THESIS

REVISION OF *PARALOBESIA* (LEPIDOPTERA: TORTRICIDAE) AND SCREENING AID DEVELOPMENT FOR PEST MANAGEMENT

Submitted by

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ABSTRACT

REVISON OF *PARALOBESIA* (LEPIDOPTERA: TORTRICIDAE) AND SCREENING AID DEVELOPMENT FOR PEST MANAGEMENT

The moth genus *Paralobesia* consists of 18 described and several undescribed species. All but three are Nearctic, present in North America and northern Mexico, with *P*. *andereggiana* (Herrich-Schäffer) present in the Palearctic (Europe). Most species are found in eastern North America, although two have been recorded from the western U.S., *Paralobesia palliolana* (McDunnough), and an unknown species. *Paralobesia viteana* (Clemens), the grape berry moth, is the most well-known member as a serious pest of grapes. Infestations can lead to crop destruction or rejection of harvests due to larval presence or damage. The introduction of *Lobesia botrana* (Denis & Schiffermüller) into California in 2008 brought about renewed interest in *Paralobesia*. *Lobesia botrana* is one of the most important pests of grape in the Palearctic and has wing patterning incredibly similar to *P*. *viteana*, necessitating the dissection of genitalia for accurate identification.

The Cooperative Agricultural Pest Survey (CAPS) aims to detect introductions of potential pests as efficiently as possible. As part of this detection program, CAPS provides screening aids to the community and field surveyors. These documents provide critical, simplified identification information on the top pests of concern each year. These detail basic biology, trapping methods, and identification protocols. With ever changing life conditions, such as weather, human travel, and commodity trade,

proper identification of insect pests is critical for understanding and control. Chapter 1 provides a detailed intoduction into the importance of this revision and screening aids in the larger picture of pest control. Chapter 2 of this thesis provides a description of a new species of *Paralobesia* that feeds on the rare Showy lady's slipper orchid, *Cypripedium reginae* Walter (Orchidaceae). Chapter 3 provides a revision of *Paralobesia* based on a combination of methods: adult morphology, focusing on genitalia features, host plant data, and a molecular phylogeny. Accompanying this revision in Chapter 4 are CAPS screening aids, used in the field and by surveyors in an effort to detect non-native pest species as early as possible.

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CHAPTER 1

INTRODUCTION

With ever increasing human travel, import and export of commodities, and global climate change, the potential for arthropod pests being introduced into non-native environments is growing. To prevent as much damage as possible to crops and native environments, early and efficient detection, monitoring and control of these pests is essential. To achieve this, accurate identification of these insects, as well as native and and non-native related species, is crucial.

Screening aids for CAPS provide field surveyors a tool for the quick identification of potential pest species, and the protocols to follow if any suspect pests are encountered in these surveys.

Prior to this revision, numerous unresolved taxonomic issues surrounded *Paralobesia* species and there has been recent misuse of scientific names in important pest literature (Brown 2006). Host plant records and wing pattern were the initial characters for the delimitation of these moth species. When examination of genitalia morphology was used for additional identification parameters, several new species were found (Clarke 1953; Freeman 1941; Heinrich 1923a,b, 1926). In this revision we add DNA sequencing as another character for the delimitation of species in *Paralobesia*.

A revision of *Paralobesia* will allow for proper identification of specimens encountered during surveys and general collecting. This is important as *Paralobesia* contains at least one major grape pest – *Paralobesia viteana* (Clemens) and are

incredibly difficult to separate from both other species in *Paralobesia* and others in related genera, particularly *Lobesia*.

While identification of potential pests is of high importance, this revision also builds upon and furthers knowledge of native species, such as new species found in California (Gilligan et al. 2011), their taxonomy, and important host-plant relationships (Royals et al. 2018). Having proper identification techniques and monitoring efforts will provide the basis for establishing control programs in case of an outbreak or range expansion of pest species. Educating current and younger generations on the importance of taxonomy and its applications will ensure that it is a continued science as pest ranges broaden and threaten more of our agricultural economy in coming years.

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CHAPTER 2

THE MYTH OF MONOPHAGY IN OLETHREUTINI? NEW SPECIES OF *PARALOBESIA* (LEPIDOPTERA: TORTRICIDAE) FEEDING ON *CYPRIPEDIUM REGINAE* (ORCHIDACEAE)[1]

Introduction

The genus *Paralobesia* Obraztsov, 1953 consists of 18 described and several undescribed species (Gilligan et al. 2008). Most are found in eastern North America, and their similarity to each other, and to species in other genera, has led to a confusing taxonomic history. Prior to 1900, all *Paralobesia* in North America were assumed to be *P*. *viteana* (Clemens, 1860), the grape berry moth, which was recorded from a variety of larval hosts, including grape. This species was treated as a junior synonym of the European grape pest *Lobesia botrana* ([Denis & *Schiffermüller*]) by Zeller (1871) and all subsequent authors until Kearfott (1904). With the assistance of M. V. Slingerland at Cornell University, Kearfott (1904) obtained a series of *L*. *botrana* from Europe and determined that they were a species different from Clemens' *viteana*. Kearfott also reared various North American *Paralobesia* (= *Polychrosis* Ragonot, 1894) from different hosts and examined reared specimens from Slingerland and others in several collections. His observation that what appeared to be different species could be separated by host plant and brood (= generation) was based on an assumption of

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monophagy, where each moth species was restricted to feeding on a single host plant species. Kearfott (1904, 1907) proceeded to describe eight new species, each reared from a single host, and the concept of monophagy, or restricted oligophagy, has been applied for subsequent species descriptions by several authors (Forbes 1923; Heinrich 1923a, 1926; McDunnough 1938).

Paralobesia are difficult to separate morphologically. Kearfott's (1904, 1907) hypothesis that different species were host-specific was based on subtle differences in wing pattern. Heinrich (1923b, 1926) pioneered the examination of tortricid genitalia in North America. He provided a revision of *Paralobesia* (then *Polychrosis*) that included photographs of the male genitalia and descriptions of several new species (Heinrich 1923a, 1926). Heinrich separated species by wing pattern and genitalia, and the majority of his taxa with rearing records were restricted to a single host, with a few exceptions. Subsequent authors (e.g., McDunnough 1938) also relied on genitalia and wing pattern along with host data to separate species. Gilligan et al. (2008) attempted to illustrate and diagnose several of the North American *Paralobesia*, and discovered that associating sexes of several species was problematic due to the lack of type material, the fact that the genus contained several undescribed species, and host records alone not being sufficient to separate closely-related species. Alternative techniques, such as DNA barcoding (Hebert et al. 2003), provide an additional data set with which to test species boundaries and congruence of morphological and/or host data. Molecular data have been successfully used to solve taxonomic problems in the Tortricidae in numerous studies (e.g., Mutanen et al. 2012; Brown et al. 2014; Gilligan et al. 2014, 2016). The most comprehensive DNA barcoding database is hosted by the Barcode of

Life Data System (BOLD; Ratnasingham and Hebert 2007). BOLD currently (March, 2018) contains 282 *Paralobesia* specimens with sequence data representing a reputed 26 species.

Recently, a species of *Paralobesia* was reared from *Cypripedium reginae* Walter (Orchidaceae) in the course of a study of two populations of this orchid in eastern Ontario and southwestern Québec (Light and MacConaill 2013; Landry *et al*. 2015). Literature suggested that *P*. *cypripediana* (Forbes) was the only lepidopteran associated with *C*. *reginae*. Life history details of this *Paralobesia* were lacking except for emergence dates for the type specimens which were reared by Norman Criddle from *C*. *reginae* fruits in Manitoba. *Cypripedium reginae*, the Showy Lady's Slipper, is present in populations throughout much of eastern North America (Rankou 2014). It is listed as endangered or threatened in 14 U.S. states (USDA, NRCS 2018), and populations are localized and disjunct due to the orchid's narrow habitat requirements.

Between 2008 and 2017, repeated attempts were made by Marilyn Light to rear adults from infested fruits of *C*. *reginae*, mostly collected from the Québec site (detailed in Light and MacConaill 2013). In late June 2012, M. Light found fresh eggs laid singly on the underside of floral bracts of *C*. *reginae* plants in bloom at both sites. J.-F. Landry recognized them as tortricid eggs and it was surmised that these were likely the eggs of *Paralobesia* that had been found to infest the fruits. A few eggs were collected for barcoding, confirming that they were conspecific with barcoded larvae harvested from the fruits at the site, as well as with the reared adults.

Attempts were made by J.-F. Landry and M. Light to find and capture *Paralobesia* adults in their habitat coincident with June dates when freshly laid eggs were repeatedly

observed on *C*. *reginae* floral bracts at both sites in 2012 and 2013. No adults were found using mercury and ultraviolet lights and sheets, as well as during day-time searching and gentle net sweeping on and around flowering orchid plants. The high susceptibility of the orchid to mechanical disturbance and treading limited the efforts that could be safely deployed to find and collect adults without damaging the fragile host plants.

All the rearing efforts had limited success despite controlling humidity and temperature and trying to mimic microhabitat conditions (which were monitored in real time with recording probes), only five adult males emerged (1 in 2014, 2 in 2015, and 2 in 2016) and no females were obtained. While most larvae placed in rearing containers completed their development, successfully overwintered, and pupated, the majority of pupae so obtained failed to metamorphose and died after overwintering. However, over the course of the same study, M. Light also managed to rear several individuals of *Paralobesia* from *Monotropa uniflora* L. (Ericaceae) and *Rhus typhina* L. (Anacardiacae) occurring in the same location.

While preparing a comprehensive systematic revision of *Paralobesia*, we examined the specimens reared by Light and MacConaill and DNA barcode data on these and other *Paralobesia* included in the BOLD database. The specimens reared from *C*. *reginae* group discretely into two separate clusters which are distinct from the specimens reared from *Monotropa* (Fig. 1). Both the *Monotropa*-feeding cluster and one of the *Cypripedium*-feeding clusters also contain specimens reared from *Rhus*. After examining the type specimens of *P*. *cypripediana* and *P*. *monotropana* (Heinrich), we determined that the former species is represented by the *Cypripedium* + *Rhus* cluster

and the latter species is represented by the *Monotropa* + *Rhus* cluster. The other *Cypripedium* cluster, consisting of only specimens from eastern Ontario and southwestern Québec, represents a new species. All three species can be reliably separated using genitalic characters and DNA sequence data. Herein, we provide redescriptions of *P*. *cypripediana* and *P*. *monotropana*, and describe the new *Cypripedium*-feeding species as *P*. *marilynae*, sp.n. We also provide a discussion of larval hosts in relation to DNA and morphological data and implications regarding monophagy in the rest of the genus.

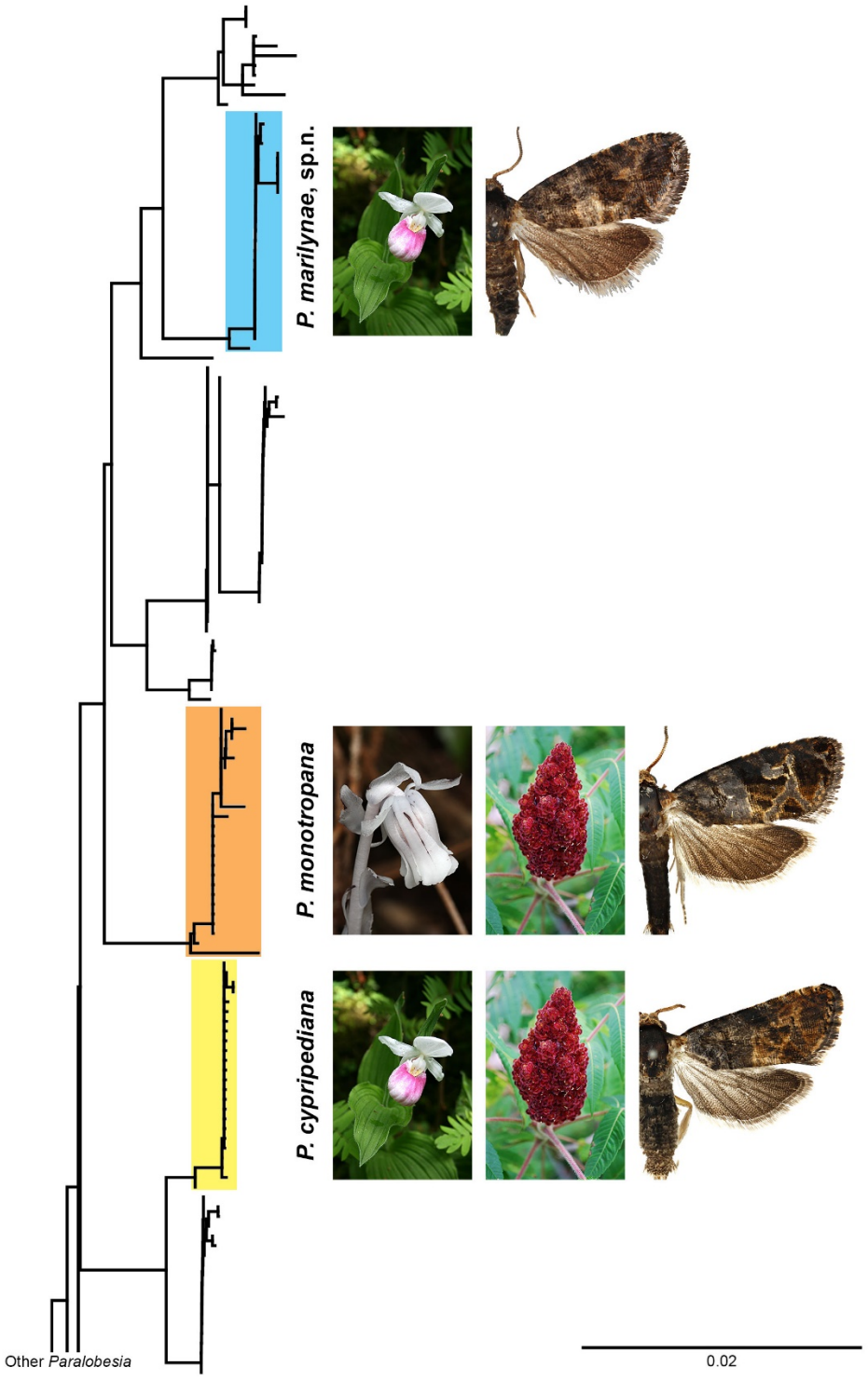


Fig. 1: Neighbor-joining tree of COI DNA barcodes (Photo credits: Walter Siegmund for *Monotropa uniflora*; Jean-Pol Grandmont for *Cypripedium reginae*; and Joshua Mayer for *Rhus typhina*; all photos used under the Creative Commons 2.0/3.0 license).

