus palaemon*) throughout Canada.

Genera: *Carterocephalus*

Abundance: uncommon to common, diurnal

Quick Recognition: Clubbed antenna, wings distinctly checkered brown and orange, stout body.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending, long, tufted; antenna clubbed, with a slight hook, far apart at base, with many scale rows per antennal segment, approximately half forewing length. THORAX: stout, wings heteroneurous, forewing broad, apex square, distinctly checkered brown and orange; hindwing broad, with a similar pattern as the forewing; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: hairy.

Similar Taxa: Heteropterinae are easily separated from other skippers by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Hesperiidae, Hesperiinae (Fig. 5-168)

Superfamily: Hesperioidea

Number of Canadian Species: 47 spp. throughout Canada, most diverse in the southeast.

Genera: *Amblyscirtes, Anatrytone, Ancyloxypha, Atalopedes, Atrytonopsis, Calpodes, Euphyes, Hesperia, Hylephila, Oarisma, Ochlodes, Panoquina, Poanes, Polites, Pompeius, Thymelicus, Wallengrenia*

Abundance: common, diurnal

Quick Recognition: Clubbed and often hooked antenna, broad stout wings, stout body.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales usually rough; proboscis naked; labial palps usually ascending, usually short, tufted; antenna clubbed, usually hooked, far apart at base, with many scale rows per antennal segment, usually less than half forewing length. THORAX: stout, wings heteroneurous, forewing broad, apex square, pattern variable, males sometimes with raised patches of sex scales, often orange, brown, or black; hindwing broad, usually with a similar pattern as the forewing; hind tibial spurs short, hind tibial spines sometimes present, tarsal spines present. ABDOMEN: hairy.

Similar Taxa: Hesperiinae are easily separated from other skippers by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Hesperiidae, Megathyminae (Fig. 5-169)

Superfamily: Hesperioidea

Number of Canadian Species: 1 sp. (*Megathymus streckeri*) in extreme SE AB.

Genera: *Megathymus*

Abundance: very rare, diurnal, associated with yucca.

Quick Recognition: Very large, clubbed antenna, broad stout wings, stout body.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps ascending, short, slightly tufted; antenna clubbed, far apart at base, with many scale rows per antennal segment, less than half forewing length. THORAX: robust, wings heteroneurous, forewing broad, apex square, brown with distinct broad cream markings in postmedian area; hindwing broad, brown; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: hairy.

Similar Taxa: Megathyminae can be separated from all other Canadian skippers by its massive size.

Taxonomic References: Brock & Kaufman 2006

Papilionidae, Parnassiinae (Fig. 5-170)

Superfamily: Papilionoidea

Number of Canadian Species: 4 spp. mostly restricted to the western Cordillera.

Genera: *Parnassius*

Abundance: uncommon to common, diurnal, in mountain and foothill areas

Quick Recognition: Clubbed antenna, wings white or yellow with black spots.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending or porrect, short, tufted; antenna clubbed, with many scale rows per antennal segment or naked, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex rounded, white or yellow with black shading and spots; hindwing broad, with a similar pattern as the forewing, but with some red spots submarginally; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: hairy.

Similar Taxa: Parnassiines can be separated from all other butterflies by the forewing pattern.

Taxonomic References: Layberry, *et al.* 1998

Papilionidae, Papilioninae (Fig. 5-171)

Superfamily: Papilionoidea

Number of Canadian Species: 14 spp. throughout Canada.

Genera: *Battus, Eurytides, Papilio*

Abundance: common, diurnal

Quick Recognition: Clubbed antenna, distinct wing pattern, hindwing with tail.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales usually rough; proboscis naked; labial palps ascending or porrect, short, tufted; antenna clubbed, usually unscaled, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex rounded or acute, lines often distinct, especially subterminal, black, often with yellow; hindwing broad, with a similar pattern as the forewing, with at least indication of a tail, normally with at least some metallic blue marginally; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth, usually boldly striped.

Similar Taxa: Papilioninae can be separated from all other butterflies by the forewing pattern coupled with hindwing tails.

Taxonomic References: Layberry, *et al.* 1998

Pieridae, Pierinae (Fig. 5-172)

Superfamily: Papilionoidea

Number of Canadian Species: 18 spp. throughout Canada.

Genera: *Anthocaris, Ascia, Euchloe, Neophasia, Pieris, Pontia*

Abundance: common, diurnal

Quick Recognition: Clubbed antenna, wings usually white with black markings.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps usually ascending, usually short, tufted; antenna clubbed, with many scale rows per antennal segment, less than half forewing length. THORAX: slender, hairy; wings heteroneurous, forewing squared, usually white with black markings, especially apically; hindwing broad, sometimes with a similar pattern as the forewing, white; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth or hairy.

Similar Taxa: Pierinae are most similar to Coliadinae and can be separated by wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Pieridae, Coliadinae (Fig. 5-173)

Superfamily: Papilionoidea

Number of Canadian Species: 22 spp. throughout Canada.

Genera: *Colias*, *Eurema*, *Nathalis*, *Phoebis*, *Zerene*

Abundance: common, diurnal

Quick Recognition: Clubbed antenna, wings usually yellow with black markings.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps usually ascending, short, often tufted; antenna clubbed, with many scale rows per antennal segment, less than half forewing length. THORAX: slender, hairy; wings heteroneurous, forewing squared, usually yellow with black markings, especially apically; hindwing broad, sometimes with a similar pattern as the forewing, usually yellow; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth or hairy.

Similar Taxa: Coliadinae are most similar to Pierinae but can be separated by wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Lycaenidae, Miletinae (Fig. 5-174)

Superfamily: Papilionoidea

Number of Canadian Species: 1 sp. (*Feniseca tarquinius*) from SK eastwards.

Genera: *Feniseca*

Abundance: rare, diurnal, most common among alder shrubs that harbour wooly aphids

Quick Recognition: Clubbed and banded antenna, wings boldly marked with orange and brown.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales somewhat roughened; proboscis naked; labial palps partially ascending, fairly short, slender; antenna clubbed, banded, with many scale rows per antennal segment, less than half forewing length. THORAX: slender, hairy; wings heteroneurous, forewing squared, orange with brown markings; hindwing broad, with a similar pattern as the forewing; hind tibial spurs short, hind tarsal spines present. ABDOMEN: slightly hairy.

Similar Taxa: Miletinae are easily separated from other lycaenids by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Lycaenidae, Lycaeninae (Fig. 5-175)

Superfamily: Papilionoidea

Number of Canadian Species: 12 spp. throughout Canada

Genera: *Lycaena*

Abundance: common to uncommon, diurnal

Quick Recognition: Clubbed and banded antenna, wings often iridescent, especially in males.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending or porrect, variable in length, tufted; antenna clubbed, banded, with many scale rows per antennal segment, usually less than half forewing length. THORAX: slender, hairy; wings heteroneurous, forewing squared, variable in pattern, often orange and black, usually iridescent in males; hindwing broad, usually with a similar pattern as the forewing; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: slightly hairy.

Similar Taxa: Lycaeninae can be separated from other lycaenids by wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Lycaenidae, Theclinae (Fig. 5-176)

Superfamily: Papilionoidea

Number of Canadian Species: 31 spp. throughout Canada

Genera: *Callophrys, Calycopis, Erora, Parrhasius, Satyrium*

Abundance: common to uncommon, diurnal, rarely crepuscular

Quick Recognition: Clubbed and banded antenna, hindwings often with slender tail, wing pattern usually more complex ventrally than dorsally.

Diagnosis: HEAD: ocelli absent; chaetosemata present; eye hairy; head scales usually rough; proboscis naked; labial palps ascending or porrect, variable in length, often tufted; antenna clubbed, banded, with many scale rows per antennal segment, less than half forewing length. THORAX: slender, hairy; wings heteroneurous, forewing squared, pattern usually weak, often brown, pattern typically more distinctive and composed of many fine lines on ventral side; hindwing broad, usually with a similar pattern as the forewing, usually with a slender tail; hind tibial spurs short, hind tibial spines often present, tarsal spines present. ABDOMEN: slightly hairy.

Similar Taxa: Theclinae can be separated from other lycaenids by ventral wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Lycaenidae, Polyommatinae (Fig. 5-177)

Superfamily: Papilionoidea

Number of Canadian Species: 19 spp. throughout Canada

Genera: *Celastrina, Cupido, Echinargus, Euphilotes, Glaucopsyche, Leptotes, Lycaeides, Plebejus*

Abundance: common, diurnal

Quick Recognition: Clubbed and banded antenna, wings often iridescent blue with black.

Diagnosis: HEAD: ocelli absent; chaetosemata present; eye sometimes hairy; head scales rough; proboscis naked; labial palps usually ascending, variable in length, tufted; antenna clubbed, banded, with many scale rows per antennal segment, less than half forewing length. THORAX: slender, hairy; wings heteroneurous, forewing squared, usually iridescent blue with black markings; hindwing broad, with a similar pattern as the forewing; hind tibial spurs short, hind tibial spines rarely present, tarsal spines present. ABDOMEN: slightly hairy.

Similar Taxa: Polyommatinae can be separated from other lycaenids by wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Riodinidae (Fig. 5-178)

Superfamily: Papilionoidea

Number of Canadian Species: 1 sp. (*Apodemia mormo*) in S. BC and S. SK

Genera: *Apodemia*

Abundance: rare, diurnal

Quick Recognition: Clubbed and banded antenna, wings brown and orange with prominent white spots.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps usually ascending, short, slightly tufted; antenna clubbed, banded, with many scale rows per antennal segment, greater than half forewing length. THORAX: slender, hairy; wings heteroneurous, forewing squared, brown and orange with prominent white spots; hindwing broad, with a similar pattern as the forewing; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Riodinidae can be separated from other butterflies by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Nymphalidae, Libytheinae (Fig. 5-179)

Superfamily: Papilionoidea

Number of Canadian Species: 1 sp. (*Libytheana carinenta*) a stray in ON and PQ

Genera: *Libytheana*

Abundance: rare, diurnal

Quick Recognition: Clubbed antenna, extremely long labial palps.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps porrect, very long, slightly tufted; antenna clubbed, with many scale rows per antennal segment, less than half forewing length. THORAX: wings heteroneurous, forewing squared at apex, brown with orange markings basally and white spots apically; hindwing broad, brown with orange; forelegs reduced to small brushes; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: The very long labial palps and wing pattern are distinctive.

Taxonomic References: Layberry, *et al.* 1998

Nymphalidae, Danainae (Fig. 5-180)

Superfamily: Papilionoidea

Number of Canadian Species: 1 sp. (*Danaus plexippus*) throughout southern Canada, more common to the south and east

Genera: *Danaus*

Abundance: common to rare migrant, diurnal; associated with milkweeds

Quick Recognition: Clubbed antenna, bold orange and black wing pattern, hind tibia unspined.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending, short, tufted; antenna clubbed, unscaled, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex acute and rounded, orange with black veins and margins with white spots; hindwing broad, similar in pattern to forewing; forelegs reduced to small brushes; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, black with white spots.

Similar Taxa: *Limenitis archippus* is a convincing mimic of this species and can be separated by having a curved line through the hindwing and hind tibial spines that *D. plexippus* lacks.

Taxonomic References: Layberry, *et al.* 1998

Nymphalidae, Limenitidinae (Fig. 5-181)

Superfamily: Papilionoidea

Number of Canadian Species: 4 spp. throughout Canada

Genera: *Limenitis*

Abundance: common, diurnal

Quick Recognition: Clubbed antenna, either black with a broad white band or bold orange and black wing pattern, hind tibia spined.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending, short, at least semi-tufted; antenna clubbed, unscaled, usually roughly half forewing length. THORAX: wings heteroneurous, forewing triangular, apex somewhat square, either predominantly black with a broad white band or orange with black veining; hindwing broad, similar in pattern to forewing; forelegs reduced to small brushes; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth, usually striped.

Similar Taxa: *Limenitis archippus* is a convincing mimic of *D. plexippus*; *L. archippus* can be recognized by the curved black line bisecting the hindwing pattern and the presence of hind tibial spines.

Taxonomic References: Layberry, *et al.* 1998

Nymphalidae, Heliconiinae (Fig. 5-182)

Superfamily: Papilionoidea

Number of Canadian Species: 27 spp. throughout Canada

Genera: *Agraulis, Argynnis, Boloria, Euptoieta*

Abundance: common, diurnal

Quick Recognition: Clubbed antenna, upperside of wings usually orange with many black spots and lines, underside of hindwing often with prominent silvery spots or complex patterns.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending, variable in length, tufted; antenna clubbed, with many scale rows per segment, variable in length. THORAX: wings heteroneurous, forewing triangular, apex somewhat square to rounded, typically orange with a complex series of black spots and lines; hindwing broad, dorsally similar in pattern to forewing, ventrally usually with abundant silvery spots or with a complex pattern; forelegs reduced to small brushes; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth to hairy, rarely boldly patterned.

Similar Taxa: Heliconiines can be easily separated from other butterflies by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Nymphalidae, Apaturinae (Fig. 5-183)

Superfamily: Papilionoidea

Number of Canadian Species: 2 spp. in extreme southern MB, ON, and PQ

Genera: *Asterocampa*

Abundance: locally uncommon, diurnal

Quick Recognition: Clubbed antenna, distinct wing pattern.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; labial palps ascending, short, fairly slender; antenna clubbed, with many scale rows per segment, usually greater than half the forewing length. THORAX: wings heteroneurous, forewing triangular, typically orange or grey with a complex series of dark spots and lines; hindwing broad, similar in pattern to forewing; forelegs reduced to small brushes; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Apaturinae can be easily separated from other butterflies by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Nymphalidae, Nymphalinae (Fig. 5-184)

Superfamily: Papilionoidea

Number of Canadian Species: 33 spp. throughout Canada

Genera: *Aglais, Chlosyne, Euphydryas, Junonia, Nymphalis, Phyciodes, Polygonia, Vanessa*

Abundance: common, diurnal; many species hibernate as adults

Quick Recognition: Clubbed antenna, distinct wing pattern, wings margins often jagged.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; compound eye sometimes with long interfacetal hairs; labial palps ascending, usually long, usually tufted; antenna clubbed, with many scale rows per segment, usually less than half the forewing length. THORAX: wings heteroneurous, forewing triangular to more squared, variable in pattern, often orange and black, often with jagged outer margin; hindwing broad, similar in pattern to forewing, often jagged, sometimes with tail; forelegs reduced to small brushes; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth to hairy.

Similar Taxa: Nymphalinae can be easily separated from other butterflies by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Nymphalidae, Satyrinae (Fig. 5-185)

Superfamily: Papilionoidea

Number of Canadian Species: 34 spp. throughout Canada

Genera: *Cercyonis, Coenonympha, Erebia, Lethe, Megisto, Neominois, Oeneis*

Abundance: common, diurnal

Quick Recognition: Slightly clubbed antenna, usually drab brown, grey, or black.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked; compound eye sometimes with long interfacetal hairs; labial palps ascending, usually long, tufted; antenna with a slight club, with many scale rows per segment, less than half the forewing length. THORAX: wings heteroneurous, forewing usually triangular, variable in pattern, often drab greyish or brownish; hindwing broad, similar in pattern to forewing, often with eyespots ventrally; forelegs reduced to small brushes; hind tibial spurs short, hind tibial and tarsal spines present. ABDOMEN: smooth to hairy.

Similar Taxa: Satyrinae can be easily separated from other butterflies by the wing pattern.

Taxonomic References: Layberry, *et al.* 1998

Drepanidae, Thyatirinae (Fig. 5-186)

Superfamily: Drepanoidea

Number of Canadian Species: 8 spp. throughout much of Canada

Genera: *Ceranemota, Euthyatira, Habrosyne, Pseudothyatira*

Abundance: uncommon to common, at lights

Quick Recognition: Overall noctuid-like, with tympana ventrally on the first abdominal segment. Some species are difficult to separate.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis naked; compound eye sometimes with long interfacetal hairs; labial palps variable in orientation, usually short, tufted; antenna filiform, rarely pectinate, with two scale rows per segment, less than half the forewing length. THORAX: wings heteroneurous, forewing usually elongate and rectangular, variable in pattern, greyish or sometimes brownish; hindwing broad, drab grey or brownish; hind tibial spurs usually short, hind tibial spines often present, hind tarsal spines present. ABDOMEN: hairy, sometimes with dorsal scale tufts, tympana present ventrally on the first abdominal segment.

Similar Taxa: Thyatirinae are superficially similar to Notodontidae and Noctuidae and are separated by forewing pattern and by the tympana being on the abdomen instead of the metathorax as they are in Noctuoidea.

Taxonomic References: Troubridge & Lafontaine 2004a (pictures and distribution), Clarke & Benjamin 1938 (*Ceranemota*); Handfield 1999 (*Euthyatira, Habrosyne, Pseudothyatira*)

Drepanidae, Drepaninae (Fig. 5-187)

Superfamily: Drepanoidea

Number of Canadian Species: 4 spp. throughout Canada

Genera: *Drepana, Eudeilina, Oreta*

Abundance: common, at lights

Quick Recognition: Overall broad-winged geometrid-like, most spp. with a distinct hook at the forewing apex. Easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth; proboscis naked; labial palps usually porrect, short, usually slender; antenna filiform or pectinate, with two scale rows per segment, less than half the forewing length. THORAX: wings heteroneurous, forewing triangular, usually with a prominent hook at the apex, variable in pattern, often brownish or yellowish, often with many fine lines; hindwing broad, usually paler, usually with a similar pattern to forewing; hind tibial spurs variable in length. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Drepaninae are superficially similar to Geometridae and are separated by forewing pattern, and often hooked apex.