Materials and Methods

We examined 51 adult specimens (29 ♂, 22 ♀) together with 42 associated genitalia preparations deposited in the following collections: National Museum of Natural History, Washington, D.C., U.S.A. (USNM); American Museum of Natural History, New York, U.S.A. (AMNH), Cornell University Insect Collection, Ithaca, New York, U.S.A. (CUIC), and Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, Ontario, Canada (CNC).

Images of adults were taken with Canon 100 mm and MP-E 65 mm macro lenses attached to a Canon 5DS digital SLR (Canon U.S.A., Inc., Melville, NY). Images of genitalia were taken with a Nikon DS-Fi1 digital microscope camera attached to a Nikon Eclipse E400 or E800 compound microscope (Nikon Instruments, Inc., Melville, NY). All images were edited using Photoshop CS6 Extended (Adobe Systems, Inc., San Jose, CA). Forewing length (FWL) is defined as the distance from the base to the apex including the fringe, reported to the nearest one-tenth of a millimeter. Measurements were made with the “Analysis” tool in Photoshop using known measurement scales. Abbreviations are as follows: HTP = holotype; LTP = lectotype; n = the number of observations supporting a particular statistic; PLTP = paralectotype; PTP = paratype. Dissection methods follow those presented in Brown and Powell (1991), and terminology for the structures of the male genitalia follows Diakonoff (1954; e.g., Spc_1 = spine cluster 1) (Fig. 2). We use the Regier et al. (2012) definitions of host plant use, where “oligophagous” refers to species that use hosts from a single plant order and “polyphagous” refers to species that use hosts in two or more plant orders. We also

define “monophagous” as referring to species that use hosts in only a single family and “strictly monophagous” as referring to taxa that utilize only a single plant species.

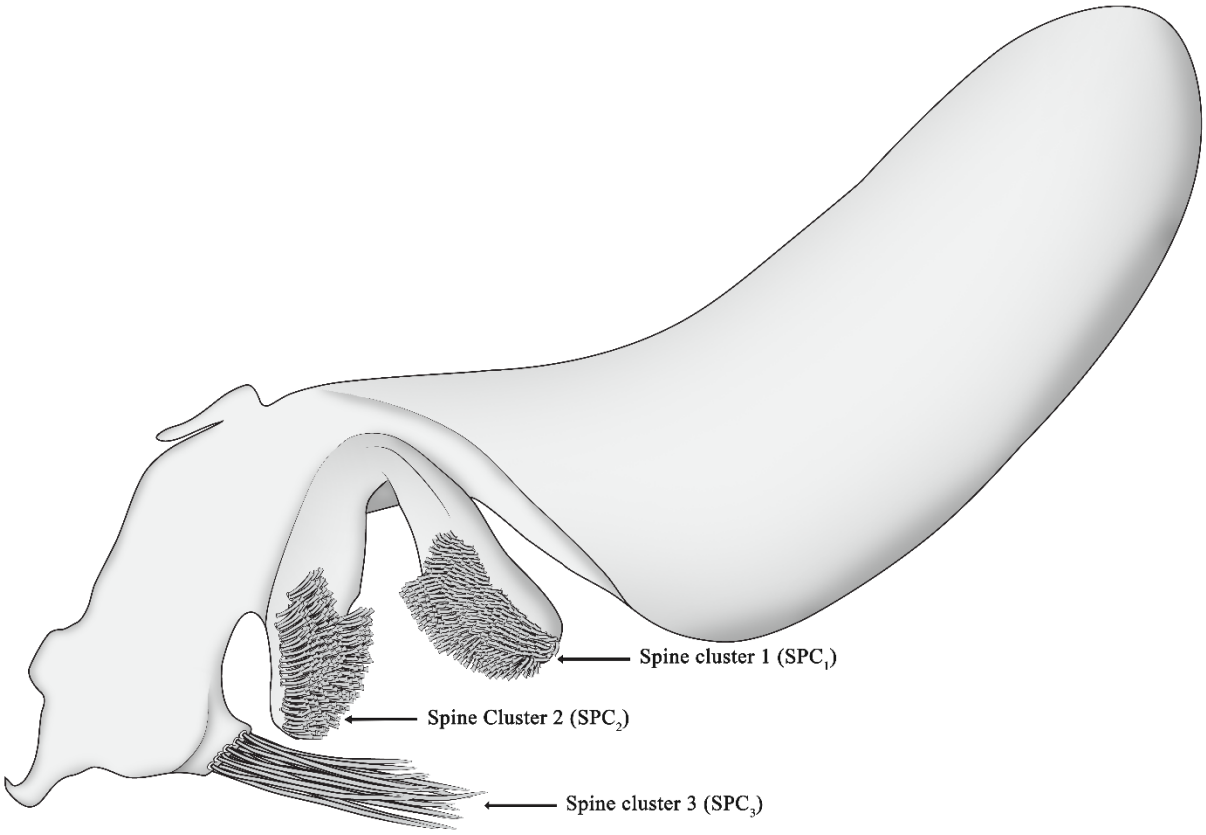


Fig. 2: Labeled spine clusters on projections from sacculus on *Paralobesia* valva.

Tissue for sequencing was prepared according to predefined standards and processed at the Canadian Centre for DNA Barcoding (CCDB, Biodiversity Institute of Ontario, University of Guelph) to obtain COI DNA barcodes using the standard high-throughput protocol (deWaard et al. 2008). DNA sequences were automatically uploaded to the Barcode of Life Data Systems (BOLD; Ratnasingham and Hebert

2007). A neighbor-joining (distance) tree of DNA barcode data was constructed under the Kimura 2 parameter model (K2P) for nucleotide substitutions using PAUP* (Swofford 2003) and Geneious Pro R9.1.5 (Drummond et al. 2012).

Results and Discussion

The neighbor-joining tree constructed from DNA barcode data clearly delineates the specimens reared by Light and MacConaill (2013) into two separate clusters (Fig. 1, top and middle). These two clusters are separate from another cluster of specimens that includes specimens reared from *Cypripedium* and *Rhus* (Fig. 1, bottom). Determination of the identities of these groupings was done by comparing genitalia dissections of several specimens within each group with those of the type material for *P*. *cypripediana* and *P*. *monotropana* deposited in the AMNH. The lectotype of *P*. *cypripediana* is a male specimen, and several female paralectotypes were also examined. Likewise, the holotype of *P*. *monotropana* is a male specimen, and one of the two female paratypes was examined.

The bottom cluster of specimens (Fig. 1) was determined to represent *P*. *cypripediana*. Male genitalia of *P*. *cypripediana* are characterized by the long setae at the apex of the uncus, the narrow and parallel-sided cucullus, Spc_1 extending only slightly past the ventral margin of the cucullus, and the relatively short (0.33 × length of the cucullus) phallus with a variable number of teeth. Female genitalia are characterized by the conical sterigma and accessory sacs originating from the anterior end of the corpus bursae that are ca. 0.2 × length of the corpus bursae. This cluster consists of

sequences from 20 individuals, and we examined another 22 specimens that were identified using genitalic dissection. Of the reared specimens, 11 are from *C*. *reginae* and 29 are from *Rhus*.

The middle cluster of specimens (Fig. 1) was determined to represent *P*. *monotropana*. In male *P*. *monotropana* (Fig. 3), Spc_1 is dilated distally, the setae on the uncus are shorter, not reaching the tegumen and the tooth-like projections on the phallus are flattened and joined near the base, and located closer towards the apex than in *P*. *cypripediana*. In females, the sterigma of *P*. *monotropana* is more bell-shaped rather than conical, with an emargination in the anterodorsal margin that is not present in *P*. *cypripediana*. This cluster consists of sequences from 26 individuals; we examined another 17 specimens that were identified using genitalic dissection. Of the specimens with host data, 21 were reared from or associated with *M*. *uniflora*. Three of the specimens reared by M. Light were collected from *R*. *typhina*. The majority of reared specimens are from Québec.

The top cluster of specimens (Fig. 1) can be separated from both *P*. *cypripediana* and *P*. *monotropana* by the shape of the cucullus, being enlarged distally rather than tapering at apex, the shape or size of all three spine clusters ($Spc_{1–3}$), the lack of setae at the apex of the uncus, and the shape and length of the phallus, which has a single tooth at the apex. These specimens are not conspecific with any currently described *Paralobesia*, and are described here as *P*. *marilynae*, sp.n. This cluster consists of sequences from 25 individuals. The majority of sequences represent unhatched eggs and larvae that did not complete development; only five male specimens completed development to the adult stage. All specimens of *P*. *marilynae* were found on and/or

reared from *Cypripedium reginae* in Québec and Ontario. Although other species of *Cypripedium* are found in North America, extensive examination of other *Cypripedium* resulted in no evidence of feeding or damage by *Paralobesia* in the field or on herbarium sheets (M. Light, pers. comm.).

All three species are internal feeders. Those feeding on *C*. *reginae* bore into the ovary as a first instar larva. Rearing experiments and dissections of infested ovaries indicate that larvae feed primarily on the ovary tissue but avoid the developing seeds. If a developing ovary is not available, or fruit and foliage resources are depleted, as during bagging for study, larvae will enter the plant stem to feed on stem pith. Those specimens feeding on *Monotropa* enter developing ovaries through the pistil and feed on the interior tissue, also avoiding feeding on the developing seeds. Those specimens feeding on *Rhus* were observed feeding among the infructescences (Light and MacConaill 2013).

Determining larval host trends in *Paralobesia* is difficult because of the number of undescribed species in the genus. After preparing genitalia dissections for hundreds of *Paralobesia*, we have determined that even common taxa (e.g., *P*. *viteana*) are routinely misidentified and mixed with undescribed cryptic species in collections. These types of misidentifications have the potential to invalidate literature records; and, although Brown et al. (2008) lists host records for 14 species of *Paralobesia*, we are hesitant to rely on any published information until the specimens are reevaluated using a combination of genitalic characters and DNA data. Thus, the conclusions we draw here are based solely on the specimens examined for this study, and their application to the remainder of the genus is yet to be determined.

For the Olethreutinae, it has been hypothesized that internal feeding favored speciation or diversification, and internal feeding is more likely to result in monophagy or oligophagy (Regier et al. 2012). This is the general trend in other Lepidoptera, where internal feeding results in a closer functional relationship with the host, and thus a higher level of specialization (Menken et al. 2010). Monophagy (or oligophagy) has been assumed for other species-rich olethreutine genera (e.g., *Olethreutes*; Gilligan et al. 2008), but unresolved taxonomic problems and species complexes with numerous cryptic species hinder these conclusions. For the current taxa, *P*. *marilynae* appears to be strictly monophagous on *C*. *reginae*, although only a few specimens have completed development to adulthood in captivity. *Paralobesia monotropana* is recorded on both *Monotropa* and *Rhus*, implying that it is polyphagous, as the two plants are in different orders. This also seems to be the case for *P*. *cypripediana*, which has number of records on either C*ypripedium* or *Rhus*. From this data, it appears that *Paralobesia* can span the range from strictly monophagous to polyphagous, even for very similar species with similar feeding habits, and that different species will feed on the same hosts. Whether this is the trend for the entire genus remains to be determined, but certainly any supposition that “different host = different species” needs to be verified using other sources of data.

Paralobesia monotropana (Heinrich, 1926)

Figs. 3, 6, 8–12

Polychrosis monotropana Heinrich 1926:91; McDunnough 1939:40; Clarke 1953:229.
Paralobesia monotropana; Obraztsov 1953:92; Brown 2005:472; Gilligan et al. 2008:47.
Endopiza monotropana; Powell 1983:31.

Diagnosis. *Paralobesia monotropana* is superficially similar to both *P*. *cypripediana* and *P*. *marilynae*, but the three species can be separated by features of the male genitalia. In *P*. *monotropana*, Spc_1 is ca. 1.5 times as large as Spc_2, and the pad of spines extends ca. 0.5 times its length past the ventral margin at the base of the cucullus. In *P*. *cypripediana*, Spc_1 is about the same size as Spc_2, and the pad of spines extends no more than 0.25 times its length past the ventral margin at the base of the cucullus. In *P*. *marilynae*, Spc_1 is about the same size as Spc_2, and the pad of spines extends ca. 0.5 times its length past the ventral margin at the base of the cucullus. The emargination between Spc_3 and Spc_2 is rounded and shallow in *P*. *monotropana*, rounded but deeper in *P*. *cypripediana*, and shallow but angular in *P*. *marilynae*. The phallus of *P*. *monotropana* has a series of short wide teeth on the apical 0.33. In *P*. *cypripediana* these teeth are smaller and narrower, and extend from a serrated dorsal keel near the middle of the phallus. In *P*. *marilynae* there is a single tooth near the apex of the phallus. The setae on posterior surface at the apex of the uncus are shorter than the uncus in *P*. *monotropana*, longer than the uncus in *P*. *cypripediana*, and absent in *P*. *marilynae*. Most other species of *Paralobesia* that resemble *P*. *monotropana* have long (extending past Spc_1) setae at Spc_3 versus the relatively short setae (not extending past

Spc_1) in *P*. *monotropana*, and a different configuration of teeth on the phallus. In females of *P*. *monotropana*, the sterigma is bell shaped and the anterodorsal margin extends past the ventral, with a medial depression that often extends posteriorly past the anteroventral margin. That of *P*. *cypripediana* is more conical, and the anterior margins are even in length.

Redescription. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.7 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales; posterior crest mottled with dark brown and orange scales; legs pale brown with white annulations on tibia and tarsal segments. Forewing length 4.2–5.2 mm (mean 4.6 mm; n = 9); ground color blue grey, wing markings varying from dark reddish brown to mottled pale brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum; median fascia dark brown in costal half with a mix of pale brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, an oval patch at costa and a triangular pretornal patch; postmedian band a large semioval patch extending to termen, usually with notch originating from termen near M_3; preterminal fascia a small indistinct patch near apex; fringe scales darkly mottled. Hindwing uniform dark brown with paler scales at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Pale to dark brown. Genitalia with uncus curved posteriorly, with patch of setae shorter than uncus extending ventrally from apex of each

lobe; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus clavate, stout, costal margin broadly concave, apex narrowly rounded, ventral margin convex with slight medial concavity, ventral half covered in stout spine-like setae, apex and dorsal half covered in fine setae; Spc_1 separated from cucullus by moderate narrow emargination, extending ventrally beyond cucullus ca. 0.5 times its length, Spc_1 and Spc_2 separated by deep U-shaped emargination, Spc_2 0.75 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by shallow emargination, Spc_3 on a raised lobe, spines on Spc_3 stout and spikelike, extending past edge of Spc_2. Phallus tapering distally, curved, length ca. 0.66 that of the cucullus, with 3–5 short broad teeth along dorsal margin near apex. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.5–5.5 mm (mean 4.9; n = 10). *Abdomen*: Coloration variable, mostly brown with darker scaling on posterior segments. Genitalia apophyses anteriores ca.1.5 times as long as apophyses posteriores; sterigma bell-like, moderately sclerotized and smooth, with a slight indentation along the dorsal anterior margin, posterior margin serrate; ostium oriented posterodorsally; ductus bursae ca. 2.0 times as long as corpus bursae; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with paired, narrow, linear signum consisting of thickened cells and two accessory sacs, usually less than 0.1 length of corpus bursae.

Holotype. ♂, “Cincinnati, O., Annette F. Braun, VIII-24-07, on *Monotropa uniflora*; 227; Am. Mus. Nat. Hist. Dept. Invert. Zool. No.; ♂ genitalia on slide, CH. 19 May 1922; *Polychrosis monotropana* Hein. TYPE” (AMNH).

Paratype. **USA**: Maryland, Cabin John Bridge, R. M. Fouts, “seed capsules of *Monotropa*,” 22 Aug 1923 (1 ♀, USNM).

Additional specimens examined. **CANADA**: Ontario: Vineland Station, W. L. Putman, 4 Jul 1942 (1 ♂, CNCLEP 00105123, slide TOR 5116, CNC); 20 Jul 1942 (1 ♀, CNCLEP00105122, slide TOR 5117, CNC). Québec: Gatineau Park, Marilyn H. S. Light; pupa from *Monotropa uniflora*, 16 Sep 2014 (1 ♀, CNCLEP 00132701, slide TOR 5115, CNC); Ramsay Lake, eggs collected 27 Jul 2015, pupated 6 Aug 2015, emerged 22 Aug 2015 (1 ♂, CNCLEP00138308, slide HRR 244, CNC); Eardley-Masham Road, Trail 56, larvae collected 30 Jul [2016], pupated 6–8 Aug [2016]; emerged 25 Aug 2016 (1 ♂, CNCLEP00141700, slide HRR 246, CNC); emerged 26 Aug 2016 (1 ♀, CNCLEP00141702, slide HRR 244, CNC); emerged 27 Aug 2016 (1 ♂, CNCLEP 00141703, slide HRR 245, CNC); emerged 28 Aug 2016 (1 ♀, CNCLEP00141704, slide HRR 247, CNC); larva from *Rhus typhina*, 5 Aug [2016], pupated 7 Aug [2016], emerged 29 Aug 2016 (1 ♂, CNCLEP00141697, slide HRR 248, CNC); **USA**: Maryland, Washington Co., N.E. Boonsboro Greenbrier St. Park, W. E. Steiner *et al*., 8–10 Aug 1986 (1 ♂, slide HRR 037, USNM; 1 ♀, slide HRR 034, USNM); Wheaton, Homerleigh Rd., woods, K. Sommerman, 23 Aug 1950, from *Monotropa uniflora* (4 ♂, slides HEE 033, HRR 035, USNM 124982 [slide missing], USNM), (3 ♀, slides HRR 032, USNM 124981 [slide missing], USNM).

Distribution and biology. *Paralobesia monotropana* is recorded from northeastern U.S. (Maryland and Ohio) and southeastern Canada (Ontario, and Québec). Rearing records indicate that *Monotropa uniflora* (Ericaceae) is the primary larval host, although a few specimens have been reared from *Rhus typhina*

(Anacardiacae). Observations indicate that this is not an occurrence of accidental oviposition (M. Light, pers. comm). Females deposit eggs on floral bracts or flower petals, rarely on stems. First instar larvae enter the developing ovary through the pistil. Larvae feed on the interior ovary tissue, but do not feed on seeds; larvae will feed on stem pith if ovary tissue is completely consumed. Collection dates indicate a flight period from early June to late August.

Discussion. Heinrich (1926) listed two female paratypes with identical collection data (USNM), but we were able to locate only one of them.

Paralobesia cypripediana **(Forbes, 1923)**

Figs. 4, 7, 13–17.

Polychrosis cypripediana Forbes 1923:473; Heinrich 1926:92; McDunnough 1939:40.
Paralobesia cypripediana; Obraztsov 1953:92; Brown 2005:472.
Endopiza cypripediana; Powell 1983:31.

Diagnosis. *Paralobesia cypripediana* is superficially similar to both *P*. *monotropana* and *P*. *marilynae*, but the three species can be separated by the arrangement of the spine clusters, the teeth on the phallus, and the setae on the uncus in the males. These differences are detailed in the diagnosis of *P*. *monotropana*. Most other species of *Paralobesia* that resemble *P*. *cypripediana* have long (extending past Spc_1) setae at Spc_3 versus the relatively short setae (not extending past Spc_1) in *P*. *cypripediana*, and a different configuration of teeth on the phallus. Female genitalia are

indistinguishable from those of *P*. *rhoifructana* (Kearfott, 1904) and *P*. *yaracana* (Kearfott, 1907).

Redescription. **Male**. *Head*: Vertex rough scaled, pale brown; labial palpus pale brown, all segments combined ca.1.75 times diameter of compound eye, segment II rough scaled with dash of black scales laterally, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales with transverse band of dark scales; posterior crest mottled with dark brown and orange scales; fore- and mid-legs dark brown with tan annulations on tibia and tarsal segments, hind legs mostly pale brown with white annulations on tarsal segments. Forewing length 4.4–5.4 mm (mean 4.7 mm; n = 11); ground color blue grey, wing markings varying from dark reddish brown to mottled pale brown; costal strigulae pairs 2–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, and narrowing from cubitus to dorsum; median fascia dark brown in costal half, mixed with pale brown in dorsal half, broad from costa to cubitus, distal margin extending towards termen along cubitus, and angling back to dorsum; postmedian fascia divided into two sections, an oval patch at costa and a triangular pretornal patch; postmedian band a large semioval patch extending to termen, usually with notch originating from termen near M_3, coloration variable; preterminal fascia a small circular patch near apex, center dark; fringe scales darkly mottled. Hindwing uniform dark brown with paler scales at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Coloration pale to dark brown. Genitalia with uncus reduced to short rounded lobe, curved posteriorly, with patch of setae longer than uncus extending ventrally from apex of each side of lobe; socius

absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus clavate, stout, costal margin broadly concave, apex narrowly rounded, ventral margin convex, ventral half covered in stout spine-like setae, apex and dorsal half covered in fine setae; Spc_1 separated from cucullus by moderate narrow emargination, extending ventrally beyond cucullus ca. 0.25 times as its length, Spc_1 and Spc_2 separated by deep U-shaped emargination, Spc_2 ca. same size as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by deep rounded emargination, Spc_3 on a raised lobe, spines on Spc_3 stout and spikelike, extending past edge of Spc_2. Phallus tapering distally, curved, length ca. 0.5 that of cucullus, with 2–5 teeth of variable size situated on keel near center. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.1–5.5 mm (mean 5.0 mm; n = 5). *Abdomen*: Coloration variable, mostly brown with darker scaling on posterior segments. Genitalia apophyses anteriores ca.1.3 times as long as apophyses posteriores; posterior 0.25 of ductus seminalis moderately sclerotized; ductus bursae ca. 2.0 times as long as corpus bursae; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with faint, shallow signum and two small accessory sacs, sacs less than 0.2 length of corpus bursae. Sterigma conical, moderately sclerotized, and microtrichiate on anterior 0.25, posterior margin serrate; ostium oriented posterodorsally.

Lectotype. ♂, “Aweme, Manitoba, N Criddle, Jan. 14. 09; Am. Mus. Nat. Hist. Dept. Invert. Zool. No.; Kearfott Col. Ac. 4667; Reared from *Cypripedium spectabile* seed pods; ♂ genitalia on slide, CH 19-May 1922; *Polychrosis cypripediana* Forbes. TYPE; LECTOTYPE” (AMNH).

Paralectotypes. **CANADA**: same data as lectotype, “reared from *Cypripedium spectabile* seed pods,” “larva found 25 Aug 1905” [Jan 1906] (1 ♀ [unconfirmed, hindwings and abdomen missing], AMNH); 14 Apr 1907 (1 ♀ [unconfirmed, only thorax and left forewing], USNM); 24 Apr 1907 (1 ♀, slide HRR 091, USNM); 14 Jan 1909 (1 ♂, slide 71760, CH wing slide, USNM); 14 Jan 1909 (1 ♀, slide 97884, wing slide 71761, USNM); 14 Jan 1909 (1 ♂, slide TOR-1355, CNC).

Additional specimens examined. **CANADA**: Manitoba: Aweme, N. Criddle; 22 Feb 1909 (1 ♀, CNCLEP00103641, slide TOR 5118, CNC); 15 Nov 1910 (1 ♂, CNCLEP00103642, slide TOR 1357, CNC; 1 ♀, CNCLEP00103643, slide TOR 5119, CNC). New Brunswick: Queens, Akerlery, from Sumac, 15 Mar 1968 (1 ♂, CNCLEP00105128, slide TOR 5085, CNC; 1 ♀, CNCLEP00099640, slide HRR 299, CNC); 20 Mar 1968 (1 ♂, CNCLEP00099639, slide TOR 5129, CNC; 1 ♀, CNCLEP00105129, slide TOR 5086, CNC). Ontario: Renfrew, Richards Twp., J. J. Dombroskie, L. M. Gilines, & R. A. St. Laurent, 22 Jun 2015 (1 ♂, TOR-DNA-1037, slide HRR 120, CUIC). Québec: Gatineau Park, edge of Gatineau Parkway, Marilyn H. S. Light, larva collected from *Rhus typhina* 31 Jul 2015, pupated 19 Aug 2015, overwintered until 31 Mar 2016, emerged 30 Apr 2016 (1 ♀, CNCLEP00141503, slide HRR 239, CNC); Kazabazua, J. McDunnough, 3 Mar 1923 from Sumac (1 ♂, CNCLEP00099638, slide HRR 262, CNC; 1 ♂, CNCLEP00099636, slide TOR 1356, CNC; 1 ♂, CNCLEP00099637, slide TOR 5128, CNC; 1 ♀, CNCLEP00099634, slide HRR 263, CNC; 2 ♀, CNCLEP00099633, CNCLEP00099635, CNC); Gatineau Park, Folly Bog (fen), near Hickory Trail, Marilyn H. S. Light, from *Rhus typhina*, larva collected 24 Jul [2016], transferred to feed on *Cypripedium reginae*, pupated 30 Jul

[2016], emerged 18 Aug 2016 (1 ♂, CNCLEP00141694, slide HRR 238, CNC); **USA**: Tennessee: Chester Co., near Henderson, K. Childs, 8-12 Apr 2015, (1 ♀, TOR-DNA-1046, slide HRR 008, CUIC). Virginia: Falls Church, C. Heinrich, reared 25 May 1915, on *Rhus copalina* [= *copallinum*] (1 ♂, CNCLEP00099632, slide TOR 5127, CNC). New York: Lake Ontario, near Roch[ester], 17, Jul 1893 (1 ♂, slide HRR 300, wing slide, USNM 71761, USNM).