Taxonomic References: Handfield 1999

Uraniidae, Epipleminae (Fig. 5-188)

Superfamily: Uranioidea

Number of Canadian Species: 2 spp. across Canada

Genera: *Calledapteryx, Callizia*

Abundance: uncommon, at lights

Quick Recognition: Overall geometrid-like, small, both wings with a dark marking in middle of outer margin, live specimens rest characteristically with the hindwing sagging away from the forewings. Easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps porrect, short, slender; antenna filiform, with two scale rows per segment, less than half the forewing length. THORAX: wings heteroneurous, forewing triangular, grey or brown with darker fine markings, prominent dark marks present in middle of outer margin; hindwing broad, with a similar pattern to forewing; hind tibial spurs long. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Uraniids can be separated from other similar moths by the forewing pattern.

Taxonomic References: Handfield 1999

Geometridae, Larentiinae, Cidariini (Fig. 5-189)

Superfamily: Geometroidea

Number of Canadian Species: 34 spp. throughout Canada

Genera: *Colostygia, Dysstroma, Ecliptoptera, Eulithis, Eurhinosea, Eustroma, Plemyria, Thera*

Abundance: common, at lights

Quick Recognition: Very broad delicate wings, forewing usually with many fine complex lines, hindwing usually pale and patterned different than forewing. Some genera are very difficult to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps usually porrect or ascending, usually short, usually tufted; antenna filiform, often with long sensillae, with two scale rows per segment, roughly half the forewing length or less. THORAX: wings heteroneurous, forewing triangular, typically with many fine complex lines; hindwing broad, paler, usually with prominent discal spot; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, sometimes boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Cidariini can be separated from other similar geometrids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Handfield 1999 (eastern spp.)

Geometridae, Larentiinae, Hydriomenini (Fig. 5-190)

Superfamily: Geometroidea

Number of Canadian Species: 53 spp. throughout Canada

Genera: *Anticlea, Ceratodalia, Coryphista, Entephria, Hydriomena, Mesoleuca, Perizoma, Rheumaptera, Spargania, Triphosa*

Abundance: common, at lights

Quick Recognition: Very broad delicate wings, forewing usually with many fine complex lines or blotchy looking, hindwing usually pale and patterned different than forewing. Most genera are difficult to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, rarely roughened on vertex; proboscis naked; labial palps porrect, short, tufted; antenna filiform, rarely with long sensillae, with two scale rows per segment, usually less than half the forewing length. THORAX: wings heteroneurous, forewing triangular, typically with many fine complex lines or large blotches; hindwing broad, paler, often with prominent discal spot; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth, rarely boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Hydriomenini can be separated from other similar geometrids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Handfield 1999 (eastern spp.)

Geometridae, Larentiinae, Stamnodini (Fig. 5-191)

Superfamily: Geometroidea

Number of Canadian Species: 6 spp. From BC and YT east to PQ, most diverse in the west

Genera: *Stamnoctenis*, *Stamnodes*

Abundance: locally uncommon to rare, at lights, some species diurnal

Quick Recognition: Broad delicate wings, upperside with subdued pattern and grey, brown, or orange, underside of hindwing with complex pattern, at rest usually with wings folded upwards over the back. Moderately easy to identify to species.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales often smooth on vertex, often rough on frons; proboscis naked; labial palps descending or ascending, short, usually tufted; antenna filiform, rarely with long sensillae, with two scale rows per segment, about half the forewing length. THORAX: wings heteroneurous, forewing triangular, patterned smeared through the centre of wing, antemedian, median, and postmedian lines most visible along costa; hindwing broad, with a similar pattern dorsally, ventrally with a complex shading; hind tibial spurs short, hind tarsal spines rarely present. ABDOMEN: smooth, rarely boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Stamnodini can be recognized easily by the bold pattern on the underside of the hindwing relative to the ventral surface.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution)

Geometridae, Larentiinae, Xanthorhoini (Fig. 5-192)

Superfamily: Geometroidea

Number of Canadian Species: 35 spp. throughout Canada

Genera: *Costaconvexa, Disclisioprocta, Enchoria, Epirrhoe, Euphyia, Orthonama, Psychophora, Xanthorhoe, Zenophleps*

Abundance: common, at lights

Quick Recognition: Broad delicate wings, forewing with many fine often scalloped lines, the median area is often shaded in, the hindwing is usually light with a faint pattern. Most species are easy to identify, others are very difficult.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps variably oriented, usually short, usually tufted; antenna filiform, often with long sensillae, with two scale rows per segment, variable in length. THORAX: wings heteroneurous, forewing triangular, patterned consists of many fine and often scalloped lines, median area often darkly shaded, discal dots usually present; hindwing broad to somewhat narrow, pale, with a faint pattern of fine lines, discal dot usually prominent; hind tibial spurs short, hind tarsal spines usually present. ABDOMEN: smooth, rarely with small dorsal scale tuft, often boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Xanthorhoini can be separated from other Larentiinae by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Handfield 1999 (eastern spp.)

Geometridae, Larentiinae, Asthenini (Fig. 5-193)

Superfamily: Geometroidea

Number of Canadian Species: 11 spp. throughout Canada

Genera: *Hydrelia, Trichodezia, Venusia*

Abundance: common, at lights or diurnal

Quick Recognition: small delicate geometrids, forewing usually grey with many fine lines that are accented on the veins in Venusia and most Hydrelia; other Hydrelia with mostly white forewing with either broad brown bands or finer yellow lines; forewing black with a prominent white line in Trichodezia. Specific identification is often fairly easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps porrect or descending, short, usually slightly tufted; antenna filiform, rarely pectinate, often with long sensillae, with two scale rows per segment, half the forewing length or less. THORAX: wings heteroneurous, forewing triangular, usually grey with many fine lines that are accented on the veins, sometimes white with brown blotches or yellow lines, rarely jet black with a prominent white line from mid-costa to anal angle; hindwing often relatively narrow, usually pale, often with some indication of forewing pattern, discal dot usually present; hind tibial spurs often long, hind tarsal spines often present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Asthenini can be separated from other Larentiinae by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Handfield 1999 (eastern spp.)

Geometridae, Larentiinae, Operophterini (Fig. 5-194)

Superfamily: Geometroidea

Number of Canadian Species: 6 spp. throughout Canada

Genera: *Epirrita, Operophtera*

Abundance: common to abundant, at lights and diurnal

Quick Recognition: Autumn-flying geometrids with broad delicate wings, in males forewing light grey with darker grey scalloped lines and bands, females brachypterous. Specific identification is often easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, sometimes roughened on vertex; proboscis naked; labial palps porrect or descending, short, sometimes tufted; antenna filiform, with long sensillae, with two or three scale rows per segment, less than half the forewing length. THORAX: females brachypterous, wings heteroneurous, forewing triangular, grey with many fine lines and bands that are scalloped; hindwing relatively narrow, pale, with some faint lines, discal dot often present; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment in males.

Similar Taxa: The late season flight time, size, and wing pattern will separate Operophterini from other geometrids.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Handfield 1999 (eastern spp.)

Geometridae, Larentiinae, Euduliini (Fig. 5-195)

Superfamily: Geometroidea

Number of Canadian Species: 2 spp. across southern Canada

Genera: *Eubaphe*

Abundance: locally uncommon to rare, at lights

Quick Recognition: Unmistakeable translucent wings either solid orange or white and yellow. Both species are easy to identify.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps slightly ascending, short, slender; antenna filiform, with two scale rows per segment, usually less than half the forewing length. THORAX: wings heteroneurous, translucent, forewing rounded or apically pointed, either solid orange or yellow with white blotches; hindwing somewhat squared, similar in pattern to forewing, sometimes paler; hind tibial spurs short, hind tarsal spines absent. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: The forewing pattern and translucency is diagnostic.

Taxonomic References: Powell & Opler (western sp.); Handfield 1999 (eastern sp.)

Geometridae, Larentiinae, Eupitheciini (Fig. 5-196)

Superfamily: Geometroidea

Number of Canadian Species: 67 spp. throughout Canada

Genera: *Eupithecia*, *Horisme*, *Pasiphila*, *Prorella*

Abundance: common, at lights

Quick Recognition: Usually small to very small geometrids with many fine lines on the forewing and a relatively small hindwing. Specific identification usually requires dissection.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, sometimes slightly roughened on vertex; proboscis naked; labial palps variable in orientation, usually short, usually slightly tufted; antenna filiform, sometimes with long sensillae, with two scale rows per segment, usually less than half the forewing length. THORAX: wings heteroneurous, forewing triangular, often with many fine lines, discal dot usually present; hindwing usually very small, often rounded, often similar in pattern to forewing but paler, discal dot often present; hind tibial spurs variable in length, hind tarsal spines sometimes present. ABDOMEN: smooth, often boldly patterned, ovipositor rarely prominent, tympana present ventrally on the first abdominal segment.

Similar Taxa: The triangular forewing and relatively small hindwing will separate Eupithecini from most other Larentiinae.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Bolte 1990 (*Eupithecia*)

Geometridae, Larentiinae, Lobophorini (Fig. 5-197)

Superfamily: Geometroidea

Number of Canadian Species: 14 spp. throughout Canada

Genera: *Acasis*, *Aplocera*, *Carsia*, *Cladara*, *Dyspteris*, *Heterophleps*, *Lobophora*

Abundance: common, at lights

Quick Recognition: Usually delicate geometrids with many fine lines on the forewing and a small and elongate hindwing. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps variable in orientation, usually short, usually tufted; antenna filiform, sometimes with long sensillae, with two or three scale rows per segment, variable in length. THORAX: wings heteroneurous, forewing triangular, often with many fine lines, discal dot often prominent; hindwing usually small and elongate, usually paler with faint or no pattern, discal dot often present; hind tibial spurs usually short, hind tarsal spines sometimes present. ABDOMEN: smooth, rarely boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Lobophorini can be separated from other geometrids by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Handfield 1999 (eastern spp.)

Geometridae, Sterrhinae (Fig. 5-198)

Superfamily: Geometroidea

Number of Canadian Species: 25 spp. throughout Canada

Genera: *Cyclophora, Haematopis, Idaea, Leptostales, Scopula, Pleuroprucha, Lobocleta*

Abundance: common, at lights

Quick Recognition: Geometrids typically pale in colour with several fine lines that run through both fore and hindwings. Specific identification can be challenging.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps porrect or ascending, short, usually tufted; antenna filiform, sometimes pectinate, with long sensillae, with two scale rows per segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing triangular, often with an angular bulge in middle of outer margin, pale white, grey, brown, or yellow, typically with fine darker lines, discal dot often prominent; hindwing broad, often with angular bulge in outer margin, with pattern continuing from forewing, discal dot often present; hind tibial spurs usually short, hind tarsal spines rarely present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Sterrhinae can be separated from other geometrids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); Handfield 1999 (eastern spp.)

Geometridae, Geometrinae (Fig. 5-199)

Superfamily: Geometroidea

Number of Canadian Species: 16 spp. throughout Canada

Genera: *Chlorochlamys*, *Chlorosea*, *Dichorda*, *Hemithea*, *Hethemia*, *Mesothea*, *Nemoria*, *Synchlora*

Abundance: common, at lights or diurnal

Quick Recognition: Geometrids that usually have green wings with white lines. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, rarely roughened; proboscis naked; labial palps usually porrect or ascending, short, sometimes slightly tufted; antenna filiform or pectinate, often with long sensillae, with two or three scale rows per segment, usually less than half forewing length. THORAX: wings heteroneurous, forewing triangular, usually green with white antemedian and postmedian lines; hindwing broad, sometimes with angular bulge on outer margin, with pattern usually continuing from forewing; hind tibial spurs short, hind tarsal spines usually present. ABDOMEN: smooth, often boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Few other geometrids are predominantly green and those can be separated by wing pattern.

Taxonomic References: Ferguson 1985

Geometridae, Archiearinae (Fig. 5-200)

Superfamily: Geometroidea

Number of Canadian Species: 3 spp. throughout Canada

Genera: *Archiearis, Boudinotiana, Leucobrephos*

Abundance: locally uncommon, diurnal in early spring

Quick Recognition: Stout and very hairy, hindwing boldly patterned with black and orange or white. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head rough and long; proboscis naked; labial palps porrect or descending, short, tufted with long hairs; antenna filiform or pectinate, sometimes with long sensillae, usually scaleless, usually less than half forewing length. THORAX: wings heteroneurous, forewing elongate triangular, with prominent antemedian and postmedian lines, black and white or brownish; hindwing broad, boldly patterned black with white or orange, often with very long hairs along inner margin; hind tibial spurs short, hind tarsal spines present. ABDOMEN: densely hairy.

Similar Taxa: No other moths with such a bold hindwing are that densely hairy.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution)

Geometridae, Ennominae, Alsophilini (Fig. 5-201)

Superfamily: Geometroidea

Number of Canadian Species: 1 sp. (*Alsophila pometaria*) from AB to NS

Genera: *Alsophila*

Abundance: common, at lights

Quick Recognition: Late season geometrid with grey wings with white lines, females brachypterous.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis reduced; labial palps porrect or descending, short, very slightly tufted; antenna filiform, with long sensillae, with two scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, females brachypterous, forewing triangular, grey with white antemedian and postmedian lines; hindwing broad, paler grey with white postmedian line and dark discal spot; hind tibial spurs short, hind tarsal spines rarely visible. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment in males.

Similar Taxa: Male Alsophilini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1988

Geometridae, Ennominae, Cassymini (Fig. 5-202)

Superfamily: Geometroidea

Number of Canadian Species: 3 spp. from NT to NS

Genera: *Nematocampa*, *Protitame*

Abundance: common, at lights

Quick Recognition: *Nematocampa* easily recognized by the complex wing pattern, *Protitame* is a small white geometrid. Specific identification can be difficult.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps porrect or ascending, short, sometimes tufted; antenna filiform or pectinate, with long sensillae, with two scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, forewing sometimes with slight bulge in outer margin, white or yellow with either faint yellow spots or with abundant fine dark lines and spots and heavy shading beyond the postmedian line; hindwing broad, sometimes with slight bulge in outer margin, pattern continuous with forewing; hind tibial spurs short, hind tarsal spines sometimes present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: *Nematocampa* is unmistakeable. *Protitame* can be difficult to separate from similar small white geometrids and drepanids.

Taxonomic References: Ferguson 2008

Geometridae, Ennominae, Macariini (Fig. 5-203)

Superfamily: Geometroidea

Number of Canadian Species: 66 spp. throughout Canada

Genera: *Digrammia, Epelis, Eumacaria, Fernaldella, Heliomata, Isturgia, Macaria, Melilla, Speranza*

Abundance: common, at lights or diurnal

Quick Recognition: Moderate-sized geometrids often with prominent lines on the forewing that are expanded to triangles at the costa, often with a prominent spot in middle of wing just beyond postmedian line, antennae often pectinate. Identification can be challenging for some species.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, rarely rough on frons; proboscis naked, rarely reduced; labial palps variable in orientation, usually short, usually tufted; antenna usually pectinate, sometimes filiform, with long sensillae, with two scale rows per segment, scales not organized into rows in some diurnal species, often less than half forewing length. THORAX: wings heteroneurous, female rarely brachypterous, forewing triangular, sometimes falcate or with that appearance due to dark scaling in the fringe below the apex, lines often prominent especially at the costa where they can be expanded to triangles, a prominent spot in middle of wing is often present beyond the postmedian line; hindwing broad, sometimes pointed in outer margin, pattern sometimes similar to forewing; hind tibial spurs variable in length, hind tarsal spines usually present. ABDOMEN: smooth, rarely boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Macariini can usually be separated from other geometrids by forewing pattern.

Taxonomic References: Ferguson 2008

Geometridae, Ennominae, Boarmini (Fig. 5-204)

Superfamily: Geometroidea

Number of Canadian Species: 28 spp. throughout Canada

Genera: *Aethalura, Anavitrinellia, Cleora, Dasyfidonia, Ectropis, Ematurga, Epimecis, Glena, Gnophos, Hesperumia, Iridopsis, Neoalcis, Orthofidonia, Protoboarmia, Stenoporpia*

Abundance: common, at lights

Quick Recognition: Usually moderate-sized geometrids with grey wings, many black lines usually present on the forewing and continue to the hindwing. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough or smooth; proboscis naked; labial palps usually ascending or porrect, usually short, tufted; antenna usually pectinate, sometimes filiform, with long sensillae, with two scale rows per segment or scales not organized into rows, usually less than half forewing length. THORAX: wings heteroneurous, forewing triangular, usually grey, lines often prominent and black, often jagged; hindwing broad, rarely scalloped, pattern usually similar to forewing; hind tibial spurs usually short, hind tarsal spines usually present. ABDOMEN: smooth, rarely boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Boarmini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1977

Geometridae, Ennominae, Melanolophini (Fig. 5-205)

Superfamily: Geometroidea

Number of Canadian Species: 6 spp. across Canada

Genera: *Eufidonia, Melanolophia*

Abundance: common, at lights or diurnally

Quick Recognition: Moderate-sized geometrids, wings usually with prominent lines and discal dots, usually heavily speckled with dark spots. Specific identification often requires dissection.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps variable in orientation, short, at least slightly tufted; antenna usually pectinate, sometimes filiform, usually with long sensillae, with two scale rows per segment, usually roughly half forewing length. THORAX: wings heteroneurous, forewing triangular, white or grey heavily speckled with dark spots, dark lines and discal dots usually prominent; hindwing broad, sometimes scalloped, pattern often similar to forewing; hind tibial spurs short, hind tarsal spines often present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Melanolophini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1977

Geometridae, Ennominae, Bistonini (Fig. 5-206)

Superfamily: Geometroidea

Number of Canadian Species: 13 spp. throughout Canada

Genera: *Biston, Erannis, Hypagyrtis, Lycia, Paleacrita, Phigalia*

Abundance: common, at lights

Quick Recognition: Moderate-sized to large geometrids, often thick bodied, females often apterous. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth or rough; proboscis naked, often absent; labial palps usually porrect, short, often tufted; antenna pectinate or filiform, usually with long sensillae, with two scale rows per segment, sometimes scales not organized into rows, usually less than half forewing length. THORAX: wings heteroneurous, females often apterous, forewing triangular, variable in pattern, typically with prominent lines; hindwing broad, pattern sometimes similar to forewing; hind tibial spurs short, hind tarsal spines usually present. ABDOMEN: smooth or hairy, often boldly patterned, tympana present ventrally on the first abdominal segment except in apterous females.