Distribution and biology. *Paralobesia cypripediana* is recorded from southern Manitoba east across southern Ontario and Québec to New Brunswick, south to Virginia and Tennessee. As its name suggests, *P*. *cypripediana* is often found in association with one of its larval hosts, *C*. *reginae* (Orchidaceae) (listed as *C*. *spectabile* on older labels). However, more specimens have been reared from *Rhus* (Anacardiaceae) (including *R*. *typhina* L. and *R*. *copallinum* L.) than *Cypripedium*, suggesting that larvae are at least oligophagous on plants in similar habitats. Collection dates suggest a flight period from early March to late August. The midwinter emergence dates listed by Criddle are likely due to indoor rearing (Heinrich 1926).

Discussion. The lectotype designation attributed to Heinrich (1926) by Klots (1942) is valid; there is only one male specimen in the AMNH. We located six labeled paratypes as listed by Heinrich (1926); however, dates for two do not match those given in the original description. We assume that the date for the male listed as “Jan. 1-09” is actually 14 Jan 1909, and that the date for one of the females cited as “14-IV-07” is actually 24 Apr 1907.

In his monograph on the Lepidoptera of New York and neighboring states, Forbes (1923) included a brief description of the wing pattern of *P*. *cypripediana*. He

credited the name to Kearfott, who had used *cypripediana* as a manuscript name for a series of specimens reared from the seeds of *Cypripedium* in Aweme, Manitoba by Criddle. As such, Forbes (1923) did not designate any types or provide any specimen data. Heinrich (1926) examined these specimens, which consist of three males and four females, and designated a male as the lectotype, attributing the name to Forbes.

Paralobesia marilynae **Royals and Gilligan, sp.n.**

Figs. 5, 18–22

Diagnosis. *Paralobesia marilynae* is similar to both *P*. *monotropana* and *P*. *cypripediana*. All three species can be separated by the arrangement of the spine clusters, the teeth on the phallus, and the setae on the uncus in the males; these differences are discussed under the *P*. *monotropana* description. Most other species of *Paralobesia* that resemble *P*. *marilynae* have long (extending past Spc_1) setae at Spc_3, versus the relatively short (not extending past Spc_1) in *P*. *marilynae*, and a different configuration of teeth on the phallus, if present. Females are unknown.

Description. **Male**. *Head*: Vertex rough scaled, pale brown; labial palpus pale brown, ca.1.75 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales; posterior crest mottled with dark brown and orange scales; fore- and mid-legs dark brown with tan annulations on tibia and tarsal segments, hind legs mostly pale brown with white annulations on tarsal segments. Forewing length 5.2–5.7 mm (n = 3); ground color blue grey, wing markings dark reddish brown and bright orange; costal

strigulae pairs 2–9 expressed as pale brown dashes along costa; subbasal fascia a narrow band narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum; median fascia dark brown, broad from costa to cubitus, distal margin extending towards termen along cubitus, and angling back to dorsum; postmedian fascia divided into two sections, an oval patch at the costa and a triangular pretornal patch, both mottled with bright orange scales; postmedian band a large semioval patch, scaled dark brown, extending to termen, usually with notch originating from termen near M_3; preterminal fascia a small irregular patch near apex; fringe scales darkly mottled. Hindwing a uniform dark brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Coloration pale to dark brown. Genitalia with uncus reduced, weakly bilobed, curved posteriorly, without patch of setae from apex; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; Cucullus clavate, costal margin concave, with slight angle medially, apex broadly rounded, ventral margin convex, ventral half covered in stout spine-like setae, apex and dorsal half covered in fine setae; Spc_1 separated from cucullus by moderate narrow emargination, extending ventrally beyond cucullus ca. 0.50-0.75 times as its length, Spc_1 and Spc_2 separated by deep U-shaped emargination, Spc_2 0.75 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by shallow emargination, Spc_3 on a raised lobe, spines on Spc_3 stout and spikelike, extending past edge of Spc_2. Caulis large, ca. same length as phallus. Phallus tapering distally, curved, ca. same length as cucullus, a single tooth near apex. **Female**. Unknown.

Holotype. ♂, “Canada, QC, Gatineau Park, Folly Bog [fen], 45.456084°N 75.782735°W; Marilyn H.S. Light, 3.VII.2014; Larvae ex *Cypripedium reginae* stem+fruit; Adult emerged 30.IV.2015; CNCLEP00132704; Barcode of Life Project, Leg(s) removed, DNA extracted; ♂ genitalia on slide, HRR 242” (CNC).

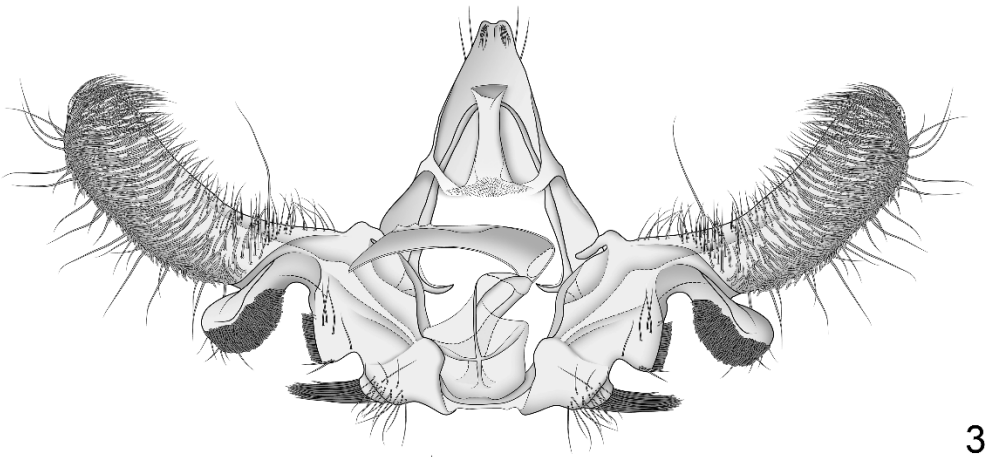
Paratypes. **CANADA**: same location, collector, and host as holotype; near Hickory Trail, 45.45°75.7667°W, 138 m, egg laid 24 Jun 2013, hatched 28 Jun 2013, holed fruit & pupal shelter 8 Sep 2013, overwintered 17 Oct 2013, taken out 26 Mar 2014, emerged 2 May 2014 (1 ♂, slide TOR 5114, CNCLEP00112595, CNC); larva bagged on plant# FB131109C on 3 Jul 2014, emerged 28 Mar 2015 (1 ♂, CNCLEP00132703, CNC); larva collected on 5 Aug 2015, adult emerged 30 Apr 2016 (1 ♂, slide HRR 241, CNCLEP00141502, CNC); larva collected on 7 Aug 2015, pupated 12 Aug 2015, emerged 28 Mar 2016 (1 ♂, CNCLEP00141501, CNC).

Etymology. This species is named in honor of Marilyn H.S. Light, who has contributed greatly to our knowledge of *Paralobesia* biology by monitoring *Cypripedium reginae* populations in Gatineau Park for many years.

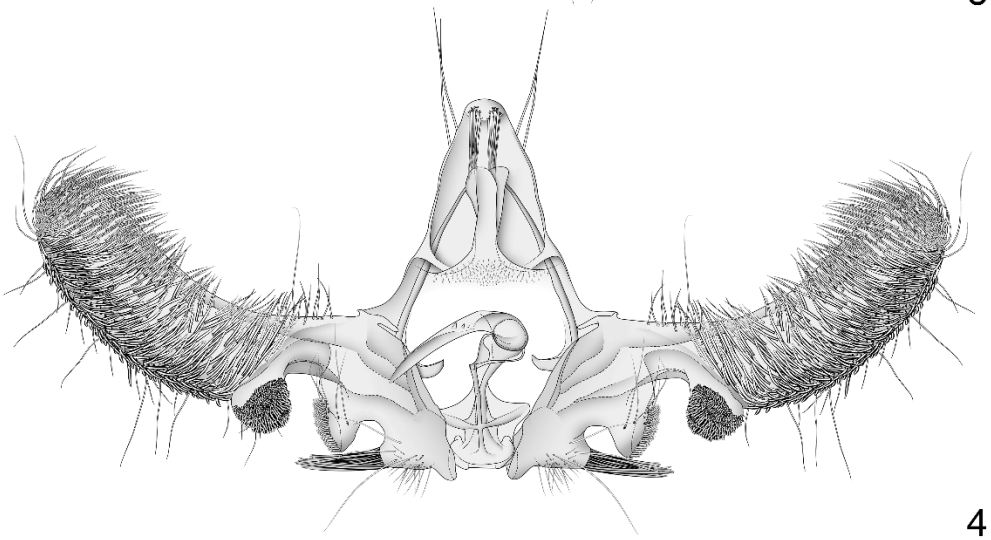
Distribution and biology. Of the 25 sequenced specimens verified as *P*. *marilynae*, 20 were collected from a population of *C*. *reginae* plants in Gatineau Park in southwestern Québec, while the remaining five were collected from *C*. *reginae* plants located in Lanark in eastern Ontario. The full range of this species is unknown. Eggs of *P*. *marilynae* are laid prior to seed development over a period of one to two weeks. Eggs are laid on the underside of the floral bracts and hatch within 36 hours. Upon hatching, larvae enter a developing ovary and feed on ovary tissue. If a capsule is not available, larvae will enter the stem of the plant. There is little evidence that they will

feed on developing seeds. Larvae will leave the seed capsule to pupate when desiccation of the capsule occurs, or when the food source is depleted. Rarely will they leave to feed on foliage. Larvae *in situ* likely drop or crawl to the ground and create a fold in deciduous litter in which to pupate.

Discussion. The five specimens listed above are the only specimens reared to adulthood. An additional 20 specimens (14 larvae and six eggs) were determined to be *P*. *marilynae* using DNA barcoding, but these are not included in the type series.



3



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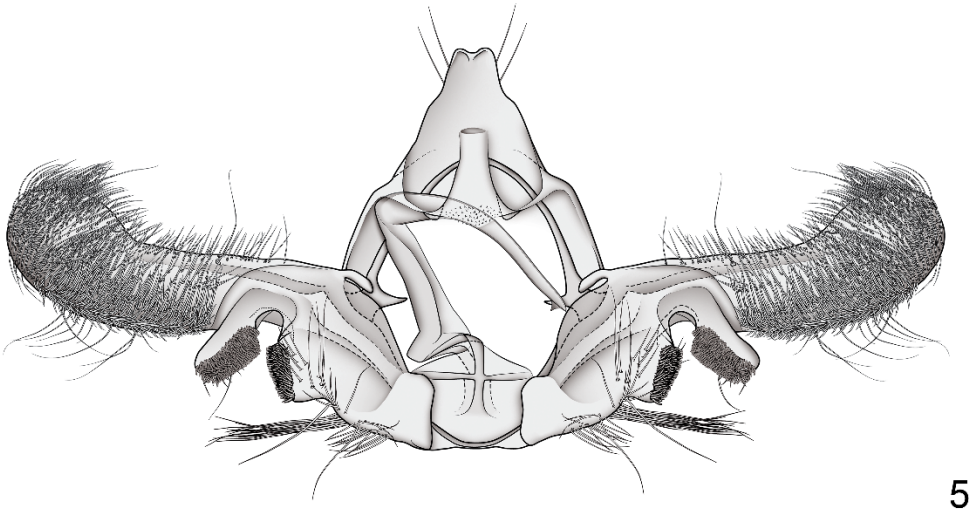

5

Illustrations of male genitalia. Fig. 3: *Paralobesia monotropana* (slide HRR 243); Fig. 4: *P. cypripediana* (slide HRR 120); Fig. 5: *P. marilynae* (slide TOR 5114).

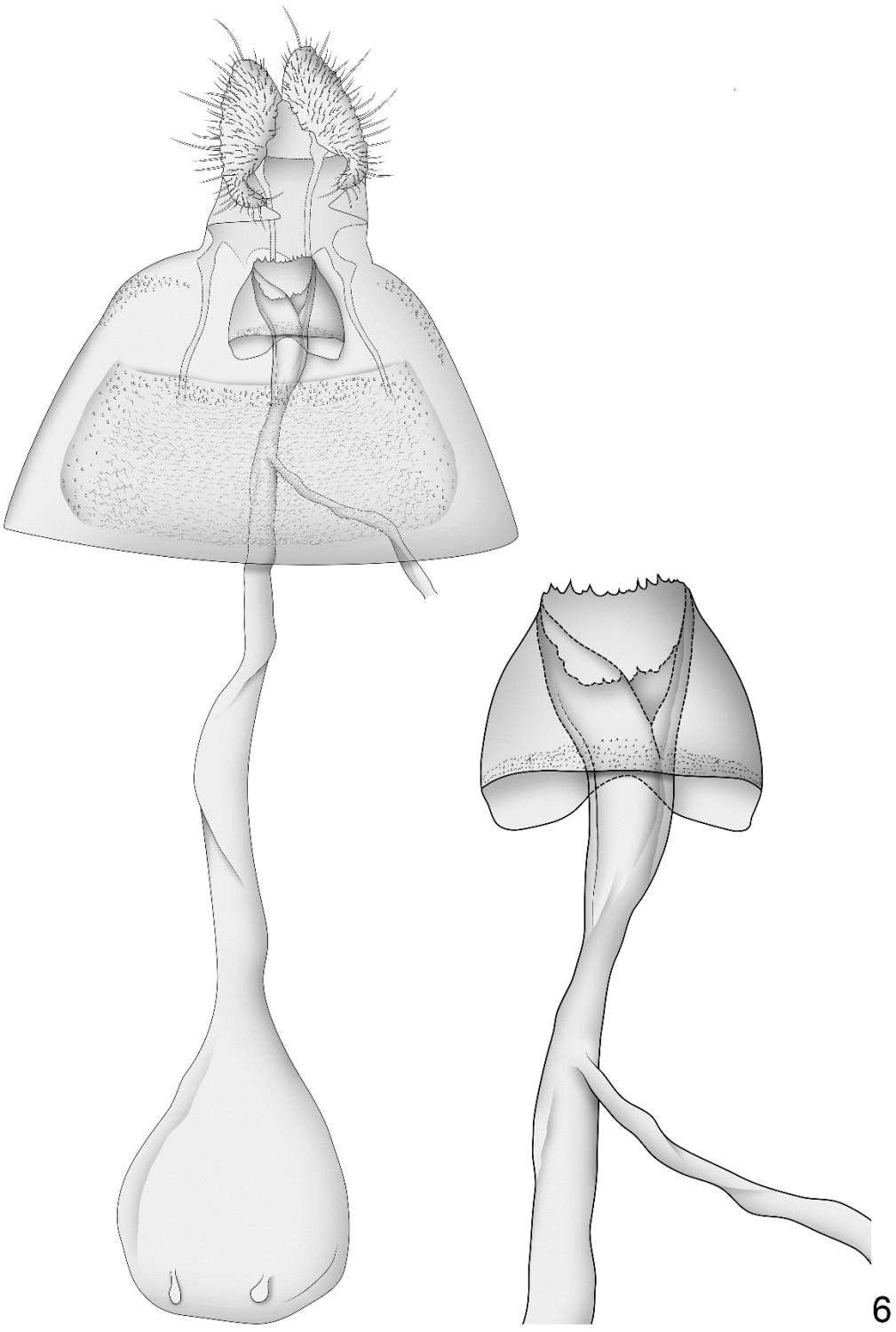

Fig. 6: Illustration of female genitalia (with sterigma enlarged) of *Paralobesia monotropana* (slide HRR 244).

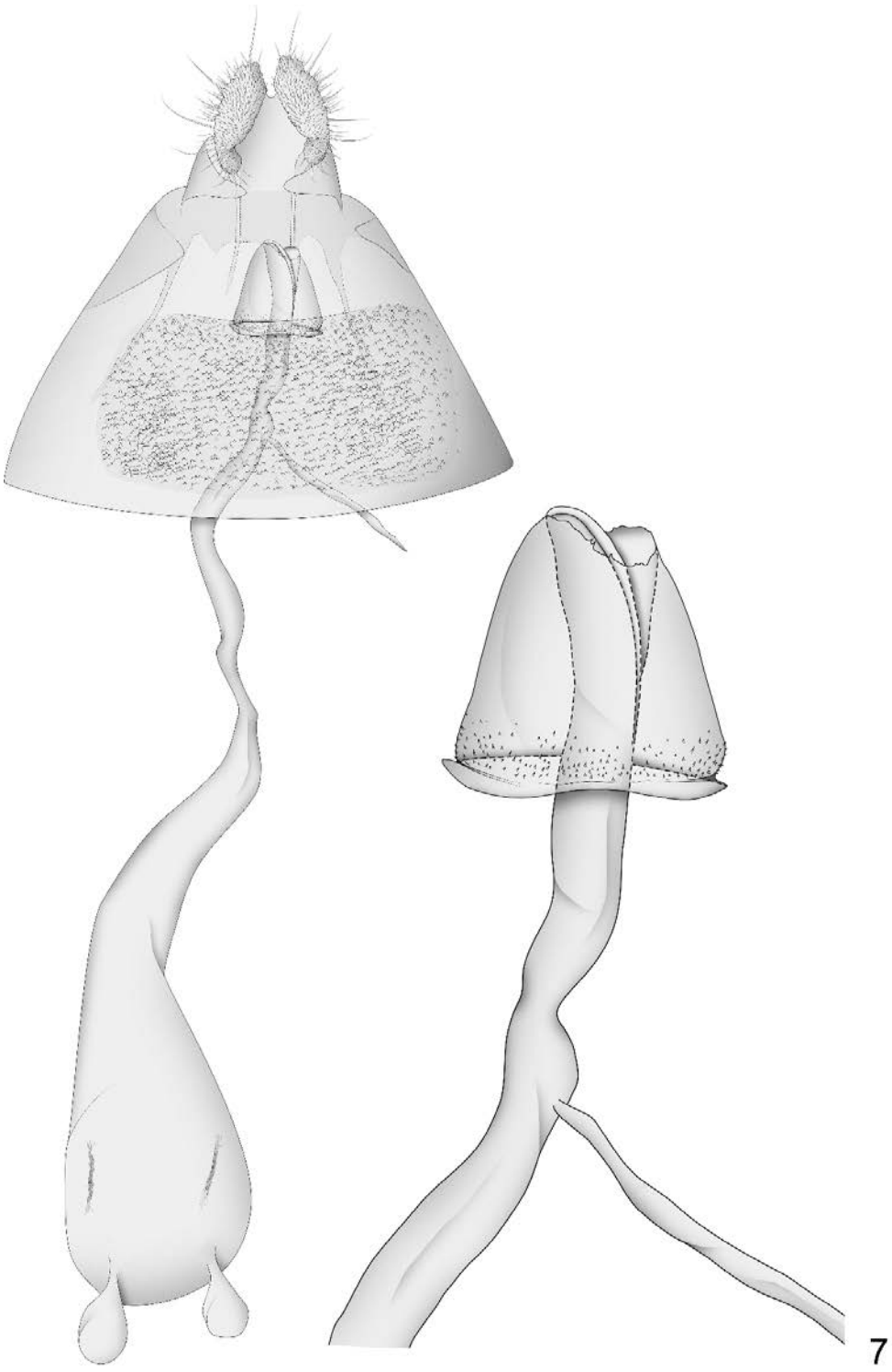

Fig. 7: Illustration of female genitalia (with sterigma enlarged) of *Paralobesia cypripediana* (slide TOR 5086).

Fig. 8: *Paralobesia monotropana* holotype; Figs. 9–12: *P. monotropana*; Fig. 13: *P. cypripediana* lectotype; Figs. 14–17: *P. cypripediana*; Fig. 18: *P. marilynae* holotype; Figs 19–22: *P. marilynae*.

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CHAPTER 3

A REVISION OF THE HOLARCTIC *PARALOBESIA* OBRAZTSOV 1953 (LEPIDOPTERA: TORTRICIDAE: OLETHREUTINI)[2]

Introduction

The genus *Paralobesia* Obraztsov, 1953 currently consists of 19 described and several undescribed species (Gilligan et al. 2008; Royals et al. 2018). All members of the genus are Nearctic except for the type species, *P*. *andereggiana* (Herrich-Schäffer, 1851), which is found in the western Palearctic (Razowski 2003). Most species are distributed throughout eastern North America, although three have been reported from the western U.S., *P*. *palliolana* (McDunnough, 1938) and two unidentified species (Gilligan et al. 2011). *Paralobesia viteana* (Clemens, 1860), the grape berry moth, is the most well-known member of the genus because it is an important pest of grapes.

The taxonomic history of Nearctic *Paralobesia* is confusing due the unresolved question of monophagy in the genus, misuse of names in previous literature, and the similarities in wing pattern between congeneric species and species in the closely related genus *Lobesia* Guenée, 1845. Clemens (1860) described the first taxon that would eventually be assigned to *Paralobesia* in North America as "*Endopiza* ?" *viteana*.

[2] A portion of this chapter will be published as:

Royals, H. R., T. M. Gilligan & J.-F. Landry. 2018. A revision of *Paralobesia* Obraztsov (Lepidoptera: Tortricidae: Olethreutini). *The Lepidopterists' Society*. Memoir No. 6. 100 pp.

Clemens' inadvertent spelling mistake while trying to assign the species to *Endopisa* Guenée, 1845 (currently a synonym of *Grapholita* Treitschke) would cause uncertainty for the next 150 years regarding the validity of *Endopiza* (Clemens, 1860) and the correct generic assignment for species in this genus. Clemens (1860) also referred to several different larval hosts in his account of *viteana*, indicating that he had likely included multiple species under this name. Packard (1869) followed several years later by describing the same species under the name *Penthina vitivorana* (Packard, 1869), and Riley (1869) expanded upon Packard's description and provided a detailed account of the life history of *vitivorana* in his "First annual report on the noxious, beneficial and other insects of the state of Missouri." Zeller (1871) authored a review of Riley's report and determined that females of *P*. *vitivorana* (= *viteana*) were identical to those of the Palearctic grape pest, *Eudemis* (now *Lobesia*) *botrana* ([Denis and Schiffermüller]). Fernald (1882) followed suit, listing *Endopiza viteana* (and *P*. *vitivorana*) as a synonym of *E*. *botrana* in his synonymical catalogue of North American Tortricidae. Fernald's (1882) "habitat" range for *botrana* included Europe as well as several U.S. states, and his list of host plants specified only grape vine for Europe, but included *Amorpha* (Fabaceae), grape, raspberry, sassafras, tulip [tree], and *Vernonia* (Asteraceae) for North America. In the Dyar catalogue several years later, Fernald (1903) also listed *botrana* with *viteana* as a synonym, this time under the genus *Polychrosis*, described by Ragonot (1894) with *P*. *botrana* as the type species. Because early identifications were based solely on wing pattern, the 20th century ended with all North American *Paralobesia* (then *Endopiza* or *Polychrosis*) assumed to be a single species, *P*. *viteana*, which was synonymous with the European *P*. *botrana*.

Kearfott (1904, 1907) was the first to provide resolution to the identity of different *Paralobesia* in North America. With the assistance of M. V. Slingerland at Cornell University, he obtained a series of *L*. *botrana* from Europe and determined that they were different from Clemens' *viteana* (Kearfott 1904). He also reared various other North American *Paralobesia* (*Polychrosis* at the time) from different hosts and examined reared specimens from Slingerland and others in several collections (Kearfott 1904, 1907). His observation that what appeared to be different species could be separated by host plant and brood (= generation) was based on an assumption of monophagy, where each moth species was restricted to feeding on a single host plant species (Royals et al. 2018). He concluded that, "After critical examination of all this material, over 100 specimens, I feel very positive that each of the food plants support a good valid species…" (Kearfott 1904). Following this general hypothesis, he provided redescriptions of *P*. *botrana* and *P*. *viteana*, and also described three new species reared from different host plants: *P*. *liriodendrana*, reared from *Liriodendron tulipifera* (Magnoliaceae); *P*. *rhoifructana*, reared from *Rhus* (Anacardiaceae); and *P*. *slingerlandana*, reared from *Eupatorium perfoliatum* (Asteraceae) (Kearfott 1904). Three years later, Kearfott (1907) followed with descriptions of five additional species: *P*. *ambrosiana*, reared from *Ambrosia trifida* (Asteraceae); *P*. *aruncana* reared from *Aruncus* (Rosaceae); *P*. *magnoliana*, reared from *Magnolia virginiana* (Magnoliaceae); *P*. *vernoniana* reared from *Vernonia noveboracensis* (Asteraceae); and *P*. *yaracana*, which was not reared. The concept of monophagy, or restricted oligophagy, was applied for subsequent species descriptions by several authors (Forbes 1923; Heinrich 1923b, 1926; McDunnough 1938).

In their North American checklist, Barnes and McDunnough (1917) listed *P*. *viteana* and all of Kearfott's new species under *Polychrosis*. This also included *P*. *carduana* Busck, 1907, which was later reassigned to *Lobesia* by Obraztsov (1953). Forbes (1923) provided an extensive review of the now ten species of *Polychrosis* in North America. He described one new species, *P*. *cypripediana*, reared from the seeds of *Cypripedium* (Orchidaceae). Although Forbes (1923) attributed the name to Kearfott, it was never previously published and thus Forbes is the author.