Similar Taxa: Bistonini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1977

Geometridae, Ennominae, Baptini (Fig. 5-207)

Superfamily: Geometroidea

Number of Canadian Species: 3 spp. across Canada

Genera: *Lomographa*

Abundance: common, diurnal or at lights

Quick Recognition: Small delicate geometrids, either with gently dusted forewings with prominent lines or immaculate white. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps porrect or descending, short, tufted; antenna filiform, with two scale rows per segment, usually roughly half forewing length. THORAX: wings heteroneurous, forewing triangular, either completely translucent white or light grey heavily speckled with dark grey and prominent antemedian and postmedian lines; hindwing broad, usually with less pattern, often with discal spots especially ventrally; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth, tympana usually present ventrally on the first abdominal segment.

Similar Taxa: Baptini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1981

Geometridae, Ennominae, Caberini (Fig. 5-208)

Superfamily: Geometroidea

Number of Canadian Species: 18 spp. across Canada

Genera: *Apodrepanulatrix, Cabera, Drepanulatrix, Erastria, Eudrepanulatrix, Ixala, Sericosema*

Abundance: common to uncommon, at lights

Quick Recognition: Moderate-sized to small geometrids, wing pattern typically diffuse or faint and with abundant dusting throughout, usually pale, antenna usually pectinate. Specific identification can be challenging in the west.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, sometimes roughened on vertex; proboscis naked; labial palps porrect or ascending, often short, at least partially tufted; antenna usually pectinate, with long sensillae, with scales not organized into rows, usually roughly half forewing length or less. THORAX: wings heteroneurous, forewing triangular to somewhat elongate, usually pale with abundant dusting, lines usually diffuse or faint; hindwing broad, often with less pattern; hind tibial spurs variable in length, hind tarsal spines present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Caberini can be separated from other geometrids by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); McGuffin 1981 (most spp.)

Geometridae, Ennominae, Angeronini (Fig. 5-209)

Superfamily: Geometroidea

Number of Canadian Species: 17 spp. across Canada

Genera: *Aspitates, Euchlaena, Lytrosis, Xanthotype*

Abundance: common, at lights or diurnal

Quick Recognition: Moderate-sized to large geometrids, wing pattern typically with prominent antemedian and postmedian lines, pattern often continues to hindwing, antennae usually pectinate. Specific identification can be challenging.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, often roughened on vertex; proboscis naked; labial palps porrect or ascending, short, sometimes tufted; antenna usually pectinate, often with long sensillae, with two scale rows per segment or with scales not organized into rows, usually roughly half forewing length or less. THORAX: wings heteroneurous, forewing triangular, sometimes with a bulge in middle of outer margin, rarely scalloped, usually drab brown or grey, antemedian and postmedian lines usually prominent; hindwing broad, sometimes scalloped, often with a continuation of the forewing pattern; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Angeronini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1981

Geometridae, Ennominae, Azelini (Fig. 5-210)

Superfamily: Geometroidea

Number of Canadian Species: 6 spp. across Canada

Genera: *Pero*

Abundance: common, at lights

Quick Recognition: Thick-bodied geometrids, forewing slightly scalloped, antemedian and postmedian lines prominent, reniform spot prominent. Specific identification can be challenging.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough, sometimes smooth; proboscis naked; labial palps porrect or ascending, short, tufted; antenna filiform, with two scale rows per segment, roughly half forewing length or greater. THORAX: wings heteroneurous, forewing triangular, at least slightly scalloped, drab brown or grey, antemedian and postmedian lines prominent, pale reniform spot usually prominent; hindwing broad, slightly scalloped, drab with a single pale line; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Azelini have the rough appearance of some noctuids which have the tympana on the metathorax instead of the abdomen.

Taxonomic References: McGuffin 1987

Geometridae, Ennominae, Nacophorini (Fig. 5-211)

Superfamily: Geometroidea

Number of Canadian Species: 4 spp. from E. AB to NS and in S. BC, most diverse in BC

Genera: *Animomyia*, *Gabriola*, *Phaeoura*

Abundance: uncommon, at lights

Quick Recognition: Usually large thick-bodied geometrids, antemedian and postmedian lines prominent, reniform spot often prominent. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough on vertex, smooth on frons; proboscis naked; labial palps porrect or ascending, short, usually tufted; antenna filiform or pectinate, often with long sensillae, with two or more scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, sometimes elongate, typically drab grey, antemedian and postmedian lines prominent, dark spot usually prominent; hindwing broad, slightly scalloped, drab or with a faint continuation of the forewing pattern; hind tibial spurs short, hind tarsal spines usually present.

ABDOMEN: smooth, rarely with dorsal scale tuft, sometimes boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Nacophorini can be separated from other geometrids by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); McGuffin 1981 (*Gabriola*, *Phaeoura*)

Geometridae, Ennominae, Campaeini (Fig. 5-212)

Superfamily: Geometroidea

Number of Canadian Species: 1 sp. (*Campaea perlata*) throughout Canada

Genera: *Campaea*

Abundance: common to abundant, at lights

Quick Recognition: Moderate-sized pale green geometrid with white antemedian and postmedian lines.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps porrect, short, slightly tufted; antenna pectinate, with long sensillae, with many scale rows per segment, roughly half forewing length. THORAX: wings heteroneurous, forewing triangular, pale greenish white, antemedian and postmedian lines white, edged with green; hindwing broad, slightly scalloped, similar to the forewing pattern; hind tibial spurs short, hind tarsal spines absent. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Campaeini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1981

Geometridae, Ennominae, Ennomini (Fig. 5-213)

Superfamily: Geometroidea

Number of Canadian Species: 3 spp. across Canada

Genera: *Ennomos*

Abundance: common, at lights

Quick Recognition: Thick or thin-bodied geometrids, both wings scalloped, either yellow with abundant darker speckling or pure white. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough; proboscis naked, sometimes reduced; labial palps porrect or descending, about twice the length of the compound eye, tufted; antenna pectinate, with many scale rows per segment, roughly half forewing length or less. THORAX: wings heteroneurous, forewing triangular, scalloped, either yellow with abundant brown speckling or pure white, dark antemedian and postmedian lines and reniform spot sometimes prominent; hindwing broad, scalloped, usually similar to forewing pattern; hind tibial spurs short, hind tarsal spines rarely visible. ABDOMEN: smooth, sometimes boldly patterned, tympana present ventrally on the first abdominal segment.

Similar Taxa: Ennomini can be separated from other geometrids by forewing shape and pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); McGuffin 1987 (most spp.)

Geometridae, Ennominae, Epiranthidini (Fig. 5-214)

Superfamily: Geometroidea

Number of Canadian Species: 1 sp. (*Spodolepis substriataria*) across Canada

Genera: *Spodolepis*

Abundance: uncommon, at lights

Quick Recognition: Slender-bodied geometrid with very large delicate wings, forewing with prominent black jagged antemedian and postmedian lines, reniform spot outlined in black.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth, sometimes roughened on vertex; proboscis naked; labial palps variable in orientation, short, tufted; antenna filiform, with two scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, forewing triangular with a bulge in the middle of the outer margin, light brown to heavily speckled in dark grey, dark jagged antemedian and postmedian lines prominent, reniform spot outlined in black; hindwing somewhat slender, pale with prominent discal dot; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Epiranthidini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1987

Geometridae, Ennominae, Lithinini (Fig. 5-215)

Superfamily: Geometroidea

Number of Canadian Species: 10 spp. from SK to NF and in BC

Genera: *Gueneria, Homochlodes, Petrophora, Philedia, Tacparia, Thallophaga*

Abundance: uncommon to common, at lights

Quick Recognition: Moderate-sized geometrids, usually brown with prominent postmedian line, pattern often mottled. Specific identification can be challenging.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales smooth; proboscis naked; labial palps usually ascending, usually short, at least slightly tufted; antenna filiform, with two scale rows per segment, typically less than half forewing length. THORAX: wings heteroneurous, forewing triangular sometimes with a bulge in the middle of the outer margin, rarely with a falcate apex, usually brown, postmedian line always prominent, others variably so; hindwing broad, similar in pattern to forewing; hind tibial spurs long, hind tarsal spines often present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Lithinini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1987

Geometridae, Ennominae, Anagogini (Fig. 5-216)

Superfamily: Geometroidea

Number of Canadian Species: 23 spp. throughout Canada

Genera: *Cepphis, Metanema, Metarranthis, Plagodis, Probole, Selenia*

Abundance: common, at lights

Quick Recognition: Small to fairly large geometrids, forewing with a prominent bulge in outer margin, hindwing often with a similar bulge, pattern on forewing and hindwing usually similar, antenna pectinate. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough or smooth; proboscis naked; labial palps usually ascending, usually short, usually tufted; antenna pectinate, with two or more scale rows per segment, typically less than half forewing length. THORAX: wings heteroneurous, forewing triangular with a bulge in the middle of the outer margin, rarely scalloped, antemedian and postmedian lines usually prominent, discal dot often prominent; hindwing broad, usually with bulge in outer margin, rarely scalloped, usually similar in pattern to forewing; hind tibial spurs usually long, hind tarsal spines usually present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Anagogini can be separated from other geometrids by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004b (pictures and distribution); McGuffin 1987 (most spp.); Handfield 1999 (eastern spp.)

Geometridae, Ennominae, Ourapterygini (Fig. 5-217)

Superfamily: Geometroidea

Number of Canadian Species: 38 spp. throughout Canada

Genera: *Antepione, Besma, Caripeta, Cingilia, Enypia, Eugonobapta, Eusarca, Eutrapela, Lambdina, Meris, Neoterpes, Nepytia, Patalene, Plataea, Prochoerodes, Sabulodes, Sicya, Synaxis, Tetracis*

Abundance: common, at lights

Quick Recognition: Moderate-sized to large geometrids, forewing typically boldly patterned and angular with prominent antemedian and postmedian lines, discal dot usually prominent. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata present; head scales rough or smooth on vertex, usually smooth on frons; proboscis naked; labial palps usually ascending, short, usually tufted; antenna filiform or pectinate, with two or more scale rows per segment, roughly half forewing length or less. THORAX: wings heteroneurous, forewing triangular, often with a bulge in the middle of the outer margin, antemedian and postmedian lines usually prominent, discal dot often prominent; hindwing broad, usually with bulge in outer margin, sometimes prolonged into slight tail, rarely scalloped, sometimes similar in pattern to forewing; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth, tympana present ventrally on the first abdominal segment.

Similar Taxa: Ourapterygini can be separated from other geometrids by forewing pattern.

Taxonomic References: McGuffin 1987

Lasiocampidae, Macromphaliinae (Fig. 5-218)

Superfamily: Lasiocampoidea

Number of Canadian Species: 4 spp. across Canada, most diverse in the east

Genera: *Tolype*

Abundance: uncommon to common, at lights

Quick Recognition: Very stout-bodied hairy moths, with stubby wings, forewing is typically grey with abundant wavy white lines. Specific identification can be tricky.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis absent; labial palps descending or porrect, short, tufted; antenna pectinate, with two or more scale rows per segment, roughly half forewing length or less. THORAX: wings heteroneurous, forewing broad to somewhat elongate, rounded, grey, typically with many prominent pale wavy lines; hindwing broad, grey, sometimes with some white lines; hind tibial spurs short, hind tarsal spines present. ABDOMEN: with long, soft hairs.

Similar Taxa: There are no other moths that are this stout with a grey and white wing pattern.

Taxonomic References: Franclemont 1973

Lasiocampidae, Lasiocampinae (Fig. 5-219)

Superfamily: Lasiocampoidea

Number of Canadian Species: 5 spp. throughout Canada, most diverse in the east

Genera: *Heteropacha*, *Malacosoma*, *Phyllodesma*

Abundance: common to abundant, at lights

Quick Recognition: Very stout-bodied hairy moths, with stubby wings, forewing is usually brown with distinct antemedian and postmedian lines. Specific identification is usually easy but can be very difficult in *Malacosoma*.

Diagnosis: HEAD: ocelli absent; compound eye hairy; chaetosemata absent; head scales rough; proboscis absent; labial palps usually porrect, short, tufted; antenna pectinate, with many scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, forewing broad to somewhat elongate, rounded to pointed, sometimes slightly scalloped, usually brown, rarely grey, typically with prominent antemedian and postmedian lines; hindwing broad, sometimes scalloped, similar in colour to forewing, sometimes with faint lines; hind tibial spurs short, hind tarsal spines present. ABDOMEN: very hairy.

Similar Taxa: The general stoutness combined with characteristic wing pattern is diagnostic.

Taxonomic References: Franclemont 1973

Mimallonidae (Fig. 5-220)

Superfamily: Mimallonoidea

Number of Canadian Species: 2 spp. in extreme S. ON

Genera: *Cicinnus, Lacosoma*

Abundance: rare, at lights

Quick Recognition: Medium-sized stout-bodied moths, forewing falcate with prominent discal spot. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough, sometimes slightly smooth on frons; proboscis absent; labial palps porrect, short, tufted or slender; antenna pectinate, with long sensillae, with many scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex falcate, with a bulge in middle of outer margin, sometimes scalloped, brown or grey, discal spot dark and prominent, typically with dark postmedian line; hindwing broad, sometimes scalloped, similar in pattern to forewing; hind tibial spurs short, hind tarsal spines present. ABDOMEN: hairy.

Similar Taxa: The wing shape and pattern is diagnostic.

Taxonomic References: Franclemont 1973

Bombycidae, Apatelodinae (Fig. 5-221)

Superfamily: Bombycoidea

Number of Canadian Species: 2 spp. in S. ON and S. PQ

Genera: *Apatelodes*, *Olceclostera*

Abundance: rare, at lights

Quick Recognition: Medium-sized fairly stout-bodied moths, forewing grey with slight falcate apex, subterminal white spot present below costa in subapical area, antemedian and postmedian lines thin jagged and black. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis absent; labial palps ascending, short, tufted; antenna pectinate, with long sensillae, with many scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex slightly falcate, with a bulge in apical half of outer margin, sometimes scalloped, grey, white spot present below costa in subterminal area, antemedian and postmedian lines thin black and jagged; hindwing broad, sometimes slightly scalloped, either paler or darker than forewing; hind tibial spurs long, hind tarsal spines absent. ABDOMEN: hairy.

Similar Taxa: The wing shape and pattern is diagnostic.

Taxonomic References: Franclemont 1973

Bombycidae, Bombycinae (Fig. 5-222)

Superfamily: Bombycoidea

Number of Canadian Species: 1 non-native sp. (*Bombyx mori*) reared for silk production

Genera: *Bombyx*

Abundance: restricted to silkworm colonies

Quick Recognition: Medium-sized plump moths, forewing white with falcate apex, other dark lines and spots may be present. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis absent; labial palps minute; antenna pectinate, with many scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, apex falcate, with a bulge in outer margin, white, rarely with darker lines and spots; hindwing broad, with prominent anal bulge, white; hind tibial spurs short, hind tarsal spines rarely visible. ABDOMEN: hairy.

Similar Taxa: The wing shape and pattern is diagnostic.

Taxonomic References: Franclemont 1973

Saturniidae, Ceratocampinae (Fig. 5-223)

Superfamily: Bombycoidea

Number of Canadian Species: 8 spp. from S. MB to NS, most diverse in S. ON

Genera: *Anisota*, *Dryocampa*, *Eacles*, *Sphingicampa*

Abundance: rare to common, at lights or diurnal

Quick Recognition: Medium-sized to large robust-bodied moths, wings often with some pink or purple shading, usually with slanted postmedian line and discal spot. Specific identification is easy, except in Anisota.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough, sometimes smooth especially on frons; proboscis usually reduced; labial palps small; antenna pectinate or filiform, usually unscaled, rarely with one scale row per segment, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, usually with some pink or purple shading, usually with slanted straight postmedian line, discal spot usually prominent; hindwing broad, usually similar to forewing in pattern and colour; hind tibial spurs short, hind tarsal spines absent. ABDOMEN: smooth or hairy, rarely boldly patterned.

Similar Taxa: Ceratocampinae can be separated from other large moths by wing pattern.

Taxonomic References: Tuskes, *et al.* 1996

Saturniidae, Hemileucinae (Fig. 5-224)

Superfamily: Bombycoidea

Number of Canadian Species: 5 spp. from BC to PQ, most diverse in the west

Genera: *Automeris, Hemileuca*

Abundance: rare to uncommon, at lights or diurnal

Quick Recognition: Large robust-bodied moths, both wings usually boldly patterned, large discal spot present on forewing. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis absent; labial palps rudimentary; antenna pectinate, sometimes with long sensillae, unscaled, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, typically with distinct antemedian and postmedian lines, discal spot large; hindwing broad, usually similar to forewing in pattern and colour; hind tibial spurs short, hind tarsal spines usually absent. ABDOMEN: hairy, often boldly patterned and coloured.

Similar Taxa: Hemileucinae can be separated from other large moths by wing pattern.

Taxonomic References: Tuskes, *et al.* 1996

Saturniidae, Saturniinae (Fig. 5-225)

Superfamily: Bombycoidea

Number of Canadian Species: 8 spp. across Canada, most diverse in the east

Genera: *Actias, Antheraea, Callosamia, Hyalophora, Samia*

Abundance: common, at lights or diurnal

Quick Recognition: Very large stout-bodied moths, wings very large, large discal spot present on both wings. Specific identification is easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis absent; labial palps small, usually tufted; antenna pectinate, usually with long sensillae, unscaled, less than half forewing length. THORAX: wings heteroneurous, forewing triangular, typically with distinct antemedian and postmedian lines, discal spot large and may be transparent; hindwing broad, similar to forewing in pattern and colour, sometimes with a long tail; hind tibial spurs short, hind tarsal spines sometimes present. ABDOMEN: hairy, sometimes boldly patterned.

Similar Taxa: Saturniinae can be separated from other large moths by wing pattern.

Taxonomic References: Tuskes, *et al.* 1996

Sphingidae, Sphinginae (Fig. 5-226)

Superfamily: Bombycoidea

Number of Canadian Species: 21 spp. across Canada, most diverse in the east

Genera: *Agrius, Ceratomia, Dolba, Lapara, Manduca, Paratrea, Sphinx*

Abundance: common, at lights

Quick Recognition: Usually large thick-bodied moths, abdomen tapered, forewing elongate and pointed, hindwing much smaller, typically grey or brown with complex pattern. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis present; labial palps ascending or porrect, usually short, tufted; antenna filiform, with two or more scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, elongate and pointed, usually grey or brown, typically with many lines, small discal dot usually present; hindwing small, usually boldly banded; hind tibial spurs variable in length, hind tarsal spines present. ABDOMEN: smooth and tapered, rarely with dorsal scale tuft, usually boldly patterned.

Similar Taxa: Similar sphingids are usually more colourful at least on the hindwing.

Taxonomic References: Tuttle 2007

Sphingidae, Smerinthinae (Fig. 5-227)

Superfamily: Bombycoidea

Number of Canadian Species: 8 spp. throughout Canada

Genera: *Amorpha, Pachysphinx, Paonias, Smerinthus*

Abundance: common, at lights

Quick Recognition: Usually large thick-bodied moths, thorax often with dark central streak, abdomen usually fairly blunt, forewing elongate and pointed, hindwing much smaller often with pink or purple, often with eyespots, proboscis reduced. Specific identification is usually easy but can be challenging in the west.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis reduced; labial palps ascending or porrect, usually short, usually tufted; antenna filiform or pectinate, with many scale rows per segment, less than half forewing length. THORAX: wings heteroneurous, elongate and pointed, sometimes scalloped, usually grey or brown, typically with some prominent lines, small discal dot usually present; hindwing small, often with eyespots, usually with some pink or purple shading; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth and somewhat blunt, rarely boldly patterned.

Similar Taxa: Similar sphingids usually have a more sharply pointed abdomen and more prominent proboscis.

Taxonomic References: Tuttle 2007

Sphingidae, Macroglossinae (Fig. 5-228)

Superfamily: Bombycoidea

Number of Canadian Species: 28 spp. throughout Canada

Genera: *Aellopos, Amphion, Darapsa, Deidamia, Deilephila, Erinnyis, Eumorpha, Hemaris, Hyles, Proserpinus, Sphecodina, Xylophanes*

Abundance: common, at lights or diurnal

Quick Recognition: Large to medium-sized thick-bodied moths, abdomen usually tapered, sometimes with anal tufts, usually at least one of the wings with bright colours or bold patterns, sometimes transparent, forewing elongate and pointed, hindwing much smaller. Specific identification can be challenging.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis naked; labial palps usually ascending, usually short, tufted; antenna filiform, sometimes with long sensillae, with two or more scale rows per segment, variable in length. THORAX: wings heteroneurous, elongate and pointed, sometimes scalloped, variable in colour and pattern, typically with some bold pattern or bright colours, centre of wing sometimes transparent; hindwing small, boldly patterned or brightly coloured; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth and tapered, sometimes with anal tufts, often boldly patterned.

Similar Taxa: Macroglossinae can be separated from other sphingids by wing pattern.

Taxonomic References: Tuttle 2007 (most spp.); Schmidt 2009a (some *Hemaris*)

Notodontidae, Pygaerinae (Fig. 5-229)

Superfamily: Noctuoidea

Number of Canadian Species: 5 spp. throughout Canada

Genera: *Clostera*

Abundance: common, at lights

Quick Recognition: Medium-sized moths with a hairy box-like thorax and slender abdomen with prominent anal tuft, forewing grey to brown with lighter lines, obvious white crescent on costa in subterminal area followed by some warmer brown shading. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; compound eye hairy; chaetosemata absent; head scales rough; proboscis naked, sometimes reduced; labial palps ascending, short, tufted; antenna pectinate, sometimes with long sensillae, with two or more scale rows per segment, less than half forewing length. THORAX: with metathoracic tympanum; with prominent dorsal tuft, usually brown through centre; wings heteroneurous, forewing rectangular, brown or grey with many pale lines throughout, subterminal line at costa a prominent crescent followed by some warm brown shading; hindwing rounded, dull grey or brown; hind tibial spurs short, hind tarsal spines absent. ABDOMEN: relatively slender and smooth, with prominent anal tuft.

Similar Taxa: Pygaerinae can be separated from other noctuoids by wing pattern stout thorax and relatively slender abdomen with prominent anal tuft, and hairy eye.

Taxonomic References: Handfield 1999

Notodontidae, Notodontinae (Fig. 5-230)

Superfamily: Noctuoidea

Number of Canadian Species: 18 spp. throughout Canada, most diverse in the east

Genera: *Cerura, Furcula, Gluphisia, Hyperaeschra, Nerice, Notodonta, Odontosia, Pheosia*

Abundance: common, at lights

Quick Recognition: Medium-sized stout, hairy moths, forewing sometimes with prominent scale tuft in middle of inner margin, often boldly patterned with black and white. Specific identification is easy in the east, sometimes challenging in the west.

Diagnosis: HEAD: ocelli absent; compound eye sometimes hairy; chaetosemata absent; head scales rough; proboscis naked, often reduced; labial palps ascending or porrect, short, tufted; antenna pectinate, sometimes with long sensillae, with two or more scale rows per segment, less than half forewing length. THORAX: with metathoracic tympanum; often with dorsal tuft; wings heteroneurous, forewing often with apex projecting well beyond anal angle, often with prominent tuft along inner margin, pattern variable, sometimes boldly marked with black and white; hindwing rounded to square, paler, sometimes with partial forewing pattern; hind tibial spurs short, hind tarsal spines sometimes visible. ABDOMEN: stout and very hairy.

Similar Taxa: Notodontinae can be separated from other noctuoids by wing pattern, few other noctuoids have a prominent tuft along the inner margin of the forewing.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Notodontidae, Phalerinae (Fig. 5-231)

Superfamily: Noctuoidea

Number of Canadian Species: 11 spp. across Canada, most diverse in the east

Genera: *Datana, Ellida, Nadata, Peridea*

Abundance: common, at lights

Quick Recognition: Medium-sized stout, hairy moths, thorax typically with a prominent dorsal tuft. Specific identification is easy except in *Datana*.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis naked, often reduced; labial palps usually ascending, short, tufted; antenna filiform or pectinate, often with long sensillae, with two scale rows per segment, half forewing length or less. THORAX: with metathoracic tympanum; often with dorsal scale tuft; wings heteroneurous, forewing sometimes with apex projecting well beyond anal angle, sometimes more squared, sometimes with slightly scalloped outer margin, sometimes with prominent tuft along inner margin, pattern variable, often yellow and brown; hindwing rounded to square, paler, sometimes with partial forewing pattern on inner margin; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: thick and hairy, sometimes with dorsal scale tuft.

Similar Taxa: Phalerinae can be separated from other noctuoids by wing pattern.

Taxonomic References: Handfield 1999

Notodontidae, Heterocampinae (Fig. 5-232)

Superfamily: Noctuoidea

Number of Canadian Species: 19 spp. across Canada, most diverse in the east

Genera: *Heterocampa, Hyparpax, Lochmaeus, Macrurocampa, Misogada, Oligiocentria, Schizura*

Abundance: common, at lights

Quick Recognition: Medium-sized stout, hairy moths, forewing typically with curved slender reniform spot. Specific identification is usually easy.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis naked, sometimes reduced; labial palps ascending or porrect, short, at least slightly tufted; antenna filiform or pectinate, usually with long sensillae, with two scale rows per segment, rarely one scale row, half forewing length or less. THORAX: with metathoracic tympanum; often with dorsal scale tuft; wings heteroneurous, forewing sometimes with apex projecting well beyond anal angle, sometimes with slightly scalloped outer margin, pattern variable, reniform spot often a thin curved line; hindwing rounded to square, paler, often with dark markings at anal angle; hind tibial spurs usually short, hind tarsal spines usually present. ABDOMEN: thick and hairy, sometimes with dorsal scale tuft, rarely boldly patterned.

Similar Taxa: Heterocampinae can be separated from other noctuoids by wing pattern, especially the slender curved reniform spot.

Taxonomic References: Handfield 1999

Notodontidae, Nystaleinae (Fig. 5-233)

Superfamily: Noctuoidea

Number of Canadian Species: 5 spp. from AB to NS

Genera: *Dasylophia, Symmerista*

Abundance: uncommon to common, at lights

Quick Recognition: Medium-sized stout moths, forewing often with irregular white edging along the outer half of the costa. Specific identification requires dissection in Symmerista.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales rough; proboscis naked, sometimes reduced; labial palps ascending or porrect, often short, slender; antenna filiform or pectinate, usually with long sensillae, with two scale rows per segment, half forewing length or greater. THORAX: with metathoracic tympanum; usually with dorsal scale tuft; wings heteroneurous, forewing somewhat elongate, sometimes with slightly scalloped outer margin, costa often with irregular white margin along costa; hindwing rounded, drab, unpatterned; hind tibial spurs often long, hind tarsal spines present. ABDOMEN: thick and hairy, sometimes with dorsal scale tuft.

Similar Taxa: Nystaleinae can be separated from other noctuoids by wing pattern, elongate forewings, and slender labial palps.

Taxonomic References: Handfield 1999

Erebidae, Lymantriinae (Fig. 5-234, 5-235)

Superfamily: Noctuoidea

Number of Canadian Species: 17 spp. throughout Canada

Genera: *Dasychira, Euproctis, Gynaephora, Leucoma, Lymantria, Orgyia*

Abundance: uncommon to common, at lights, sometimes diurnal

Quick Recognition: Medium-sized and very hairy moths, forewing is usually triangular, forelegs often very hairy and held prominently forwards at rest, females in some species wingless. Specific identification can be challenging in *Dasychira* and *Orgyia*.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales usually rough; proboscis naked, sometimes reduced; labial palps variable in orientation, short, tufted; antenna usually pectinate, usually with long sensillae, with many scale rows per segment, less than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, females sometimes apterous; forewing usually triangular, typically grey, brown, reddish, or white, often with dark jagged antemedian, postmedian, and subterminal lines; hindwing rounded, usually unpatterned; forelegs often prominently hairy, hind tibial spurs short, hind tarsal spines sometimes present. ABDOMEN: thick and hairy, sometimes with dorsal scale tuft.

Similar Taxa: The combination of densely hairy forelegs and forewing pattern is usually diagnostic. In species with a pure white wing, Lymantriinae can usually be separated from similar looking Arctiini by the lack of patterning on the abdomen.

Taxonomic References: Handfield 1999 (eastern spp.); Troubridge & Lafontaine 2004c (western spp.)

Erebidae, Arctiinae, Lithosiini (Fig. 5-236)

Superfamily: Noctuoidea

Number of Canadian Species: 13 spp. throughout Canada.

Genera: *Acsala, Bruceia, Cisthene, Clemensia, Crambidia, Eilema, Hypoprepia, Lycomorpha*

Abundance: common at lights, some species are diurnal

Quick Recognition: Small to medium-sized erebids, forewing usually slender, hindwing usually relatively broad, forewing pattern either boldly patterned, drab grey, or pure white. Specific identification is easy, except in *Crambidia*.

Diagnosis: HEAD: ocelli absent; chaetosemata absent; head scales smooth, rarely rough; proboscis naked, rarely absent; labial palps ascending or porrect, short, rarely tufted; antenna filiform, rarely pectinate, usually with long sensillae, with two scale rows per segment, half the forewing length or less. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually slender, apex usually squared, either boldly patterned with bright colours, drab grey, or pure white, rarely with all wing scales raised making it translucent; hindwing triangular to squared, usually relatively broad, sometimes boldly patterned and brightly coloured, otherwise drab; hind tibial spurs usually short, hind tarsal spines usually present. ABDOMEN: smooth, rarely hairy, sometimes boldly patterned.

Similar Taxa: Brightly coloured species are easy to separate from all others by forewing pattern. The more drably patterned species can be separated from superficially similar crambids by the lack of a scaled proboscis. More broad winged species can be confused with Herminiinae, but are easily separated by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Erebidae, Arctiinae, Arctiini (Fig. 5-237)

Superfamily: Noctuoidea

Number of Canadian Species: 82 spp. throughout Canada.

Genera: *Acerbia, Apantesis, Arctia, Cisseps, Ctenucha*, *Cycnia, Dodia*, *Estigmene, Euchaetes, Gnophaela, Grammia*, *Halysidota, Haploa, Holoarctia, Hyphantria, Leptarctia*, *Lophocampa, Neoarctia, Pararctia, Parasemia, Phragmatobia, Platarctia, Platyprepia, Pygarctia, Pyrrharctia, Spilosoma, Turuptiana, Tyria, Utetheisa, Virbia*

Abundance: common at lights, some species are diurnal

Quick Recognition: Medium-sized erebids, usually stout, forewing elongate to triangular, forewing often boldly or brightly patterned, or pure white. Specific identification is often easy, but is challenging in a few genera like *Grammia* and *Virbia*.

Diagnosis: HEAD: ocelli usually present; chaetosemata absent; head scales usually rough; proboscis naked, rarely reduced; labial palps usually porrect or slightly descending, usually short, often tufted; antenna usually pectinate, usually with long sensillae, usually with two scale rows per segment, usually less than half the forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually stout, sometimes triangular or elongate, apex squared or acute, usually either boldly patterned with bright colours, or pure white; hindwing rounded, sometimes boldly patterned and brightly coloured, otherwise drab; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth or hairy, usually boldly patterned.

Similar Taxa: Most Arctiini have distinctive wing patterns and aren`t easily confused with other taxa. Some of the species that have pure white wings can be confused with Lymantriinae, and can usually be separated by having a boldly patterned abdomen.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (most eastern spp.); Schmidt 2009b (*Grammia*); Zaspel, *et al.* 2008 (*Virbia*)

Erebidae, Herminiinae (Fig. 5-238)

Superfamily: Noctuoidea

Number of Canadian Species: 48 spp. across Canada

Genera: *Bleptina, Chytolita, Idia, Lascoria, Macrochilo, Palthis, Phalaenophana, Phalaenostola, Reabotis, Redectis, Renia, Tetanolita, Zanclognatha*

Abundance: common, at lights

Quick Recognition: Small to moderate-sized erebids with a triangular forewing, reniform spot and antemedian, postmedian, and subterminal lines usually prominent, labial palps often large and ascending, often with large scale tufts on legs in males. Specific identification can be difficult.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth on vertex, usually smooth on frons; proboscis naked; labial palps usually ascending, long, often slender, sometimes tufted; antenna filiform, rarely pectinate, rarely with a subapical thickening and hook, with two scale rows per segment, variable in length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually triangular, sometimes with bulge in outer margin, rarely notched, yellow, brown, or grey, pattern variable, usually with prominent reniform spot and antemedian, postmedian, and subterminal lines; hindwing rounded to squared, often with some patterning, sometimes with a continuation of the forewing pattern; hind tibial spurs variable in length, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Herminiinae are similar to several other noctuid subfamilies and can usually be separated from them by forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Erebidae, Pangraptinae (Fig. 5-239)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. from AB to NS

Genera: *Ledaea, Pangrapta*

Abundance: uncommon to rare, at lights or diurnal

Quick Recognition: *Ledaea perditalis* is easily recognized by the grey forewings with dark lower half of the PM line and dark slanted mark at the apex and with sharply produced apex and bulge in the outer margin. *Pangrapta decoralis* has a similar shaped forewing that varies in colour but always has a prominent broad dark band that edges the inside of the postmedian line and has prominent reniform spots on both the forewing and hindwing.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth; proboscis naked; labial palps ascending, long, slender; antenna filiform, with long sensillae, with two scale rows per segment, roughly half forewing length or less. THORAX: with metathoracic tympanum; wings heteroneurous, forewing with a bulge in outer margin, and a produced apex, grey or brown, reniform spot may be prominent, antemedian, postmedian and subterminal lines often prominent; hindwing rounded, sometimes slightly scalloped, sometimes with a continuation of the forewing pattern; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Pangraptinae are similar to several other erebids and can be separated from them by forewing pattern.