Heinrich (1923a, 1926) was one of the first North American taxonomists to incorporate the study of genitalia into his descriptions of new Tortricidae. In the same year as Forbes, Heinrich (1923b) described *P*. *spiraeifoliana* from a series of specimens reared from *Spiraea salicifolia* (Rosaceae) that Kearfott had set aside as a potential new species. He distinguished *P*. *spiraeifoliana* from *P*. *ambrosiana* based on differences in the male and female genitalia. Heinrich's Olethreutinae revisions (1923a, 1926) were the most extensive ever produced for North America. *Polychrosis* was included in the second volume (Heinrich 1926), and he concluded that the North American species should indeed remain separate from *Lobesia* based on differences in forewing venation and genitalia. His genitalic descriptions included the naming of diagnostic spine clusters, a convention used by subsequent authors when discussing the genitalia of many Olethreutini. Heinrich (1926) described four new species of *Polychrosis* based on differences in genitalia, wing coloration, and/or host plants: *P*. *aemulana*; *P*. *blandula*; *P*. *cyclopiana*, reared from *Magnolia* (Magnoliaceae); and *P*. *monotropana*, reared from *Monotropa uniflora* (Ericaceae). He proposed that *P*. *magnoliana* should be relegated to a junior synonym of *P*. *liriodendrana* since the only major difference he could identify

was size. He also synonymized *P*. *ambrosiana* with *P*. *vernoniana* and provided a key to the now 14 different species of *Polychrosis* in North America (including *P*. *carduana*).

McDunnough (1938), in his report on “Some apparently new Eucosmidae (Lepid.),” described three new *Polychrosis* from Nova Scotia. *Polychrosis palliolana* and *P*. *exasperana* were described from female specimens; and, although no male-female breeding associations were observed, male descriptions for each species were provided for specimens having the same wing coloration as the females but genitalia different from other described species. *Polychrosis spiraeae* was described from specimens reared from the flower-heads of *Spiraea* (Rosaceae) and previously identified by Heinrich as *P*. *artemisiana*, a European species (now placed in *Lobesia*). Several years later, Freeman (1941) described *P*. *piceana* as feeding on *Picea mariana* (Pinaceae).

The genus *Paralobesia* was described by Obraztsov (1953) in a review of the classification of Holarctic *Lobesia*. He determined that, while the separation of *Lobesia* and *Polychrosis* was originally based on two major characters (presence of hair pencils on the hind tibia and hindwing venation), these were insufficient to separate the genera due to variation and a lack of correlation of these characters across species. He proposed that the classification should be based on the morphology of the genitalia due to strong correlation with other characters. To resolve this problem, he relegated *Polychrosis* to a subgenus of *Lobesia*, still containing *P*. *botrana*, and described the new genus *Paralobesia*, with the European *Tortrix andereggiana* Herrich-Schäffer as the type species. *Paralobesia* was described as having the same characters as *Lobesia* but with slight differences in wing venation and male genitalia. Obraztsov (1953) also provided a complete list of the Holarctic species of *Lobesia* and *Paralobesia* under his

new classification system. This included all of the North American *Paralobesia* with the exception of *P*. *sambuci*, which was described by Clarke (1953) in the same year. This was the last *Paralobesia* described until the initial phase of the current study (Royals et al. 2018).

Despite Obraztsov's (1953) attempts at resolving the generic assignments surrounding *Lobesia* and *Paralobesia*, subsequent authors did not always agree on the status of the genus or the correct name. Diakonoff (1954) initially agreed with Obraztsov (1953), but later (Diakonoff 1973) determined that *Endopiza* was a valid name (not a misspelling), thus *Paralobesia* was a junior subjective synonym. Powell (1983) followed this convention in his checklist of North American Tortricidae and listed all North American *Paralobesia* under *Endopiza*. In the same year, Razowski (1983) relegated *Paralobesia* to a junior synonym of *Lobesia*, claiming that the genitalic characters used to distinguish *Endopiza*, *Paralobesia*, and *Lobesia* were too inconsistent. Brown, in the first tortricid world catalogue (2005), did not follow Razowski and treated *Paralobesia* as senior status. He (Brown 2006) also provided reasoning for treating *Endopiza* as a misspelling and thus a junior synonym of *Paralobesia*. The most recent Online World Catalogue of the Tortricidae (Gilligan et al. 2014a) also follows this convention. Issues surrounding the generic status of *Paralobesia* are detailed later in the discussion.

There has not been a complete species-level revision for the genus since Heinrich (1926). Gilligan et al. (2008) provided descriptions for eight *Paralobesia* for which they could confidently associate males and females with the type material, but were unable to resolve any taxonomic issues. The issue of *Paralobesia* identification was raised again in 2009 when *L*. *botrana* larvae found in Napa, California were initially thought to

be those of *P*. *viteana* (Gilligan et al. 2011), and an apparently undescribed species of *Paralobesia* was found in an *E*. *postvittana* pheromone trap in Oregon (Gilligan et al. 2011). At the same time, larvae found on *Cypripedium reginae* Walter (Orchidaceae) in eastern Ontario and southwestern Québec were determined to be *Paralobesia* using DNA barcoding, and an extensive DNA barcode database of various *Paralobesia* was compiled on the Barcode of Life Data System (BOLD; Ratnasingham and Hebert 2007). While preparing this revision, we examined the specimens reared from *Cypripedium* and determined they were a new species, which we described as *P*. *marilynae* (Royals et al. 2018). In that same study we also redescribed *P*. *cypripediana* and *P*. *monotropana*, and examined the concept of monophagy in relation to morphology and DNA data in this group of species (Royals et al. 2018).

Here we complete a comprehensive systematic revision of *Paralobesia*. We combine information from morphology, DNA barcodes, and host data to provide diagnoses for all species in the genus. We reexamine the morphological characters that define the genus, test monophyly of the genus using DNA data, and provide evidence that *Paralobesia* is indeed separate from *Lobesia*. We describe 12 new species and provide detailed redescriptions of 17 species.

Materials and Methods

We examined 1,061 adult specimens (620 ♂, 441 ♀) together with 891 associated genitalia preparations and an additional 418 databased specimens deposited in the following collections: American Museum of Natural History, New York, U.S.A. (AMNH);

Essig Museum of Entomology, University of California, Berkeley, California, U.S.A. (EMEC); Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, Ontario, Canada (CNC); Center for Biodiversity Genomics, Guelph, Ontario, Canada (CBG); Cornell University Insect Collection, Ithaca, New York, U.S.A. (CUIC); Florida State Collection of Arthropods, Florida, U.S.A. (FSCA); Illinois Natural History Survey Insect Collection, Illinois, U.S.A. (INHS); Mississippi Entomological Museum, Mississippi, U.S.A. (MEM); National Museum of Natural History, Washington, D.C., U.S.A. (USNM); Northern Forestry Centre Research Collection, Canadian Forest Service, Natural Resources Canada, Edmonton, Alberta, Canada (NFRC); and Oregon Department of Agriculture, Salem, Oregon, U.S.A. (ODAC).

Images of adults were taken with Canon 100 mm and MP-E 65 mm macro lenses attached to a Canon 5DS digital SLR (Canon U.S.A., Inc., Melville, New York). Images of genitalia were taken with a Nikon DS-Fi1 digital microscope camera attached to a Nikon Eclipse E400 or E800 compound microscope (Nikon Instruments, Inc., Melville, New York). All images were edited using Photoshop CS6 Extended (Adobe Systems, Inc., San Jose, California). Forewing length (FWL) is defined as the distance from the base to the apex including the fringe, reported to the nearest one-tenth of a millimeter. Measurements were made with the “Analysis” tool in Photoshop using known measurement scales. Abbreviations are as follows: HTP = holotype; LTP = lectotype; n = the number of observations supporting a particular statistic; PLTP = paralectotype; PTP = paratype. Dissection methods follow those presented in Brown and Powell (1991), and terminology for the structures of the male genitalia follows Diakonoff (1954; e.g., Spc_1 = spine cluster 1; see discussion) (Fig. 27). The discal spot, for the purpose of

these descriptions, refers to the small circular patch of scales situated in the curvature of the costal distal edge of triangular median fascia. We use the Regier et al. (2012) definitions of host plant use, where “oligophagous” refers to species that use hosts from a single plant order and “polyphagous” refers to species that use hosts in two or more plant orders. We also define “monophagous” as referring to species that use hosts in only a single family and “strictly monophagous” as referring to taxa that utilize only a single plant species.

Tissue for sequencing was prepared according to previously described standards and processed at the Canadian Centre for DNA Barcoding (CCDB, Biodiversity Institute of Ontario, University of Guelph) to obtain COI DNA barcodes (Hebert et al. 2003) using the standard high-throughput protocol (deWaard et al. 2008). DNA sequences were automatically uploaded to the Barcode of Life Data Systems (BOLD; Ratnasingham and Hebert 2007). Additional sequences were obtained from DNA extracted using a Qiagen DNeasy Blood and Tissue Kit following the manufacturer’s recommended protocol. The primers LepF1/LepR1 (Hebert et al. 2004) were used to amplify the DNA barcode region, which was sequenced on an Applied Biosystems 3730XL DNA sequencer. Individual contigs were assembled and trimmed using Geneious Pro R9.1.5 (Drummond et al. 2012). All DNA sequences generated by this study outside of BOLD were submitted to GenBank.

All *Paralobesia* sequences were downloaded to Geneious Pro R9.1.5 including 284 sequences from BOLD and 43 newly generated sequences. Publically available sequences of several species of *Lobesia* and Olethreutini were included as outgroups to test monophyly, and a sequence of *Cryptaspasma* (Microcorsini) was included to root

the tree (98 outgroups total). All sequences (425 total) were aligned with MAFFT ver. 6 using the G-INS-i algorithm (Katoh et al. 2002). A likelihood analysis was performed using Garli ver. 2.0 (Zwickl 2006) and the GTR + gamma nucleotide substitution model. Optimal likelihood trees were searched for using 1000 independent searches and likelihood bootstrap (BS; Felsenstein 1985) values were obtained using 1000 replicates. The final maximum likelihood trees showing relative branch lengths are provided in Figs. 23–26; the entire tree is displayed on the left with highlighting to indicate the portion that is enlarged on the right. Likelihood bootstrap support is listed for clades with values ≥ 50.

Results and Discussion

The status of *Paralobesia* has been debated by many authors as part of a much larger issue regarding the circumscription of *Lobesia* and related genera (e.g., Diakonoff 1954; Razowski 1989; Bae and Komai 1991; Horak 2006). Although determining the status of *Lobesia* in the context of the various proposed subgenera and their relationships to *Paralobesia* is outside the scope of this study, we must provide some insights on these topics in order to determine the validity of *Paralobesia* as a genus.

Paralobesia was described by Obraztsov (1953) as part of a study to resolve the classification of *Lobesia* and *Polychrosis*. The debate regarding the relationships between these two genera actually began many years before (e.g., Heinrich 1926) and the two genera were traditionally separated by the presence or absence of a hair pencil on the hind tibia in the male and differences in hindwing venation (Kennel 1908–1921).

Obraztsov (1953) determined that these characters were too variable and relegated *Polychrosis* to a subgenus of *Lobesia*, using spine clusters on the male valva to differentiate the subgenera. He described *Paralobesia* as similar to *Lobesia* but with an additional (third) spine cluster on the sacculus that was not present in *Lobesia*.

Diakonoff (1950) initially hypothesized that *Lobesia* was intermediate between *Bactra* Stephens, 1834 and *Polychrosis*; but later, following Obraztsov's (1953) review, agreed that *Polychrosis* and *Lobesia* were congeneric (Diakonoff 1954). Diakonoff (1954) examined the variety of morphological characters that had been used to differentiate this group of genera, and determined that male genitalia, specifically the division of the cucullus from the sacculus and arrangement of spine clusters on the latter, were the most important characters for separating genera and subgenera. He (Diakonoff 1954) illustrated the hypothetical evolution of male valvae and proposed six subgenera for *Lobesia*, retaining *Paralobesia* as a separate genus. Several years later, Diakonoff (1963) added a seventh subgenus for a species that was formerly placed in *Bactra*. In his monograph on South Asiatic Olethreutini, Diakonoff (1973) retained the seven subgenera under *Lobesia*, but treated *Endopiza* (= *Paralobesia*) as a separate genus.

At nearly the same time, Falkovitsh (1970) treated *Lobesiodes* Diakonoff, 1954 and *Paralobesia* as subgenera of *Lobesia*, while Kuznetsov (1978) elevated *Lobesiodes* to generic status and treated *Endopiza* (= *Paralobesia*) and *Lobesia* s. str. as subgenera under *Lobesia*. Razowski (1983) followed Kuznetsov (1978) and formally synonymized *Paralobesia* (and *Polychrosis*) under *Lobesia*. *Lobesia* and *Lobesiodes* have been variably treated as genera or subgenera (of *Lobesia*) in recent European publications

and checklists. Razowski used subgeneric names in his tortricid catalogue series (Razowski 1995), but dropped the subgeneric designations in other publications (Razowski 1989; 1996; 2003). Aarvik (2013), in the latest catalogue of European Lepidoptera, included both *Lobesia* and *Lobesiodes* as subgenera.