Taxonomic References: Handfield 1999

Erebidae, Hypeninae (Fig. 5-240)

Superfamily: Noctuoidea

Number of Canadian Species: 19 spp. across Canada

Genera: *Colobochyla, Hypena, Lomanaltes, Melanomma*

Abundance: common, at lights

Quick Recognition: Moderate-sized erebids with a broad hindwing and either a triangular or slender brownish forewing, often with a bulge in the middle of the outer margin or with the costa slightly concave. Specific identification is not usually difficult.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth; proboscis naked; labial palps usually porrect or ascending, long to very long, tufted, rarely slender; antenna filiform, with long sensillae, with two scale rows per segment, typically greater than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing either triangular or slender, often with bulge in outer margin or with the costa slightly concave, brownish, with prominent lines and often with dark spots; hindwing rounded to squared, usually broad relative to forewing, usually drab brown; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth, often with dorsal scale tuft.

Similar Taxa: The lack of a scaled proboscis and presence of a metathoracic tympanum will separate Hypeninae from superficially similar Crambidae. It can be separated from similar erebids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Erebidae, Rivulinae (Fig. 5-241)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. across Canada

Genera: *Oxycilla, Rivula*

Abundance: uncommon to common, at lights

Quick Recognition: Both species are small with fairly blunt wings. *Rivula propinqualis* has a yellow forewing with fine dark oblique median and postmedian lines and prominent grey smeared blotch bordering the median line at the costa. The rarer *Oxycilla malaca* is light brown with darker brown markings in the median and terminal areas and with a prominent curved pale postmedian line.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough on frons, smooth on vertex; proboscis naked; labial palps porrect, long, tufted; antenna filiform, with long sensillae, with two scale rows per segment, usually less than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing fairly blunt, either yellow with thin dark oblique median and postmedian lines, or brown with darker brown shading in median and terminal areas and a pale curved postmedian line; hindwing may slightly excavated along outer margin, drab; hind tibial spurs long, hind tarsal spines sometimes visible. ABDOMEN: smooth.

Similar Taxa: The characteristic forewing pattern will separate Rivulinae from all other similar erebids.

Taxonomic References: Handfield 1999

Erebidae, Scoliopteryginae (Fig. 5-242)

Superfamily: Noctuoidea

Number of Canadian Species: 4 spp. throughout Canada

Genera: *Alabama, Anomis, Scoliopteryx*

Abundance: uncommon to rare, at lights

Quick Recognition: Usually moderate-sized noctuids, often boldly patterned, usually with at least slightly scalloped forewing. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough; proboscis naked; labial palps ascending, long, at most slightly tufted; antenna filiform or pectinate, usually with long sensillae, with two scale rows per segment, half forewing the length or less. THORAX: sometimes with slight dorsal scale tuft, with metathoracic tympanum; wings heteroneurous, forewing variable in shape, usually at least slightly scalloped, with prominent bulge in middle of outer margin, lines thin and prominent; hindwing rounded to squared, pattern usually dull; hind tibial spurs usually long, hind tarsal spines present. ABDOMEN: smooth to hairy.

Similar Taxa: Scoliopteryginae can be separated from similar erebids by forewing pattern and by the scalloped forewing margin.

Taxonomic References: Troubridge & Lafontaine 2004d

Erebidae, Calpinae (Fig. 5-243)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. from AB to NS

Genera: *Calyptra, Eudocima, Plusiodonta*

Abundance: uncommon to rare, at lights

Quick Recognition: Usually moderate-sized erebids, often boldly patterned, with distinct scale tufts on inner margin of forewing. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough; proboscis naked; labial palps ascending, long, slender or tufted; antenna filiform or pectinate, sometimes with long sensillae, with two scale rows per segment, half forewing the length or less. THORAX: sometimes with dorsal scale tuft, with metathoracic tympanum; wings heteroneurous, forewing variable in shape, sometimes with prominent bulge in middle of outer margin, with scale tuft along inner margin, pattern and colour variable; hindwing rounded to squared, pattern usually dull, rarely very contrasting; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth to hairy, rarely with dorsal scale tuft, rarely brightly coloured.

Similar Taxa: Calpinae can be separated from similar erebids by forewing pattern and by the scale tuft along the inner margin.

Taxonomic References: Handfield 1999

Erebidae, Hypocalinae (Fig. 5-244)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. in extreme southern ON and PQ

Genera: *Hypocala, Hypsoropha*

Abundance: very rare, at lights

Quick Recognition: *Hypocala andremona* is a rare stray with a variable forewing pattern and a prominent black hindwing with yellow streaks. *Hypsoropha hormos* has a grey forewing with a series of prominent white dots composing the lower part of the postmedian line.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or slightly smoothed; proboscis naked; labial palps ascending, long, tufted; antenna filiform, usually with long sensillae, with two scale rows per segment, usually less than half the forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing slightly scalloped on outer margin, sometimes with bulge in middle of outer margin, variable in pattern, or grey with a series of prominent white dots composing the lower part of the postmedian line; hindwing squared to rounded, black with prominent yellow streaks or drab brown; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth, sometimes boldly patterned, sometimes with dorsal scale tuft.

Similar Taxa: Hypocalinae can be separated from similar erebids by wing pattern.

Taxonomic References: Handfield 1999

Erebidae, Scolecocampinae (Fig. 5-245)

Superfamily: Noctuoidea

Number of Canadian Species: 4 spp. in S. BC, S. MB, and S. ON

Genera: *Gabara, Nigetia, Phobolosia, Scolecocampa*

Abundance: rare, at lights

Quick Recognition: An odd-assemblage of often boldly-patterned small to fairly large noctuids. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually somewhat roughened; proboscis naked; labial palps usually ascending, usually long, tufted; antenna filiform, with long sensillae, with two scale rows per segment, usually less than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing variable in shape from elongate with a pointed apex to triangular, variable in colour and pattern; hindwing rounded to slightly squared, unpatterned; hind tibial spurs long, hind tarsal spines sometimes present. ABDOMEN: smooth, rarely with slight dorsal scale tuft.

Similar Taxa: The lack of a scaled proboscis and presence of a metathoracic tympanum will separate Scolecocampinae from superficially similar Crambidae. It can be separated from similar erebids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c, 2004d

Erebidae, Hypenodinae (Fig. 5-246)

Superfamily: Noctuoidea

Number of Canadian Species: 9 spp. from AB to NS

Genera: *Dyspyralis, Hypenodes, Parahypenodes*

Abundance: common to rare, at lights

Quick Recognition: Tiny erebids typically with a prominent reniform spot and median line on the forewing, ocelli absent. Specific identification can be challenging.

Diagnosis: HEAD: ocelli absent, rarely barely visible; chaetosemata absent; head scales smooth; proboscis naked; labial palps usually ascending, long, slender; antenna filiform, sometimes with long sensillae, with two, rarely three scale rows per segment, usually roughly half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing fairly slender with a slight bulge in outer margin, brown or grey, reniform spot typically prominent, orbicular spot tiny or obscured, median and subterminal lines often heavily shaded and prominent; hindwing squared to pointed at apex; hind tibial spurs long, hind tarsal spines absent. ABDOMEN: smooth, rarely with dorsal scale tuft.

Similar Taxa: The combination of size, lack of ocelli, and presence of a metathoracic tympanum will separate Hypenodinae from all others.

Taxonomic References: Handfield 1999; Ferguson 1954 (*Hypenodes*)

Erebidae, Boletobiinae (Fig. 5-247)

Superfamily: Noctuoidea

Number of Canadian Species: 5 spp. throughout Canada

Genera: *Metalectra, Mycterophora, Parascotia*

Abundance: uncommon to rare, at lights

Quick Recognition: Geometrid-like with broad wings and similar forewing and hindwing pattern, antenna often pectinate. Specific identification is fairly easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth; proboscis naked; labial palps porrect or ascending, fairly long, at least somewhat tufted; antenna filiform or pectinate, with long sensillae, with two scale rows per segment, usually roughly half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing very broad and triangular, with prominent jagged antemedian, postmedian, and subterminal lines; hindwing rounded, with a continuation of the forewing pattern; hind tibial spurs long, hind tarsal spines sometimes present. ABDOMEN: smooth.

Similar Taxa: Boletobiinae can be separated from geometrids by the presence of a metathoracic tympanum. They can be separated from other erebids by the forewing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Erebidae, Phytometrinae (Fig. 5-248)

Superfamily: Noctuoidea

Number of Canadian Species: 7 spp. across southern Canada.

Genera: *Hyperstrotia, Isogona, Phytometra, Spargaloma*

Abundance: common, at lights or diurnal

Quick Recognition: An odd-assemblage of boldly-patterned and sometimes colourful small to medium-sized erebids. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually smooth on vertex, smooth or rough on frons; proboscis naked; labial palps ascending, long, usually tufted; antenna filiform, with long sensillae, with two scale rows per segment, usually roughly half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually somewhat triangular, apex often pointed, rarely rounded, variable in colour and pattern but sometimes brightly coloured in yellow and pink; hindwing somewhat rounded, often unpatterned; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: The lack of a scaled proboscis and presence of a metathoracic tympanum will separate Phytometrinae from superficially similar Crambidae. It can be separated from similar erebids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004d

Erebidae, Erebinae, Toxocampini (Fig. 5-249)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. in BC

Genera: *Lygephila*, *Tathorhynchus*

Abundance: uncommon to rare, at lights

Quick Recognition: *Lygephila victoria* is a stout, moderate-sized erebid, forewing fairly broad and grey with antemedian, median, and subterminal lines well represented at the costa by dark smudges, hindwing with a smudged darker outer band. *Tathorhynchus exsiccata* has a narrower forewing with a dark mid-basal streak and dark streak between the small white orbicular and reniform spots, the hindwing is similar to *L. victoria*.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending, long, at least slightly tufted; antenna filiform, with long sensillae, with two scale rows per segment, greater than half the forewing length. THORAX: with dorsal scale tuft, with metathoracic tympanum; wings heteroneurous, forewing slightly stout to relatively slender, sometimes with prominent bulge in middle of outer margin, most commonly grey with darker suffused antemedian, median, and subterminal lines that are expanded at the costa, rarely with pale orbicular and reniform spots connected by a black streak; hindwing squared, pattern dull with smudged dark outer band, sometimes with discal lunule; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Toxocampini can be separated from similar erebids by forewing pattern.

Taxonomic References: Powell & Opler 2009

Erebidae, Erebinae, Thermesiini (Fig. 5-250)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. Neotropical strays found throughout Canada

Genera: *Ascalapha, Thysania*

Abundance: very rare, at lights or bait

Quick Recognition: Gigantic erebids with boldly patterned fore and hindwings. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending, short, slender; antenna filiform, with two scale rows per segment, less than half forewing the length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing triangular and pointed, sometimes scalloped, with a complex pattern, reniform and orbicular spots present, antemedian, median, postmedian and subterminal lines prominent, grey or brown; hindwing squared, scalloped, pattern continuing from the forewing; hind tibial spurs variable in length, hind tarsal spines present. ABDOMEN: smooth, sometimes slightly patterned.

Similar Taxa: Nothing is similar.

Taxonomic References: Covell 1984; Handfield 1999

Erebidae, Erebinae, Catocalini (Fig. 5-251)

Superfamily: Noctuoidea

Number of Canadian Species: 56 spp. across Canada, most diverse in the SE.

Genera: *Catocala*, *Spiloloma*

Abundance: common, at lights

Quick Recognition: Fairly small to very large, forewing with a complex pattern of lines and spots, hindwing usually boldly patterned with a bright yellow, orange, red, pink or white contrasted with broad curved black bands. Specific identification can be challenging, especially in the west.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending, variable in length, often slender; antenna filiform, usually with long sensillae, with two scale rows per segment, roughly half the forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing broad, with squared apex to slightly pointed apex, outer margin usually straight, sometimes with slight medial bulge, pattern complex, antemedian and postmedian lines present and usually jagged and black, other lines are often present, reniform, orbicular and claviform spots often present, ground colour usually grey; hindwing rounded to slightly squared, either yellow, orange, red, pink, or white, contrasted with broad black curved bands along the outer margin and through the middle, rarely solid black or grey with fine jagged lines, fringe usually at least partially contrastingly pale; hind tibial spurs short, hind tibial spines present, hind tarsal spines present. ABDOMEN: smooth, sometimes with a small dorsal scale tuft.

Similar Taxa: Other noctuids with a boldly patterned hindwing typically have a more complex pattern. When present, the broad curved black line through the centre of the hindwing is diagnostic.

Taxonomic References: Troubridge & Lafontaine 2004c, 2004d

Erebidae, Erebinae, Melipotini (Fig. 5-252)

Superfamily: Noctuoidea

Number of Canadian Species: 18 spp. across Canada, most diverse in the west

Genera: *Bulia, Cissusa, Drasteria, Melipotis, Phoberia*

Abundance: uncommon to common, at lights

Quick Recognition: Moderate-sized noctuids often with brightly and boldly patterned hindwings, forewing pattern variable but usually complex. Specific identification can be challenging.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending, usually short, tufted; antenna filiform, rarely with long sensillae, with two scale rows per segment, half the forewing length or greater. THORAX: with metathoracic tympanum; wings heteroneurous, forewing somewhat square to triangular, variable in pattern, usually with a prominent reniform spot, lines typically well marked, especially postmedian line, typically grey or brown; hindwing rounded to squared, often boldly patterned with black and white, yellow, orange, or pink, often drably patterned; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Melipotini can be separated from similar noctuids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Erebidae, Erebinae, Euclidiini (Fig. 5-253)

Superfamily: Noctuoidea

Number of Canadian Species: 9 spp. throughout Canada

Genera: *Caenurgina*, *Celiptera*, *Doryodes*, *Euclidia*, *Mocis*

Abundance: common, at lights or flushed during the day

Quick Recognition: Moderate-sized noctuids typically with fairly broad wings, forewing usually brown with large darker blotches. Specific identification can be challenging.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth; proboscis naked; labial palps ascending, usually long, usually slender; antenna filiform, rarely pectinate, sometimes with long sensillae, with two scale rows per segment, usually half the forewing length or greater. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually broad, rarely slender and pointed, usually brown with large darker blotches in the antemedian and postmedian area; hindwing rounded, often boldly patterned; hind tibial spurs usually short, hind tibial spines sometimes present, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Euclidiini can be separated from similar erebids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Erebidae, Erebinae, Poaphilini (Fig. 5-254)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. from SK to NS.

Genera: *Allotria, Argyrostrotis, Parallelia*

Abundance: common, at lights

Quick Recognition: All species with similar triangular forewings but with different patterns. *Allotria elonympha* has a dark forewing with obscure markings and a yellow hindwing with broad contrasting black border. *Argyrostrotis anilis* is chocolate brown with thin straight lines from anal angle to nearly median area of costa and in the upper third of the postmedian area. *Parallelia bistriaris* has a brown forewing with thin, nearly straight pale antemedian and postmedian lines and frosty suffusion in the subterminal area.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending, short, slender; antenna filiform, with two scale rows per segment, variable in length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing broad, triangular, with squared apex, the antemedian and postmedian lines are always present; hindwing rounded to squared, either solid brown with a paler fringe or boldly patterned yellow with broad black outer band; hind tibial spurs short, hind tibial spines present, hind tarsal spines present. ABDOMEN: fairly smooth, sometimes with a small dorsal scale tuft.

Similar Taxa: These three species can be separated from all other erebids by wing pattern.

Taxonomic References: Covell 1984

Erebidae, Erebinae, Ophiusini (Fig. 5-255)

Superfamily: Noctuoidea

Number of Canadian Species: 18 spp. from BC to NS, most diverse in SE Canada.

Genera: *Amolita*, *Euparthenos*, *Lesmone*, *Zale*

Abundance: common, at lights

Quick Recognition: Moderate to large, often thick-bodied noctuids usually with fairly broad wings, forewing typically with a squared apex, pattern often continuous from forewing to hindwing, hindwing rarely boldly patterned with yellow and black. Specific identification can be challenging in *Zale*.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked; labial palps ascending, usually roughly twice as long as compound eye, at least somewhat slender; antenna filiform, rarely pectinate, usually with long sensillae, with two scale rows per segment, variable in length. THORAX: with metathoracic tympanum, sometimes with dorsal scale tuft; wings heteroneurous, forewing usually broad, with squared apex, often with a complex pattern of lines, the antemedian and postmedian lines are usually present, typically grey or brown, reniform and orbicular spots often present; hindwing rounded to squared, sometimes scalloped, pattern is often continuous with the forewing, rarely with bold yellow and black patterning, sometimes drab but at least similar to ground colour of forewing; hind tibial spurs usually short, hind tibial spines often present, hind tarsal spines present. ABDOMEN: fairly smooth, usually with a small dorsal scale tuft.

Similar Taxa: Ophiusini can be separated from similar erebids by a combination of wing pattern and usual presence of a small dorsal scale tuft.

Taxonomic References: Handfield 1999

Erebidae, Eulepidotinae (Fig. 5-256)

Superfamily: Noctuoidea

Number of Canadian Species: 4 spp. in SE Canada.

Genera: *Anticarsia, Panopoda*

Abundance: rare to uncommon, at lights

Quick Recognition: Moderate-sized, often thick-bodied noctuids with fairly broad wings, forewing with a prominent reniform spot and antemedian and postmedian lines. Specific identification is usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough on vertex, rough or smooth on frons; proboscis naked; labial palps ascending, roughly twice as long as compound eye or longer, usually slender; antenna filiform, usually with long sensillae, with two scale rows per segment, roughly half the forewing length or greater. THORAX: with metathoracic tympanum; wings heteroneurous, forewing broad, grey or brownish with a pale postmedian line, reniform spot usually dark, other markings variable; hindwing rounded to squared, usually drably patterned; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth to hairy.

Similar Taxa: Eulepidotinae can be separated from similar erebids by wing pattern.

Taxonomic References: Covell 1984

Euteliidae (Fig. 5-257)

Superfamily: Noctuoidea

Number of Canadian Species: 6 spp. in S. BC and from SK to NS, most diverse in SE Canada.

Genera: *Eutelia, Marathyssa, Paectes*

Abundance: rare to uncommon, at lights

Quick Recognition: Moderate-sized noctuids, often with complexly patterned wings, anal area of forewing often has a curved line, at rest the wings are held out away from the body and sometimes rolled. Specific identification is usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth; proboscis naked; labial palps ascending or porrect, roughly twice the length of the compound eye or more, usually slender; antenna usually pectinate, with long sensillae, with two scale rows per segment, variable in length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing fairly slender, with at least a slight bulge on the outer margin, with squared to rounded apex, pattern usually complex, curved black lines usually present in anal area, with a tiny black reniform spot, antemedian and postmedian lines usually present; hindwing squared to rounded, sometimes boldly patterned; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth, often boldly coloured.

Similar Taxa: Euteliidae can be separated from other noctuoids by the characteristic wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004d

Nolidae (Fig. 5-258)

Superfamily: Noctuoidea

Number of Canadian Species: 16 spp. throughout Canada except the far north.

Genera: *Baileya, Garella, Meganola, Nola, Nycteola*

Abundance: uncommon to rare, at lights

Quick Recognition: Small noctuoids, forewing usually grey with darker lines, males sometimes with a small basal costal fold, sometimes with raised scales. Specific identification is fairly easy, except in *Nycteola* which often requires dissection.

Diagnosis: HEAD: ocelli usually absent; chaetosemata absent; head scales usually smooth; proboscis naked; labial palps variable in orientation, variable in length, usually tufted; antenna filiform, rarely pectinate, usually with long sensillae, with two scale rows per segment, usually less than half the forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing triangular to rectangular, with squared to pointed apex, grey to white with prominent lines, postmedian line typically with a curve around the reniform area, often with some small patches of raised scales, males sometimes with a small basal costal fold; hindwing squared to rounded, drab; hind tibial spurs variable, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Wing pattern, usual lack of ocelli, and presence of metathoracic tympana will separate Nolidae from all other similar looking moths.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Plusiinae (Fig. 5-259)

Superfamily: Noctuoidea

Number of Canadian Species: 60 spp. throughout Canada.

Genera: *Abrostola, Allagrapha, Anagrapha, Argyrogramma, Autographa, Chrysanympha, Ctenoplusia, Diachrysia, Eosphoropteryx, Euchalcia, Exyra, Megalographa, Plusia, Polychrysia, Pseudeva, Pseudoplusia, Rachiplusia, Syngrapha, Trichoplusia*

Abundance: common, at lights, some species at flowers

Quick Recognition: medium-sized stout noctuids, often with prominent thoracic and abdominal scale tufts, forewings usually held sharply roof-like at rest, often with a hook at the anal angle, and a prominent silvery stigma in the middle of the forewing. Specific identification is easy for most, but can be challenging in *Autographa* and *Syngrapha*.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough; proboscis naked; labial palps ascending, often long, usually tufted; antenna filiform, sometimes with long sensillae, with two scale rows per segment, usually greater than half the forewing length. THORAX: with metathoracic tympanum; often with prominent dorsal scale tuft; wings heteroneurous, forewing at least somewhat triangular, with squared to pointed apex, anal angle often produced into a hook, variable in colour and pattern, though pattern usually complex, silvery stigma usually present in middle of forewing, larger metallic patches often present; hindwing squared to rounded, drab to boldly bicoloured in yellow and brown; hind tibial spurs usually short, hind tibial spines rarely present, hind tarsal spines present. ABDOMEN: smooth, prominent dorsal scale tuft usually present.

Similar Taxa: The combination of quick recognition characters will separate most plusiines from other noctuids.

Taxonomic References: Lafontaine & Poole 1991 (most spp.); D. Handfield & L. Handfield 2006 (some *Plusia*).

Noctuidae, Bagisarinae (Fig. 5-260)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. in southernmost MB, ON, and PQ.

Genera: *Amyna*, *Bagisara*

Abundance: very rare, at lights.

Quick Recognition: medium-sized stout to moderately stout noctuids, forewing slightly triangular, lines usually prominent.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales slightly roughened on vertex, smooth on frons; proboscis naked; labial palps ascending, short, slender; antenna filiform, with two scale rows per segment, greater than half the forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing somewhat triangular, with squared apex, either greyish brown with fine yellow median, postmedian, and subterminal lines or more mottled brownish with jagged lines; hindwing broad, drab with discal lunule, sometimes with darker outer shading or prominent median line; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Bagisarinae can be separated from other noctuids by wing pattern.

Taxonomic References: Covell 1984, Handfield 1999 (*Amyna*); Troubridge & Lafontaine 2004c (*Bagisara*)

Noctuidae, Eustrotiinae (Fig. 5-261)

Superfamily: Noctuoidea

Number of Canadian Species: 8 spp. throughout Canada.

Genera: *Capis*, *Cobubatha, Deltote, Prodeltote*, *Maliattha*

Abundance: common, at lights.

Quick Recognition: Small noctuids, usually with boldly-marked and often colourful forewings, reniform spot usually prominent. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually smooth; proboscis naked; labial palps ascending or porrect, variable in length, usually slender; antenna filiform, with long sensillae, with two scale rows per segment, usually less than half the forewing length. THORAX: with metathoracic tympanum; sometimes with prominent dorsal scale tuft; wings heteroneurous, forewing at least somewhat triangular, with squared apex, variable in colour and pattern, pattern usually complex, reniform spot usually present; hindwing squared to rounded, drab; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth, dorsal scale tuft sometimes present.

Similar Taxa: The forewing pattern and size will separate Eustrotiinae from similar noctuids.

Taxonomic References: Troubridge & Lafontaine 2004d (most spp.); L. Handfield & D. Handfield 2006 (some *Capis*)

Noctuidae, Acontiinae (Fig. 5-262)

Superfamily: Noctuoidea

Number of Canadian Species: 15 spp. across Canada.

Genera: *Ponometia, Spragueia, Tarache*

Abundance: uncommon to common, at lights.

Quick Recognition: Small noctuids, usually with white and grey mottled forewings, usually resemble bird-droppings at rest. Specific identification is usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales smooth; proboscis naked; labial palps ascending, short, slender; antenna filiform, sometimes with long sensillae, with two scale rows per segment, variable in length. THORAX: with metathoracic tympanum; sometimes with dorsal scale tuft; wings heteroneurous, forewing slender to somewhat triangular, with squared to acute apex, variable in colour and pattern, often good bird-dropping mimics; hindwing squared, broad, drab; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: smooth, rarely boldly banded.

Similar Taxa: Acontiinae can be separated from similar noctuids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c, 2004d; Lafontaine & Poole 2010 (key to genera)

Noctuidae, Pantheinae (Fig. 5-263)

Superfamily: Noctuoidea

Number of Canadian Species: 7 spp. across Canada.

Genera: *Charadra, Colocasia, Panthea*

Abundance: common, at lights.

Quick Recognition: Stout, hairy noctuids, moderate sized to large, eye hairy, forewing grey with darker prominent lines and spots. Specific identification is fairly easy.

Diagnosis: HEAD: ocelli present or absent; chaetosemata absent; head scales rough; proboscis naked, reduced; labial palps porrect, short, densely hairy; antenna filiform or pectinate, variable number of scale rows per segment, usually less than half the forewing length. THORAX: with metathoracic tympanum; sometimes with dorsal scale tuft; wings heteroneurous, forewing somewhat triangular, usually with acute apex, light to dark grey, usually with darker prominent orbicular and reniform spots, and jagged lines; hindwing rounded, drab, but usually with some faint pattern, usually with a checkered fringe; legs densely hairy, hind tibial spurs short, hind tarsal spines present. ABDOMEN: hairy, rarely with dorsal scale tuft.

Similar Taxa: Pantheinae are easily recognized by the hairy eyes, hairy body, and wing pattern.

Taxonomic References: Handfield 1999 (eastern spp.); Anweiler 2009 (*Panthea*)

Noctuidae, Dilobinae (Fig. 5-264)

Superfamily: Noctuoidea

Number of Canadian Species: 1 sp. (*Raphia frater*) across Canada.

Genera: *Raphia*

Abundance: common, at lights.

Quick Recognition: Stout, hairy noctuid, forewing grey with darker, curved antemedian and postmedian lines and hollow reniform and orbicular spots, hindwing pale with sharpest markings at anal angle.

Diagnosis: HEAD: ocelli very difficult to see; chaetosemata absent; head scales rough, sometimes smooth on frons; proboscis naked; labial palps variable in orientation, short, at least somewhat tufted; antenna filiform or pectinate, two scale rows per segment, usually less than half the forewing length. THORAX: with metathoracic tympanum; sometimes with dorsal scale tuft; wings heteroneurous, forewing slightly triangular, with somewhat acute apex, grey with darker, curved antemedian and postmedian lines and hollow reniform and orbicular spots; hindwing squared, drab, with sharpest markings at anal angle; legs hairy, hind tibial spurs short, hind tarsal spines present. ABDOMEN: hairy, sometimes with slight dorsal scale tuft.

Similar Taxa: This species is easily recognized by its wing pattern.

Taxonomic References: Covell 1984; Handfield 1999; Powell & Opler 2009

Noctuidae, Balsinae (Fig. 5-265)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. in southern Canada as far west as SK.

Genera: *Balsa*

Abundance: uncommon, at lights.

Quick Recognition: Small noctuids with broad rectangular wings, forewing grey with dark median and postmedian lines prominent on costal half. Specific identification can be challenging.

Diagnosis: HEAD: ocelli usually visible; chaetosemata absent; head scales generally smooth; proboscis naked; labial palps usually ascending, usually short, slender; antenna filiform, rarely pectinate, two scale rows per segment, variable in length. THORAX: with metathoracic tympanum; sometimes with subtle dorsal scale tuft; wings heteroneurous, forewing rectangular, with square apex, grey with dark median and postmedian lines prominent on costal half; hindwing squared, drab; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, sometimes with slight dorsal scale tuft.

Similar Taxa: Balsinae are easily recognized by their size and forewing pattern.

Taxonomic References: Covell 1984; Handfield 1999

Noctuidae, Acronictinae (Fig. 5-266)

Superfamily: Noctuoidea

Number of Canadian Species: 54 spp. throughout Canada.

Genera: *Acronicta, Agriopodes, Cerma, Harrisimemna, Polygrammate, Simyra*

Abundance: common, at lights.

Quick Recognition: Typically medium-sized stout noctuids with white, grey or black forewings, often with dark streaks at the base, near the anal angle and near the apex. Specific identification is challenging for some Acronicta groups.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, sometimes smooth on frons; proboscis naked; labial palps ascending or porrect, short, often tufted; antenna filiform, rarely pectinate, rarely with long sensillae, two scale rows per segment, usually less than half forewing length. THORAX: with metathoracic tympanum; often with dorsal scale tuft; wings heteroneurous, forewing rectangular to triangular, with square to acute apex, white, grey, or black with prominent lines and spots, often with dark streaks at the base, near the anal angle and near the apex; hindwing squared to rounded, drab, sometimes with discal spot and median line; hind tibial spurs variable, hind tarsal spines present. ABDOMEN: smooth, often with dorsal scale tuft, rarely boldly patterned.

Similar Taxa: Acronictinae are usually readily identified by their forewing markings.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Cuculliinae (Fig. 5-267)

Superfamily: Noctuoidea

Number of Canadian Species: 18 spp. across Canada, especially the southern portions.

Genera: *Cucullia*

Abundance: uncommon to common, at lights.

Quick Recognition: Stout noctuids with sharply pointed forewing and prominent forward projecting scale tuft on thorax, forewing pattern often grey and streaky with most prominent markings along inner margin. Specific identification can be challenging.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, sometimes smooth on frons; proboscis naked; labial palps ascending, short, tufted; antenna filiform, two scale rows per segment, half forewing length or greater. THORAX: with metathoracic tympanum; often with prominent forward projecting scale tuft; wings heteroneurous, forewing elongate and acutely pointed, often grey and streaky with most prominent markings along inner margin; hindwing usually squared, drab, sometimes with dark outer shade; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, sometimes with dorsal scale tuft.

Similar Taxa: Cuculliinae are easily recognized by the wing shape, pattern, and forward projecting scale tuft.

Taxonomic References: Poole 1995 (most spp.); Handfield & Handfield 2010 (some spp.)

Noctuidae, Amphipyrinae, Amphipyrini (Fig. 5-268)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. across Canada.

Genera: *Amphipyra*

Abundance: common, at lights.

Quick Recognition: Stout noctuids with rectangular shiny forewings, brownish to greyish with closely set orbicular and reniform spots, the most common species with coppery hindwing. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, sometimes smooth on frons; proboscis naked; labial palps ascending, usually long, slender; antenna filiform, two scale rows per segment, greater than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing rectangular, shiny, brownish to greyish with closely set orbicular and reniform spots, lines may be present, sometimes paler in subterminal area;

hindwing rounded, drab or metallic copper; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, sometimes banded.

Similar Taxa: Amphipyrini are most easily identified by wing pattern.

Taxonomic References: Handfield 1999

Noctuidae, Amphipyrinae, Psaphidini (Fig. 5-269)

Superfamily: Noctuoidea

Number of Canadian Species: 13 spp. across Canada, more diverse in southern areas.

Genera: *Acopa, Brachionycha, Copivaleria, Feralia, Psaphida*

Abundance: uncommon, at lights.

Quick Recognition: Stout, hairy noctuids often with acutely pointed forewings, pattern either subdued or complex, sometimes green, most species active in early spring. Specific identification is easy.

Diagnosis: HEAD: ocelli present or absent; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked; labial palps ascending or porrect, short, hairy; antenna filiform or pectinate, two scale rows per segment, half forewing length or greater. THORAX: with metathoracic tympanum; wings heteroneurous, forewing often acutely pointed, sometimes broadly triangular with more squared apex, pattern either subdued or complex, sometimes green, reniform spot usually prominent; hindwing rounded to squared, often with diffuse shading and a discal spot; hind tibial spurs short, hind tarsal spines present. ABDOMEN: hairy, rarely with dorsal scale tuft, sometimes boldly patterned.

Similar Taxa: Psaphidini can be separated from other really hairy noctuids by wing shape and pattern.

Taxonomic References: Poole 1995 (all except *Acopa*); Troubridge & Lafontaine 2004c (*Acopa* and western spp.)

Noctuidae, Amphipyrinae, Stiriini (Fig. 5-270)

Superfamily: Noctuoidea

Number of Canadian Species: 10 spp. from southern BC to southern ON.

Genera: *Annaphila, Azenia, Cirrhophanus, Plagiomimicus, Stiria*

Abundance: rare, at lights, some species diurnal.

Quick Recognition: Moderately slender noctuids, forewing triangular, either bright yellow with grey or brown markings, or grey to brown, hindwing sometimes boldly patterned. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth; proboscis naked; labial palps ascending or porrect, usually short, usually tufted; antenna filiform, rarely with long sensillae, two scale rows per segment, half forewing length or less. THORAX: with metathoracic tympanum; wings heteroneurous, forewing triangular, some species bright yellow with brown or grey markings, others grey to brown, sometimes with prominent lines; hindwing rounded to squared, usually drab, sometimes boldly patterned; hind tibial spurs usually long, hind tarsal spines present, sometimes difficult to see. ABDOMEN: smooth.

Similar Taxa: Stiriini have fairly distinct wing markings.

Taxonomic References: Poole 1995 (all except *Annaphila*); Troubridge & Lafontaine 2004c (*Annaphila* and western spp.)

Noctuidae, Oncocnemidinae (Fig. 5-271)

Superfamily: Noctuoidea

Number of Canadian Species: 62 spp. throughout Canada, most diverse in the west.

Genera: *Behrensia, Calophasia, Catabena, Pleromelloida, Pseudacontia, Sympistis*

Abundance: uncommon to common, at lights, some species diurnal.

Quick Recognition: A diverse group of stout noctuids, a channel is cut across the top of the base of the abdomen, best viewed laterally. Specific identification can be very challenging in *Sympistis*, but is otherwise easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth; proboscis naked; labial palps ascending, usually short, usually tufted; antenna filiform, rarely pectinate with long sensillae, two scale rows per segment, half forewing length or greater. THORAX: with metathoracic tympanum, sometimes with dorsal scale tuft; wings heteroneurous, forewing triangular to rectangular, variable in pattern, usually grey, lines and spots often prominent, sometimes with dark dashes; hindwing rounded to squared, sometimes boldly patterned; hind tibial spurs short, hind tibial spines rarely present, hind tarsal spines present. ABDOMEN: smooth to hairy, rarely with dorsal scale tufts.

Similar Taxa: The channel across the base of the abdomen will separate Oncocnemidinae from most other noctuids. The other noctuids with this channel like some Stiriini and Agaristinae have distinctively different wing patterns.