Bae and Komai (1991), in their review of Japanese *Lobesia*, expanded upon Diakonoff (1973) by defining eight subgenera under *Lobesia*, including *Endopiza* and *Lobesiodes* along with *Neolobesia* Bae & Komai, 1991, *Harmosma* Diakonoff, 1963, *Lomaschizodes* Diakonoff, 1954, *Apolobesia* (Diakonoff, 1954), *Lomaschizai* Lower, 1901, and *Lobesia*. They (Bae and Komai 1991) treated *Polychrosis* as a synonym of *Lobesia*, following Razowski (1983) and provided a key to subgenera using characters of the male genitalia. Later, Bae and Liu (1995) added a ninth subgenus to *Lobesia* by describing *Neodasyphora*.

Horak (2006) was the last to evaluate the generic status of *Lobesia* on a worldwide scale. She listed the nine subgenera as synonyms under *Lobesia*, stating that several derived groups could be identified in the diverse Australian fauna, but that their removal from *Lobesia* would create paraphyletic residual taxa (Horak 2006). Although Horak (2006) stated that “There is little doubt that *Paralobesia* Obraztsov… is subordinate within *Lobesia*…,” she did not list *Paralobesia* as a synonym of *Lobesia*. In addition, Horak (2006) did not list *Lobesiodes* as a synonym of *Lobesia*.

Morphological characters that define *Lobesia*, *Paralobesia*, and the various subgenera have been discussed in depth by many of the authors cited here. Horak (2006) provided what is likely the most comprehensive list of defining characters for the genus, expanding upon those from Bae and Komai (1991). This list includes (from

Horak 2006): pockets with modified scales laterally on S2 in the male; hook-shaped apodemes for muscle attachments on the pedunculi; flaplike socii continuous with the teguminal apex; inception of the ductus seminalis close to the “neck” of the corpus bursae; and antenna with the flagellum scaled also on its anterior surface. In addition, many males have a pterostigma in the forewing and resulting modifications to veins R1 and R2, although this character is absent in some species. Bae and Komai (1991) also listed tibial hair pencils in the male (in conjunction with the abdominal pockets) and the sterigma situated on a membranous pocket under 7th abdominal sternite in the female. Again, both of these characters are not present in all species.

While the above characters define *Lobesia* s. lat., structures of the male genitalia have been employed to define the related genera or subgenera, depending on the classification system used. Heinrich (1926) was the first to attempt to identify diagnostic spine clusters (Spc) in the Olethreutini, and Obraztsov (1953) generally followed Heinrich (1926) in his study of *Lobesia*/*Paralobesia*. Diakonoff (1954) provided a detailed discussion of the various characters associated at the time with *Lobesia* and determined it was indeed the male genitalia that provided the most useful information when forming species groups. He suggested that Heinrich’s (1926) naming of spine clusters was not always homologous and that the location of spine clusters was determinate on the separation of the cucullus from the sacculus (Diakonoff 1954). In *Lobesia* and related genera, the separation of these two structures is designated by a “notch” in the ventral margin of the valva, or as termed by Diakonoff (1954), the “primary incision.” The named spine clusters all reside on the sacculus: Spc_1, proximad of the primary incision; Spc_2, proximad of Spc_1; and Spc_3, consisting of usually long spines

located at the base of the sacculus (Diakonoff 1954; Fig. 27). The first two spine clusters (Spc_1 and Spc_2) are often separated by a second emargination of the ventral margin of the sacculus, termed the “secondary incision” or a “scalloped sacculus” by Diakonoff (1954). The third spine cluster (Spc_3) was termed simply “Spc” by Obraztsov (1953) and is present only in *Paralobesia*. Bae and Komai (1991) used the saccular spine clusters along with other male characters (phallus, gnathos, etc.) to define the eight subgenera they recognized in *Lobesia*.

The results of our maximum likelihood phylogenetic analysis are presented in Figs. 23–26. The tree in Fig. 23 is expanded to show the relationships between *Paralobesia* and the various outgroups. Basal relationships are not supported with this data (no BS values above 50%), as is to be expected with rapidly evolving COI sequence data (Gilligan et al. 2014b), and taxon sampling was inadequate to provide any definitive resolution to the relationships of the various subgenera in *Lobesia*. However, *Paralobesia* is clearly resolved as a monophyletic taxon with moderate bootstrap support (68% BS; Fig. 23). *Lobesia* is split into several clades, and some “species” are well-supported as being separate taxa. At the very base of the tree, *L*. *physophora* (Lower, 1901) from Queensland, Australia is strongly supported (99% BS) as being separate from *L*. *physophora* from the Northern Territory, and possibly even in a separate genus from *Lobesia*. A strongly supported (94% BS) clade resolved as sister to *Eudemis* containing *L*. *arescophanes* (Turner, 1945) and *L*. *peltophora* (Meyrick, 1911), is separated from the remaining *Lobesia*. *Lobesia bicinctana* (Duponchel, in Godart, 1842) from Canada is well-supported as being a separate taxon from *L*.

bicinctana from Europe. Two "*Lobesia*" group with the remaining Olethreutini outgroups. We suspect these are misidentifications and include their names in quotes.

In regards to *Paralobesia*, we believe that the genus can be adequately defined morphologically using a combination of the characters for *Lobesia* s. lat. listed by Bae and Komai (1991) and Horak (2006), and the presence of three distinct spine clusters on the sacculus ($Spc_{1–3}$). We view the status of genus versus subgenus as being largely arbitrary; and thus, it could be possible to elevate Bae and Komai's (1991) subgenera to generic status if the characters they list for each group hold true. Horak (2006) clearly disagrees and states that removal of subordinate groups under *Lobesia* s. lat. would result in paraphyly of the remaining taxa. This could be true for some subgenera and not an issue for others. For instance, *Lobesiodes* was elevated to generic status based on the structure of the male valva by Kuznetsov (1978), and it has been treated as a separate genus by most authors since that time (Bae and Komai 1991 is the exception). *Paralobesia* has been recently treated as a separate genus in North America (e.g., Gilligan et al. 2008; Brown 2005), and as a subgenus or synonym of *Lobesia* in the Old World (e.g., Bae and Komai 1991; Razowski 2003; Horak 2006). We suspect this is partially because of the many *Paralobesia* species present in North America, whereas only *P. andereggiana* is present in Europe. Given the phylogenetic analysis in which *Paralobesia* is supported as being a monophyletic grouping, and the ability to consistently diagnose *Paralobesia* as a group separate from other *Lobesia* by the presence of Spc_3 on the male sacculus, it would be counterproductive to treat *Paralobesia* as a subgenus pending a more rigorous phylogenetic analysis involving all of the groups under *Lobesia* s. lat. and using several different genes (or even genomic

data). Thus, we elevate *Paralobesia* back from synonymy and define the genus using a combination of the following characters:

1. Abdominal pockets with modified scales laterally on S2 in the male (Figs. 28-30)
2. Hook-shaped apodemes for muscle attachments on the pedunculi (Fig. 31)
3. Flaplike socii continuous with the teguminal apex (Fig. 32)
4. Inception of the ductus seminalis immediately anterior of colliculum (Fig. 33)
5. Antenna with the flagellum scaled also on its anterior surface (Fig. 34)
6. Forewing with lengthened dark scales at base of dorsum (Fig. 35)
7. Pterostigma usually present in the male forewing with veins R_1 and R_2 parallel (Fig. 36)
8. Hair pencil on the tibia in the male (Fig. 40)
9. Sterigma situated on a membranous pocket under 7th abdominal sternite in the female (Fig. 38)
10. Corpus bursae with two small accessory sacs on the anterior margin in most species (Fig. 39)
11. Cucullus divided from the sacculus by an obvious ventral emergination (Fig. 37)
12. Sacculus with three spine clusters (Fig. 27):
    a. Spc_1 located proximad of the division of the cucullus and sacculus, often on a prominent projection
    b. Spc_2 located proximad of Spc_1, usually on a prominent projection, occasionally mediad of Spc_1 not on a projection (e.g., *P. andereggiana*), and occasionally absent (e.g., *P. liriodendrana*)

c. Spc_3 consisting of stout usually flat spines located at the base of the sacculus, ocassionally reduced to a cluster of smaller spines (e.g., *P*. *viteana*), and occasionally located behind Spc_2 (e.g., *P*. *piperana*; *P*. *carduana*)

The species-level phylogeny for *Paralobesia* is shown in Figs. 24-26. Notes about individual species are included in the species descriptions. Many species can be differentiated by DNA barcodes, while for some, no barcode data are available; however, short branch lengths across much of the tree indicate closely related taxa that cannot be differentiated using only COI data in some instances. *Paralobesia cypripediana* is inseparable from *P*. *rhoifructana* (Fig. 25) and in one clade, up to 3 species share identical barcode sequences: *P*. *vernoniana*, *P*. *sambuci*, and *P*. *wontonana* (Fig. 26). Different species that share identical DNA barcode sequences are rare within the Lepidoptera, although there are several documented examples (e.g., Kaila and Ståhls 2006; Hausmann et al. 2011; Huemer et al. 2014), and multiple species sharing mtDNA sequences is common in other insect orders (e.g., Diptera; Meier et al. 2006). Explanations for this could include incomplete lineage sorting, mitochondrial introgression (Funk and Omland 2003), unrecognized synonymy (Huemer et al. 2014), or even the presence of nuclear mitochondrial pseudogenes (Song et al. 2008). In *Paralobesia*, we were able to identify consistent morphological differences (usually genitalia) to diagnose all species, thus we believe that shared barcodes are not a result of unrecognized synonymy and are most likely due to lineage sorting and/or introgression. The difficulty in identifying *Paralobesia*, the related taxonomic issues

resolved in this revision, and the potential for closely related species to share mtDNA sequences should serve as a cautionary tale for identifying specimens using only DNA barcodes. Although DNA barcoding is a valuable tool in resolving taxonomic issues and identifying unknown specimens, it must be used in combination with careful morphological study and comparison with type material, and reference sequences should be generated from voucher specimens that are positively identified using morphology.

Descriptions and redescriptions

PARALOBESIA Obraztsov **stat.rev.**

Paralobesia Obraztsov, 1953, Tijdschr. Ent. 96: 92. Type species: *Tortrix* (*Coccyx*) *andereggiana* Herrich-*Schäffer*, 1851.
Endopiza Clemens, 1860, Proc. Acad. Nat. Sci. Philad. 12: 359. Type species: "*Endopiza ?*" *viteana* Clemens, 1860.

Diagnosis. The diagnostic characters of *Paralobesia* are primarily those of the male and female genitalia. Males in *Paralobesia* usually have three clusters of spine-like setae (Fig. 27), two padlike groups of spines on a lobe extending from the distal end of the sacculus, and near the center of the sacculus, while a third is always present at the base, either along the ventral edge or on the back of this cucullus. It is this third spine cluster that differentiates *Paralobesia* from other Olethreutines. The forewing costal fold

is absent, and a patch of elongate dark scales is present at the base of the dorsum. Females, with few exceptions, have simple, moderately setose papillae anales, the sterigma situated in a membranous pouch behind the 7th sternite, two variably-sized accessory sacs from the anterior end of the corpus bursae, and a paired narrow, linear signum consisting of thickened cells.

Redescription. **Male**. *Head*: Vertex with rough scales originating laterally and meeting in middle. Upper frons with erratic rough scales, lower frons with smooth, apressed white scales. Labial palpus 3-segmented, weakly sinuate with segment II enlarged distally by scales, segment III exposed, length of all segments combined ca. 1.2-2.7 times diameter of compound eye; maxillary palp inconspicuous; ocellus well developed, about one quarter diameter of scape; chaetosema simple, and unmodified. Antenna ca. 0.5 length of forewing costa, filiform, with one row of scales per flagellomere, sensory setae inconspicuous in both sexes. *Thorax*: Dorsum and tegula smooth scaled, with metathoracic tuft; mesothoracic tibia with one set of apical spurs and metathoracic tibia with two; hair pencil of vairable length on inner dorsal edge of hind tibia. Forewing costa with slight curve throughout; apex rounded; termen oblique with slight concavity; pterostigma variable; costal fold absent; all veins present and separate; M-stem and chorda weak in discal cell; discal cell ca. 0.6 length of forewing; veins 9, 10 and 11 equidistant and not reaching costa; 10 and 11 thickened, not sinuate; cubital pecten present in both sexes, patch of dark elongate scales present at base of dorsum. Male frenulum with one acanthus, female with variable number. *Abdomen*: Variable coloration; with invaginated abdominal scent organ on second sternite; male genitalia with tegumen an inverted V shape; uncus reduced, weakly bilobed, posteriorly

curving, variably setose; socius variable in size, usually absent; cucullus obliquely clavate to parallel-sided, densely bristled, separated from sacculus by primary incision. Sacculus scalloped with three clusters of spines: Spc1 at distal end of sacculus, separate from cucullus, Spc2 proximad of Spc1, rarely absent (e.g. *P*. *liriodendrana* Kearf.) and Spc3 present at base of sacculus, with setae of variable length, rarely reduced (e.g. P. viteana Clem.). Phallus curvature, length and armature variable. Cornuti rarely present (e.g. *P*. *cyclopiana*); **Female**. *Head:* As in male. *Thorax*: As in male, lacking tibial hair pencils. *Abdomen:* As in male except segments 6-8 often with dark brown to black scaling. Genitalia with papillae anales simple, moderately setose, sterigma variable, situated in membranous pocket behind 7th sternite, ductus bursa longer than corpus bursa; corpus bursa with paired linear signum consisting of thickened cells, distal end with two accessory sacs variable in size.