Taxonomic References: Troubridge 2008 (*Sympistis*); Troubridge & Lafontaine 2004c (most western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Agaristinae (Fig. 5-272)

Superfamily: Noctuoidea

Number of Canadian Species: 7 spp. throughout Canada, most diverse in southern ON.

Genera: *Alypia, Androloma, Eudryas, Psychomorpha*

Abundance: uncommon to rare, most species diurnal, some at lights.

Quick Recognition: Most species jet black with large white, yellow or red blotches on both wings, Eudryas with a large white blotch through most of the forewing and a yellow hindwing. Specific identification is usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth; eye rarely slightly hairy, proboscis naked; labial palps ascending or porrect, usually short, hairy; antenna often with an elongate club, rarely pectinate with long sensillae, two scale rows per segment, rarely scale-less, half forewing length or greater. THORAX: with metathoracic tympanum, usually furry, often with brightly coloured tegulae, rarely with dorsal scale tuft; wings heteroneurous, forewing usually triangular, in most species jet black with large white or yellow blotches, in Eudryas more mottled grey or brown with a broad white blotch through most of the wing; hindwing rounded to squared, jet black with white blotches in most, rarely with a large red blotch, in Eudryas bright yellow with a brownish border; hind tibial spurs short, hind tibial spines sometimes present, hind tarsal spines present. ABDOMEN: usually hairy, rarely with dorsal scale tufts, sometimes boldly patterned.

Similar Taxa: The combination of boldly marked wings and size are unmistakeable.

Taxonomic References: Powell & Opler 2009 (most western spp.); Covell 1984 (eastern spp.)

Noctuidae, Condicinae (Fig. 5-273)

Superfamily: Noctuoidea

Number of Canadian Species: 12 spp. throughout Canada.

Genera: *Condica, Crambodes, Homophoberia, Leuconycta, Ogdoconta, Perigea*

Abundance: uncommon to common, at lights.

Quick Recognition: Somewhat slender-bodied noctuids with variable wing pattern, usually consisting of typical lines and spots, sometimes streaky. Specific identification is usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth on vertex, smooth on frons; proboscis naked; labial palps ascending or porrect, short, slender; antenna filiform, sometimes with long sensillae, two scale rows per segment, half forewing length or less. THORAX: with metathoracic tympanum, usually with dorsal scale tuft; wings heteroneurous, forewing usually triangular, sometimes elongate, pattern variable, lines and spots often prominent, markings sometimes streaky; hindwing squared, drab, sometimes with discal lunule; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth, usually with dorsal scale tuft.

Similar Taxa: Condicinae are best separated from similar noctuids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Heliothinae (Fig. 5-274)

Superfamily: Noctuoidea

Number of Canadian Species: 42 spp. across Canada, most diverse in the south and west.

Genera: *Eutricopis, Helicoverpa, Heliocheilus, Heliothis, Melaporphyria, Pyrrhia, Schinia*

Abundance: uncommon to common, most species diurnal at flowers, some species come to lights.

Quick Recognition: Small to medium-sized noctuids with variable but usually boldly patterned or brightly coloured wings. Specific identification is usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked; labial palps usually ascending, usually short, tufted; antenna filiform, sometimes with long sensillae, two scale rows per segment, variable in length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing variable in shape, usually triangular, pattern variable, usually boldly patterned or brightly coloured, lines and spots often prominent; hindwing rounded to squared, often boldly patterned or brightly coloured; hind tibial spurs variable, hind tibial spines often present, hind tarsal spines present. ABDOMEN: smooth, rarely with dorsal scale tuft.

Similar Taxa: Heliothinae are usually easily separated from other noctuids by the wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c; 2004d

Noctuidae, Eriopinae (Fig. 5-275)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. MB to NF.

Genera: *Callopistria*

Abundance: uncommon to common, at lights.

Quick Recognition: Small noctuids with wings held sharply roof-like at rest, forewing brown with large silver spots or mottled brown and purple, abdomen with a small dorsal scale tuft. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked; labial palps usually ascending, short, fairly slender; antenna filiform, with long sensillae, two scale rows per segment, roughly half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing triangular, sometimes with a hook at anal angle, brown with large silver spots or mottled brown and purple; hindwing squared, drab; hind tibial spurs variable, hind tarsal spines present. ABDOMEN: smooth, with small dorsal scale tuft.

Similar Taxa: Eriopinae are unmistakeable because of their distinctive forewing pattern.

Taxonomic References: Handfield 1999

Noctuidae, Bryophilinae (Fig. 5-276)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. in BC and adjacent AB.

Genera: *Cryphia*

Abundance: uncommon to rare, at lights.

Quick Recognition: Fairly small, slender noctuids with mottled greyish wings, antemedian and postmedian lines as well as orbicular, claviform, and reniform spots usually prominent, a small dorsal scale tuft present on abdomen. Specific identification is challenging.

Diagnosis: HEAD: ocelli usually visible; chaetosemata absent; head scales rough on vertex, smooth on frons; proboscis naked; labial palps porrect, short, slender; antenna filiform, with long sensillae, two scale rows per segment, roughly half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing with a slightly acute apex, mottled grey with prominent antemedian and postmedian lines as well as orbicular, claviform, and reniform spots; hindwing squared, drab; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth, with small dorsal scale tuft.

Similar Taxa: Bryophilinae are best recognized by a combination of forewing pattern and dorsal abdominal scale tuft.

Taxonomic References: Powell & Opler 2009

Noctuidae, Noctuinae, Pseudeustrotiini (Fig. 5-277)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. from AB to NF.

Genera: *Anterastria, Pseudeustrotia*

Abundance: common, at lights.

Quick Recognition: Small slender noctuids with blunt wings, forewing either with a slanted pink bar from costa to middle or evenly dark with white reniform spot and white costal tips of postmedian and subterminal lines. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales smooth, rarely rough on vertex; proboscis naked; labial palps ascending, short, slender; antenna filiform, sometimes with long sensillae, two scale rows per segment, half forewing length or less. THORAX: with metathoracic tympanum; wings heteroneurous, forewing blunt with square apex, either with a slanted pink bar from costa to middle or evenly dark with white reniform spot and white costal tips of postmedian and subterminal lines; hindwing squared with slight indentation in upper half of outer margin, drab; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth, with small dorsal scale tuft, rarely boldly patterned.

Similar Taxa: Pseudeustrotiini can be separated from other similar noctuids by forewing pattern.

Taxonomic References: Handfield 1999

Noctuidae, Noctuinae, Phosphilini (Fig. 5-278)

Superfamily: Noctuoidea

Number of Canadian Species: 2 spp. in extreme southern MB and ON.

Genera: *Phosphila*

Abundance: common, at lights.

Quick Recognition: A stout medium-sized noctuid with mottled green and grey forewing and large white reniform spot or mottled brown with a slightly darker medain area and prominent dark dashes in the lower median and postmedian areas.

Diagnosis: HEAD: ocelli usually visible; chaetosemata absent; head scales rough on vertex, smooth on frons; proboscis naked; labial palps ascending or porrect, variable in length, slender; antenna filiform, two scale rows per segment, half forewing length or greater. THORAX: with metathoracic tympanum; wings heteroneurous, forewing triangular, either mottled green and grey, reniform spot large and white, or mottled brown with a slightly darker medain area and prominent dark dashes in the lower median and postmedian areas; hindwing drab grey with some dark line on outer half; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth, usually with dorsal scale tuft.

Similar Taxa: Our species of Phosphilini are easy to recognize by forewing pattern.

Taxonomic References: Covell 1984

Noctuidae, Noctuinae, Prodenini (Fig. 5-279)

Superfamily: Noctuoidea

Number of Canadian Species: 4 spp. across Canada.

Genera: *Spodoptera*

Abundance: common to rare, at lights, migratory.

Quick Recognition: A stout medium-sized noctuid with mottled forewing pattern and broad white hindwing with sharp black veins.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales usually rough on vertex, usually smooth on frons; proboscis naked; labial palps usually ascending, short, usually slender; antenna filiform, two scale rows per segment, variable in length. THORAX: with metathoracic tympanum, often with dorsal scale tuft; wings heteroneurous, forewing elongate, usually with a complex mottled pattern; hindwing broad, white with prominent dark veins; hind tibial spurs variable in length, hind tarsal spines present. ABDOMEN: smooth to hairy, usually with dorsal scale tuft.

Similar Taxa: Prodenini can be separated from other noctuids by wing pattern and shape.

Taxonomic References: Powell & Opler 2009 (western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Noctuinae, Elaphriini (Fig. 5-280)

Superfamily: Noctuoidea

Number of Canadian Species: 5 spp. across Canada.

Genera: *Elaphria, Galgula*

Abundance: common, at lights.

Quick Recognition: Fairly small noctuids with prominent postmedian line and reniform spot. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough or smooth on vertex, smooth on frons; proboscis naked; labial palps usually ascending, short, slender; antenna filiform, usually with long sensillae, two scale rows per segment, roughly half forewing length. THORAX: with metathoracic tympanum, sometimes with dorsal scale tuft; wings heteroneurous, forewing rectangular or triangular, variable in pattern, reniform spot and postmedian line typically prominent; hindwing squared, drab; hind tibial spurs variable in length, hind tarsal spines present. ABDOMEN: smooth, rarely with dorsal scale tuft.

Similar Taxa: Elaphriini can be separated from similarly sized noctuids by forewing pattern.

Taxonomic References: Handfield 1999

Noctuidae, Noctuinae, Caradrinini (Fig. 5-281)

Superfamily: Noctuoidea

Number of Canadian Species: 10 spp. across Canada.

Genera: *Caradrina, Protoperigea, Proxenus*

Abundance: uncommon, at lights.

Quick Recognition: Fairly small noctuids with subdued pattern. Specific identification can be challenging.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked; labial palps usually ascending, usually short, slender or tufted; antenna filiform, sometimes with long sensillae, two scale rows per segment, usually longer than half forewing length. THORAX: with metathoracic tympanum, sometimes with dorsal scale tuft; wings heteroneurous, forewing rectangular or triangular, sometimes fairly elongate, variable in pattern, though usually subdued; hindwing broad, squared, usually pale; hind tibial spurs short, hind tarsal spines present. ABDOMEN: smooth.

Similar Taxa: Caradrinini can be difficult to characterize, though some species can be easily separated from other noctuids by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c; 2004d

Noctuidae, Noctuinae, Dypterygiini (Fig. 5-282)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. from AB to NS.

Genera: *Dypterygia, Magusa, Trachea*

Abundance: uncommon to rare, at lights.

Quick Recognition: Stout noctuids with varying pattern. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending or porrect, short, slender or tufted; antenna filiform, sometimes with long sensillae, two scale rows per segment, greater than half forewing length. THORAX: with metathoracic tympanum, at least with slight dorsal scale tuft; wings heteroneurous, forewing somewhat rectangular, sometimes elongate, variable in pattern; hindwing rounded or broadly triangular, drab; hind tibial spurs long, hind tarsal spines present. ABDOMEN: smooth, sometimes with dorsal scale tuft.

Similar Taxa: The three Dypterygiini can be recognized by their wing pattern.

Taxonomic References: Handfield 1999

Noctuidae, Noctuinae, Actinotiini (Fig. 5-283)

Superfamily: Noctuoidea

Number of Canadian Species: 4 spp. in BC and from MB to NF.

Genera: *Alastria*, *Iodopepla*, *Nedra*

Abundance: uncommon to rare, at lights.

Quick Recognition: Stout noctuids with usually with streaky forewing pattern and U-shaped reniform spot. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending, short, slender or tufted; antenna filiform, usually with long sensillae, two scale rows per segment, usually greater than half forewing length. THORAX: with metathoracic tympanum, often with dorsal scale tuft; wings heteroneurous, forewing somewhat rectangular, pattern usually streaky, reniform spot usually U-shaped; hindwing squared to rounded, drab; hind tibial spurs variable, hind tarsal spines present. ABDOMEN: hairy to smooth, sometimes with dorsal scale tuft.

Similar Taxa: All of our Actinotiini have distinctive forewing patterns.

Taxonomic References: Lafontaine & Troubridge 2004 (*Alastria*); Handfield 1999 (*Iodopepla*); Troubridge & Lafontaine 2004c (*Nedra*)

Noctuidae, Noctuinae, Phlogophorini (Fig. 5-284)

Superfamily: Noctuoidea

Number of Canadian Species: 4 spp. across Canada

Genera: *Conservula, Euplexia, Phlogophora*

Abundance: common, at lights.

Quick Recognition: Stout noctuids often with a broad V-shaped blotch through the centre of the forewing, at rest the costal edge forms a distinct crease. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps usually ascending, short, slender or tufted; antenna filiform, often with long sensillae, two scale rows per segment, usually greater than half forewing length. THORAX: with metathoracic tympanum, with dorsal scale tuft; wings heteroneurous, forewing triangular, sometimes with an acute apex, often scalloped, often light brown with large dark brown V-shaped blotch through centre of wing, reniform spot usually prominent; hindwing squared to triangular, often slightly scalloped, with some diffuse lines; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: hairy to smooth, with dorsal scale tuft.

Similar Taxa: Phlogophorini can be recognized by the forewing pattern and resting posture.

Taxonomic References: Handfield 1999

Noctuidae, Noctuinae, Apameini (Fig. 5-285)

Superfamily: Noctuoidea

Number of Canadian Species: 129 spp. throughout Canada

Genera: *Achatodes, Amphipoea, Apamea, Benjaminiola, Capsula, Chortodes, Eremobina, Helotropha, Hydraecia, Lateroligia, Lemmeria, Loscopia, Macronoctua, Meropleon, Neoligia, Papaipema, Resapamea, Rhizedra, Spartiniphaga, Xylomoia*

Abundance: common, at lights.

Quick Recognition: A diverse group of usually stout noctuids. Specific identification is challenging in some groups, but usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked; labial palps usually ascending or porrect, usually short, usually tufted; antenna filiform, usually with long sensillae, two scale rows per segment, usually greater than half forewing length. THORAX: with metathoracic tympanum, often with dorsal scale tuft; wings heteroneurous, forewing usually somewhat rectangular with bulging outer margin, pattern variable; hindwing variable in shape and pattern, usually drab; hind tibial spurs variable, hind tarsal spines present. ABDOMEN: hairy to smooth, often with dorsal scale tuft.

Similar Taxa: Apameini are difficult to characterize, it is easiest to eliminate less diverse tribes first.

Taxonomic References: Troubridge & Lafontaine 2004c (most western spp.); Handfield 1999 (most eastern spp.); Mikkola, *et al.* 2009 (*Apamea, Lateroligia*); Troubridge & Lafontaine 2002 (*Neoligia*)

Noctuidae, Noctuinae, Arzamini (Fig. 5-286)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. across Canada

Genera: *Bellura*

Abundance: common, at lights, associated with wetlands.

Quick Recognition: Stout brown large to medium-sized noctuids, abdomen long, reniform spot slanted. Specific identification is easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending or porrect, short, tufted; antenna usually pectinate, often with long sensillae, two scale rows per segment, less than half forewing length. THORAX: with metathoracic tympanum, with dorsal scale tuft; wings heteroneurous, forewing usually triangular, with acute or square apex, brown with darker markings, reniform spot slanted towards apex; hindwing rounded with square apex, brown with dark discal spot; hind tibial spurs variable, hind tarsal spines present. ABDOMEN: long, hairy.

Similar Taxa: Arzamini are easily recognized by the forewing shape and pattern.

Taxonomic References: Handfield 1999

Noctuidae, Noctuinae, Xylenini (Fig. 5-287)

Superfamily: Noctuoidea

Number of Canadian Species: 131 spp. throughout Canada

Genera: *Agrochola, Anathix, Andropolia, Aseptis, Brachylomia, Cerapoda, Chaetaglaea, Chytonix, Cosmia, Dryotype, Enargia, Epidemas, Epiglaea, Eucirroedia, Eupsilia, Fagitana, Fishia, Hillia, Homoglaea, Hyppa, Ipimorpha, Litholomia, Lithomoia, Lithophane, Mesogona, Metaxaglaea, Mniotype, Parastichtis, Platypolia, Properigea, Psectraglaea, Pseudanarta, Pseudobryomima, Pyreferra, Rhizagrotis, Sutyna, Ufeus, Xanthia, Xylena, Xylotype, Zotheca*

Abundance: common, at lights.

Quick Recognition: A very diverse group of usually stout noctuids, several genera make up the bulk of the overwintering noctuid fauna. Specific identification is challenging in some groups, but usually easy.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked, rarely reduced; labial palps ascending or porrect, usually short, usually tufted; antenna filiform, rarely pectinate, usually with long sensillae, two scale rows per segment, variable in length. THORAX: with metathoracic tympanum, sometimes with dorsal scale tuft; wings heteroneurous, forewing usually rectangular, pattern variable; hindwing variable in shape and pattern, usually drab; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: usually hairy, rarely with dorsal scale tuft.

Similar Taxa: Xylenini are difficult to characterize, it is easiest to eliminate less diverse tribes first.

Taxonomic References: Troubridge & Lafontaine 2004c, d (most spp.); Troubridge & Lafontaine 2007 (*Brachylomia*); Lafontaine & Troubridge 2003 (*Cosmia*); Schmidt 2010 (*Enargia*); Troubridge & Lafontaine 2004e (*Hyppa*); Troubridge 2006, Troubridge & Lafontaine 2003 (some *Lithophane*); Crabo & Hammond 1997 (*Mesogona*)

Noctuidae, Noctuinae, Orthosiini (Fig. 5-288)

Superfamily: Noctuoidea

Number of Canadian Species: 32 spp. throughout Canada

Genera: *Acerra*, *Achatia, Admetovis*, *Crocigrapha*, *Egira, Himella*, *Morrisonia, Orthosia, Stretchia*

Abundance: common, at lights.

Quick Recognition: Stout noctuids, usually with hairy eyes, relatively small abdomen, most species fly early in the year. Specific identification is usually fairly easy.

Diagnosis: HEAD: ocelli present; eyes usually hairy; chaetosemata absent; head scales rough; proboscis naked; labial palps usually porrect, short, tufted; antenna filiform, sometimes pectinate, often with long sensillae, two scale rows per segment, usually more than half forewing length. THORAX: with metathoracic tympanum, usually with dorsal scale tuft; wings heteroneurous, forewing fairly stout, sometimes with elongate apex, pattern variable; hindwing rounded to squared, usually drab; hind tibial spurs short, hind tarsal spines present. ABDOMEN: relatively short, hairy, rarely with dorsal scale tuft.

Similar Taxa: Orthosiini can be separated from other noctuids with hairy eyes by wing pattern and the relatively short abdomen.

Taxonomic References: Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Noctuinae, Tholerini (Fig. 5-289)

Superfamily: Noctuoidea

Number of Canadian Species: 3 spp. throughout Canada

Genera: *Cerapteryx*, *Nephelodes*, *Tholera*

Abundance: common, at lights.

Quick Recognition: Stout noctuids with hairy eyes and pectinate antennae, forewing either shiny bronze or greyish with pale streaks. Specific identification is easy.

Diagnosis: HEAD: ocelli present; eyes hairy; chaetosemata absent; head scales rough; proboscis naked; labial palps ascending, short, tufted; antenna pectinate, usually with long sensillae, two or more scale rows per segment, usually less than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing triangular with square apex, pattern either shiny bronze or grey with pale streaks; hindwing squared, with some subdued pattern; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: hairy.

Similar Taxa: Tholerini can be separated from other noctuids with hairy eyes by wing pattern and having pectinate antennae.

Taxonomic References: Morris 1979 (*Cerapteryx*); Handfield 1999, Powell & Opler 2009 (*Nephelodes*); Troubridge & Lafontaine 2004c (*Tholera*)

Noctuidae, Noctuinae, Hadenini (Fig. 5-290)

Superfamily: Noctuoidea

Number of Canadian Species: 69 spp. throughout Canada

Genera: *Afotella, Anarta, Coranarta, Dargida, Escaria, Hada, Hadena, Hadenella, Lacanobia, Mamestra, Melanchra, Papestra, Polia, Scotogramma, Sideridis, Spiramater, Trichordestra*

Abundance: common, at lights.

Quick Recognition: Stout noctuids with hairy eyes, most species with a dorsal abdominal scale tuft. Specific identification is challenging in some genera.

Diagnosis: HEAD: ocelli present; eyes hairy; chaetosemata absent; head scales rough, rarely smooth on frons; proboscis naked; labial palps variable in orientation, short, usually tufted; antenna filiform, usually with long sensillae, two scale rows per segment, usually greater than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually rectangular, pattern variable; hindwing variable in shape and pattern; hind tibial spurs usually short, hind tarsal spines present. ABDOMEN: hairy, usually with dorsal scale tuft.

Similar Taxa: Hadenini can be separated from other noctuids with hairy eyes by wing pattern and the usual presence of a dorsal abdominal scale tuft.

Taxonomic References: Lafontaine, *et al.* 1987 (*Coranarta*); Troubridge & Crabo 2002 (*Hada, Hadena*); McCabe 1980 (*Lacanobia, Melanchra, Papestra, Polia, Spiramater, Trichordestra*); Troubridge & Lafontaine 2004c (western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Noctuinae, Leucaniini (Fig. 5-291)

Superfamily: Noctuoidea

Number of Canadian Species: 18 spp. throughout Canada

Genera: *Leucania, Mythimna*

Abundance: common, at lights, usually in open habitats.

Quick Recognition: Stout noctuids with hairy eyes, most species with pale yellow to grey streaky forewing pattern. Specific identification can be challenging in *Leucania*.

Diagnosis: HEAD: ocelli present; eyes hairy; chaetosemata absent; head scales rough; proboscis naked; labial palps porrect or ascending, short, tufted; antenna filiform, sometimes with long sensillae, two scale rows per segment, greater than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually somewhat elongate, pale yellow, brown or grey, pattern usually streaky, rarely without streaks and with dark dots forming postmedian and antemedian lines; hindwing variable in shape, usually drab with darker veins; hind tibial spurs short, hind tarsal spines present. ABDOMEN: hairy.

Similar Taxa: Leucaniini can be separated from other noctuids with hairy eyes by wing pattern.

Taxonomic References: Troubridge & Lafontaine 2004c (most western spp.); Handfield 1999 (eastern spp.)

Noctuidae, Noctuinae, Eriopygini (Fig. 5-292)

Superfamily: Noctuoidea

Number of Canadian Species: 86 spp. throughout Canada

Genera: *Anhimella, Homorthodes, Hydroeciodes, Lacinipolia, Lasionycta, Neleucania, Orthodes, Protorthodes, Pseudorthodes, Trichocerapoda, Tricholita, Ulolonche, Zosteropoda*

Abundance: common, at lights.

Quick Recognition: Small stout noctuids usually with hairy eyes, pattern usually drab. Specific identification can be difficult.

Diagnosis: HEAD: ocelli usually present; eyes usually hairy; chaetosemata absent; head scales rough; proboscis naked; labial palps usually porrect or ascending, usually short, tufted; antenna filiform, sometimes pectinate, sometimes with long sensillae, two scale rows per segment, usually greater than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually stout with square apex, usually brown or grey, reniform and orbicular spots usually present, antemedian, postmedian, and subterminal lines usually present; hindwing squared, drab; hind tibial spurs short, hind tarsal spines present. ABDOMEN: hairy, dorsal scale tuft rarely present.

Similar Taxa: Eriopygini can be separated from other noctuids with hairy eyes by wing pattern and by their smaller size.

Taxonomic References: Troubridge & Lafontaine 2004c (most western spp.); Handfield 1999 (most eastern spp.); Crabo & Lafontaine 2009 (*Lasionycta*); McCabe 1980 (some *Orthodes*)

Noctuidae, Noctuinae, Noctuini (Fig. 5-293)

Superfamily: Noctuoidea

Number of Canadian Species: 306 spp. throughout Canada, most diverse in the west

Genera: *Abagrotis, Actebia, Adelphagrotis, Agnorisma, Agrotis, Anaplectoides, Anicla, Aplectoides, Cerastis, Chersotis, Choephora, Coenophila, Copablepharon, Cryptocala, Diarsia, Dichagyris, Eucoptocnemis, Eueretagrotis,* *Eurois, Euxoa, Feltia, Graphiphora, Hemipachnobia, Lycophotia, Noctua, Ochropleura, Parabagrotis, Parabarrovia, Paradiarsia, Peridroma, Prognorisma, Pronoctua, Protogygia, Protogygia, Protolampra, Pseudohermonassa, Rhyacia, Setagrotis, Spaelotis, Tesagrotis, Xestia*

Abundance: common to abundant, at lights, especially in open areas.

Quick Recognition: Stout noctuids with a spiny hind tibia, forewings usually tightly overlapping and flat over the back at rest. Specific identification can be very difficult in some genera.

Diagnosis: HEAD: ocelli present; chaetosemata absent; head scales rough, rarely smooth; proboscis naked; labial palps usually porrect or ascending, usually short, usually tufted; antenna filiform, rarely pectinate, often with long sensillae, two scale rows per segment, usually greater than half forewing length. THORAX: with metathoracic tympanum; wings heteroneurous, forewing usually elongate with square apex, usually with prominent reniform and orbicular spots, often with streaks; hindwing squared, usually drab, rarely boldly patterned with black and yellow; hind tibial spurs short, hind tibial spines present, rarely absent, hind tarsal spines present. ABDOMEN: hairy to smooth, dorsal scale tuft rarely present.

Similar Taxa: Noctuini are easily separated from other noctuids by the spiny hind tibia.

Taxonomic References: Lafontaine 1998 (*Abagrotis, Adelphagrotis, Agnorisma, Anaplectoides, Aplectoides, Cerastis, Chersotis, Choephora, Coenophila, Cryptocala, Diarsia, Eueretagrotis, Eurois, Graphiphora, Hemipachnobia, Lycophotia, Noctua, Ochropleura, Parabagrotis, Parabarrovia, Paradiarsia, Prognorisma, Pronoctua, Protolampra, Pseudohermonassa, Rhyacia, Setagrotis, Spaelotis, Tesagrotis, Xestia*); Lafontaine 2004 (*Actebia, Agrotis, Anicla, Copablepharon, Eucoptocnemis, Feltia, Peridroma, Protogygia*); Lafontaine 1987 (most *Euxoa*); Lafontaine & Troubridge 2010 (some *Euxoa*)

Chapter 6

General Conclusions

Thesis Summary

In this thesis, I assessed the taxonomy of Archipini at the species, genus, and tribal level and developed an identification tool for Lepidoptera in Canada. The description of *Clepsis anderslaneyii* in Chapter 2 filled a nomenclatural gap in our understanding of the Nearctic Archipini, as it facilitated delimitation of a species otherwise confused with the much more common *Argyrotaenia dorsalana*. Its generic placement was based on genitalic morphology and subsequently supported by molecular data in Chapter 4. Chapter 3 examined the *Pandemis limitata* species group and several outgroup taxa. The species in this group were confirmed as being closely related, and a combination of morphology, geographical distribution, and DNA characters was needed to distinguish and identify them. No single type of character was sufficient for successful separation of the three species, which emphasizes the need for a total evidence approach. A two-gene molecular phylogeny of the Archipini based on 134 species was developed in Chapter 4 as a framework for reconstructing zoogeographic and morphological history. This phylogeny gave good support for rearrangement of generic boundaries that were also supported by morphology. Although there was a large polytomy within the core Archipini, which made it difficult to detect correlated evolutionary change, there was strong overall correlation between polyphagy and secondary sexual characters (SSCs), but not between the loss of a costal fold and the appearance of novel SSCs. Reconstruction of the zoogeographical affinities of archipine genera and species showed a probable Australasian origin for the Archipini that later radiated into the Palaearctic and to a limited extent into the Nearctic. The radiation of Nearctic species shows a strong correlation with lack of SSCs, as compared to Old World species. Lastly, the interactive, matrix-based key to the Lepidoptera of Canada produced in

Chapter 5 provides a novel way to identify Lepidoptera to subfamily or tribe. The key covers 222 taxon groups, using 73 characters and 266 character states, and is particularly useful for microlepidopteran identifications.

Broader Implications

There are broad taxonomic implications in Chapters 2, 3, and 4. The description of *C. anderslaneyii* and the support for the maintenance of *Pandemis canadana*, *P. limitata*, and *P. pyrusana* as separate species all help to delimit the Nearctic fauna. This is important as several of our major pest species and complexes belong to the Archipini. Having clear ideas of species boundaries can help us determine the most efficient response to a population outbreak or novel introduction. Chapter 4 has generic implications for several globally distributed and economically important species; several genera are synonymised (*Archepandemis=Pandemis, Cudonigera=Choristoneura, Epiphyas=Clepsis*) and four subgenera of *Aphelia* are elevated to the genus level (*Anaphelia, Aphelia s. s., Sacaphelia,* and *Zelotherses*). Genera and other higher level taxa should be determined based upon at least some of these five criteria: 1) monophyly, 2) nomenclatural stability, 3) age of divergence, 4) a distinct phylogenetic gap, and 5) consistent number of species (Nazari, *et al.* 2007). I employ the first two criteria in decisions on generic synonymies.

Two prime examples illustrate the importance of these taxonomic changes to agricultural entomologists: the *Pandemis limitata* group and *Epiphyas postvittana*. Uncertainty behind the identity of the *Pandemis* species in apple crops has led to arbitrary names that lack justification, due to the assumption that all three names in the *P. limitata* group referred to the same variable species (Freeman 1958; Powell 1964). This is exemplified by my analyses, which indicate the same entity is being called *P. pyrusana* in Washington state (Curkovic, *et al.* 2009) and *P. limitata* just across the border in British Columbia (Cossentine, *et al.* 2007), although a few authors suggest that there is nomenclatural uncertainty (Knight & Turner 1999).

The second example is that of the Light Brown Apple Moth (*Epiphyas postvittana*) which has been introduced to many parts of the world (Suckling & Brockerhoff 2010), most recently California which has caused much alarm (Brown, *et al.* 2010; Varela, *et al.* 2008). Millions of dollars are being spent on monitoring, controlling, and determining the population structure and origin of this pest (Guttierez, *et al.* 2010; Barr, *et al.* 2009; Gilligan & Epstein 2009; Simpson, *et al.* 2007), so it is important that we establish a more stable generic name to avoid confusion in the literature. As my analyses confidently place it within *Clepsis* and there is no morphological reason for excluding it from that genus, future publications should refer to it as *Clepsis postvittana*.

In Chapter 3, I show that the process of testing species boundaries using a multiple evidence approach is appropriate for identifying closely related species that are not easily discernable, as in the *P. limitata* group. This is in concordance with several other recent studies focusing on species groups in other insects (e.g. Lumley & Sperling 2010; Mousseau & Sikes 2011; Radenković, *et al.* 2011, see also Schlick-Steiner, *et al.* 2010; Sites & Marshall 2004). The additional use of a molecular phylogenetic framework in Chapters 2 and 3 was important because morphological characters are either lacking or confusing. By developing a phylogenetic hypothesis, we were able to test mechanisms of evolution and zoogeographical origins. This method is standard for zoogeography (Jesse, *et al.* 2011; Vila, *et al.* 2011), although correlated evolution is less frequently examined on large taxonomic scales (Ridgway, *et al.* 2011).

Molecular data should be phylogenetically informative at appropriate depths and therefore genes should be carefully selected with consideration given to 1) genes that are widely used (to facilitate future work), and 2) the use of pre-existing sequences. Regier, *et al.* (2009) focused on deeper relationships across the ditrysian Lepidoptera and thus relied on the slower evolving genes CAD (carbamoyl-phosphate synthetase 2, aspartate transcarbamylase, and dihydroorotase), DDC (dopa decarboxylase), enolase, period, and wingless. Unfortunately, reverse transcription PCR was used to avoid introns, which requires extraction methods that use a lot of tissue from freshly killed specimens, something that is not feasible for several of the rarer taxa that require dissection for identification. Mutanen, *et al.* (2010), with similar taxon coverage as the previous study, used COI, EF-1α (elongation factor 1α), wingless, RpS5 (40S ribosomal protein S5), MDH (malate-lactate dehydrogenase), GAPDH (glyceraldehyde-3-phosphate dehydrogenase), CAD, and IDH (isocitrate dehydrogenase). My study utilized genomic DNA extraction which requires less high quality tissue. I also used more standardized genes for Lepidoptera (see Caterino, *et al.* 2000). I had consistent difficulty amplifying EF-1α and CAD for both Chapters 3 and 4, which excluded them from use.

Gene choice in my research focused on the particular taxonomic levels I was interested in. Although COI is less useful above the generic level (Sperling & Roe 2009), it provided good resolution for both the *Pandemis* and the Archipini phylogenies. Also since a portion of COI is standard for DNA barcoding, I was able to obtain 15 extra species in Chapter 4. However, COI was not as useful as ITS2 for distinguishing species in the *P. limitata* group. This illustrates that while barcoding is useful for some aspects of species determination and delimitation, it should not be relied upon solely (Rubinoff, *et al.* 2006). ITS2 had utility within the genus *Pandemis* and produced different results than COI (Chapter 3), though its utility is limited beyond the genus level due to its rapid evolution and prevalent indels (Hillis & Dixon 1991). 28S had limited utility within the tribe Archipini (Chapter 4) due to relative invariance in sequences at this level (Klopfstein, *et al.* 2010); however, this made for easy alignment. Work to further resolve the polytomy in the core Archipini should involve more data, with likely candidate genes being the remainder of 28S and also 18S (Caterino, *et al.* 2000).

Finally, the key to the Lepidoptera of Canada provides an efficient way for non-experts to identify some of the more difficult to identify groups of Lepidoptera. The current scarcity of ecological and biodiversity studies on microlepidoptera is due mostly to the difficulty in identifying specimens (Scoble 1992). This difficulty has resulted in the majority of lepidopteran surveys in Canada traditionally examining only the macrolepidoptera (Summerville & Crist 2008) and more recent surveys (e.g. B. Bodeux, *in prep.*; E. Kamunya, *in prep.*) identifying only macrolepidopteran adults. The only Canadian surveys that have included microlepidoptera were either done by workers with microlepidopteran taxonomic expertise (e.g. Dombroskie & Simonsen 2010; Macaulay 2008; Bird 2006) or by relying on DNA barcoding (Hebert, *et al.* 2010; deWaard, *et al.* 2009), which has its own uncertainties, as illustrated by the *Pandemis limitata* group.

The key presented here will also facilitate a more in-depth taxonomic coverage of Lepidoptera in entomology courses, since it provides students with a less subjective identification method than the available alternatives. I tested the key in forest entomology and terrestrial arthropod diversity courses, and it gave nearly 100% successful identification. Once the next generation of entomologists is familiar with the use of this kind of identification tool, we will have established a fast and effective way to identify Lepidoptera, especially in cases of potential economic importance (Murphy, *et al.* 2008). Lastly, by making the key freely available online we also foster citizen science, which is poised to become one of our most valuable future assets (Wynne, *et al.* 2011).

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