Distribution and Biology.

Present in the Palearctic is the type species *P*. *andereggiana*, and *P*. *crimea* (Falkovitsh, 1970) and *P*. *glebifera* (Meyrick, 1912), two additional species that we are here transferring from *Lobesia* to *Paralobesia*. Identifications of these three in collections are likely to be inaccurate and exact geographic distribution needs further study once this material is reexamined. In North America, ranges of *Paralobesia* are primarily on the eastern half of North America, with the exception of two species present in coastal Washington, California and Oregon. This is perhaps due to a lack of sampling in the western states as this contradicts past studies in regional diversity of insects

(Danks, 1994). A number of western states lack a record of *Paralobesia*: Idaho, Nevada, Utah, Montana, Wyoming, New Mexico, North Dakota, South Dakota, and Nebraska. *Paralobesia viteana* has been recorded from a single specimen in Colorado, and a male and female pair from Arizona.

With tortricids commonly known as leaf-roller moths, *Paralobesia* life cycles usually support this common name with their larvae creating safe-havens from the leaves of their host plants in which to hide, feed, and grow. In most species, some pupae overwinter to emerge as early spring adults which allows for multiple generations throughout the summer and fall months up to 4 in some species that range further south (Forbes 1923). Eggs are most often laid in developing flower buds. Once larvae emerge they feed on developing flowers or fruits and leaves near their sheltering tents. Some exceptions are present; *Paralobesia piceana* (Freeman) feeds almost exclusively on cones of various host plants (Larcenaire 2015) whereas *P*. *viteana* is partial to the young and mature grape berries depending on the generation, and *P*. *marilynae* and *P*. *cypripediana* feed in the developing fruits of *Cypripedium reginae*. Larvae pupate most commonly wrapped in the leaves or berry clusters of their host plant, or in the leaf litter below, such as *P*. *viteana*.

Checklist of Holarctic *Paralobesia*

The following checklist follows the format of Gilligan et al. (2014a). Twelve new species are added, *P*. *piceana* is relegated to a synonym of *P*. *palliolana*, and *P*. *magnoliana* is elevated to species level from a synonym of *P*. *liriodendrana*. Three former *Lobesia* are transferred to *Paralobesia* based on the number of spine clusters on

the sacculus and/or arrangement in the phylogenetic tree: *P*. *carduana*, *P*. *crimea*, and *P*. *glebifera*. Although we were unable to locate specimens of the last two species to examine, drawings of the male genitalia indicate they are closely related to *P*. *andereggiana* (Kuznetsov 1978; Razowski 2003).

aemulana Heinrich, 1926 (*Polychrosis*), Bull. U.S. natn. Mus. 132: 94. TL: USA, Pennsylvania, Hazelton. Holotype: AMNH. male.

albiterminana Royals and Gilligan **sp.n.** (*Paralobesia*). TL: USA, Florida, East Silver Springs Shores. Holotype: FSCA. male.

andereggiana Herrich-Schäffer, 1851 (*Tortrix* (*Coccyx*)), Syst. Bearbeitung Schmett. Eur. 4: 225. TL: Switzerland, Syntype(s): Unknown. unknown.

> *anderreggiana* Ragonot, 1894 (*Polychrosis*), Annls Soc. Entomol. Fr. 63: 210. no type [misspelling].
>
> *anderreggi* Ragonot, 1894 (*Polychrosis*), Annls Soc. Entomol. Fr. 63: 210. no type [unjustified emendation].
>
> *kreithneriana* Hornig, 1883 (*Eudemis*), Verh. zool.-bot. Ges. Wien. 32(1882): 279. TL: Turkey. Syntypes: MNHU. male, female.

aruncana Kearfott, 1907 (*Polychrosis*), Trans. Am. Entomol. Soc. 33: 5. TL: USA, Maryland, Cabin John Bridge. Lectotype: AMNH. male.

blandula Heinrich, 1926 (*Polychrosis*), Bull. U.S. natn. Mus. 132: 96. TL: Canada, Manitoba, Aweme. Holotype: CNC. male.

carduana Busck, 1907 **comb.n.** (*Polychrosis*), J. New York Entomol. Soc. 15: 134. TL: USA, Maryland, Hyattsville. Holotype: USNM. female.

crassus Royals and Gilligan **sp.n.** (*Paralobesia*). TL: USA, Virginia, Burke. Holotype: USNM. male.

crimea Falkovitsh, 1970 **comb.n.** (*Lobesia* (*Paralobesia*)), Vestnik Zool. 1970(5): 65. TL: Ukraine, (Crimea) Ukraine. Holotype: ZMAS. male.

crispans Royals and Gilligan, **sp.n.** (*Paralobesia*), TL: North Carolina, Highlands. Holotype: USNM. male

cyclopiana Heinrich, 1926 (*Polychrosis*), Bull. U.S. natn. Mus. 132: 97. TL: USA, New Jersey, Brown's Mills. Holotype: USNM. female.

cypripediana Forbes, 1923 (*Polychrosis*), Mem. Cornell Univ. Agric. Exp. Stn. 68: 473. TL: Canada, Manitoba, Aweme. Lectotype: AMNH. male.

exasperana McDunnough, 1938 (*Polychrosis*), Can. Entomol. 70: 91. TL: Canada, Nova Scotia, S Milford. Holotype: CNC. female.

glebifera Meyrick, 1912 **comb.n.** (*Polychrosis*), Exotic Microlepid. 1: 34. TL: Asia Minor, Alma Dagh. Holotype: BMNH. male.

hodgesi Royals and Gilligan **sp.n.** (*Paralobesia*), TL: USA, Arkansas, Devil's Den State Park. Holotype: USNM. male.

kearfotti Royals and Gilligan **sp.n.** (*Paralobesia*), TL: USA, Illinois, Putnam County. Holotype: INHS. male.

landryi Royals and Gilligan **sp.n. (***Paralobesia*), TL: Canada, Ontario, Owen Sound. Holotype: CBG. male

liriodendrana Kearfott, 1904 (*Polychrosis*), Trans. Am. Entomol. Soc. 30: 293. TL: USA, District of Columbia. Lectotype: AMNH. male.

magnoliana Kearfott, 1907 **stat.rev.** (*Polychrosis*), Trans. Am. Entomol. Soc. 33: 6. TL: USA, District of Columbia. Lectotype: AMNH. male.

marilynae Royals and Gilligan, 2018 (*Paralobesia*), Zootaxa XXXX: X. TL: Canada, Québec, Gatineau Park, Folly Bog. Holotype: CNC. male.

monotropana Heinrich, 1926 (*Polychrosis*), Bull. U.S. natn. Mus. 132: 91. TL: USA, Ohio, Cincinnati. Holotype: AMNH. male.

pallicirculus Royals and Gilligan **sp.n.**(*Paralobesia*). TL: USA, Ohio, Killdeer Plains. Holotype. CNC. male.

palliolana McDunnough, 1938 (*Polychrosis*), Can. Entomol. 70: 91. TL: Canada, Nova Scotia, S Milford. Holotype: CNC. female.

> *piceana* Freeman, 1941 **syn.n.** (*Polychrosis*), Can. Entomol. 73: 124. TL: Canada, Québec, Senneterre. Holotype: CNC. male.

parsaurum Royals and Gilligan **sp.n.** (*Polychrosis*). TL: USA, Alabama, Weeks Bay NERS. Holotype: CNC. male.

piperana Royals and Gilligan **sp.n.** (*Paralobesia*), TL: USA, Tennessee, Great Smoky Mountain National Park. Holotype: MEM. male.

ridingsi Royals and Gilligan **sp.n.** (*Polychrosis*), TL: Canada, Manitoba, Riding Mountain National Park. Holotype: CNC. female.

rhoifructana Kearfott, 1904 (*Polychrosis*), Trans. Am. Entomol. Soc. 30: 296. TL: USA, District of Columbia. Holotype: USNM. male.

sambuci Clarke, 1953 (*Polychrosis*), J. Wash. Acad. Sci. 43: 228. TL: USA, Illinois, Putnam Co. Holotype: USNM. male.

slingerlandana Kearfott, 1904 (*Polychrosis*), Trans. Am. Entomol. Soc. 30: 295. TL: USA, New Jersey, Monclair. Lectotype: USNM. female.

spiraeifoliana Heinrich, 1923 (*Polychrosis*), Proc. Entomol. Soc. Wash. 25: 106. TL: USA, Pennsylvania, Luzerne Co., Hazelton. Holotype: USNM. male.

vernoniana Kearfott, 1907 (*Polychrosis*), Trans. Am. Entomol. Soc. 33: 7. TL: USA, New Jersey, Caldwell. Lectotype: AMNH. male.

> *ambrosiana* Kearfott, 1907 (*Polychrosis*), Trans. Am. Entomol. Soc. 33: 8. TL: USA. Ohio, Cincinnati. Lectotype: AMNH. male.

viteana Clemens, 1860 (*Endopiza*), Proc. Acad. Nat. Sci. Philad. 12: 359. TL: USA, Pennsylvania. Lectotype: ANSP. female.

> *vitivorana* Packard, 1869 (*Penthina*), Guide Study Ins. : 336. TL: USA Ohio, Hudson. Holotype: MCZ. unknown.

wontonana Royals and Gilligan **sp.n.** (*Paralobesia*), TL: Canada, Ontario, Port Franks. Holotype: CNC. male.

worthi Royals and Gilligan **sp.n.** (*Paralobesia*), TL: USA, Oregon, Eugene. Holotype: USNM. male.

yaracana Kearfott, 1907 (*Polychrosis*), Trans. Am. Entomol. Soc. 33: 5. TL: USA, Ohio, Cincinnati. Lectotype: AMNH. male.

> *signifera* Meyrick, 1912 (*Polychrosis*), Entomol. mon. Mag. 48: 34. no type [unnecessary replacement name].

Paralobesia andereggiana (Herrich-Schäffer, 1851)

Figs. 41–44, 158, 190

Tortrix (*Coccyx*) *andereggiana* Herrich-Schäffer 1851:225.

Polychrosis andereggiana; Rebel 1901:109; Kennel 1908–1921:452.

Eudemis andereggiana; Wocke 1871:251.

Lobesia andereggiana; Aarvik 2013; Razowski 2003:23.

Lobesia (*Lobesia*) *andereggiana*; Kuznetsov 1978:451; Razowski 1995:296; Aarvik 2013.

Paralobesia andereggiana; Obraztsov 1953:93; Diakonoff 1954:14; Brown 2005:471.

Polychrosis anderreggiana Ragonot 1894:210 (misspelling).

Polychrosis anderreggi Ragonot 1894:210 (unjustified emendation).

Eudemis kreithneriana Hornig 1883:279.

Diagnosis. *Paralobesia andereggiana* is similar in wing pattern to *P*. *worthi*, distinguishable by wing coloration. The forewings of *P*. *andereggiana* have muted brown wing markings without pale outlines to clearly contrast them from the ground color. Forewing markings in *P*. *worthi* are dark with a pale outline, clearly contrasting them from the grey ground color. In male genitalia, *P*. *andereggiana* is similar to *P*. *crimea* and *P*. *glebifera*, but may be distinguished based on the arrangement of the three spine clusters, with Spc_1 very widely separated from the base of the cucullus, and Spc_2 situated at the base of the emargination between Spc_1 and Spc_3. In *P*. *crimea*, the

emargination between the base of the cucullus and Spc_1 is very narrow, while in *P*. *glebifera*, it is similar in width to *P*. *andereggiana* but a deeper U shape.

Redescription. **Male**. *Head*: Vertex mottled brown and dark brown; labial palpus pale brown, all segments combined ca.1.8 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum with alternating bands of reddish brown and dark brown scales; posterior crest dark brown; legs dark brown with white annulations on tibia and tarsal segments. Forewing length **5.6–5.8** mm (mean 5.7 mm; n = 2); ground color dark grey, wing markings reddish and dark brown; costal strigulae pairs 3–9 expressed as pale brown and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; median fascia dark brown, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, a small dark patch at costa and a triangular pretornal patch; postmedian band a large semioval patch extending to termen, usually with notch originating from termen near M_3, dorsal margin tapering, sometimes meeting tornal patch; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing brown; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown dorsally, pale brown ventrally. Genitalia with uncus weakly bilobed, lacking setae patches from apex; socius small flattened lobes, not reaching center line of tegumen, with apical patch of flattened setae just longer than socius; gnathos a thin, weakly sclerotized band, fused with membranous subscaphium; cucullus narrowed in center, costal margin concave, apex rounded, ventral margin weakly concave, nearly straight, ventral half covered in spine-

like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by very wide emargination, extending ventrally 0.0-0.2 times its length past the ventral margin of the cucullus; Spc_2 situated at base of emargination between Spc_1 and Spc_3, with only a few long spines; Spc_3 from projection at base, spines on Spc_3 short and thin, reaching but not extending past Spc_1. Phallus tapering distally, curved, length ca. 0.5 times that of the cucullus, without projections. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 6.4–7.0 mm (mean 6.5; n = 2). *Abdomen*: Dark brown dorsally, brown ventrally. Genitalia with apophyses anteriores ca.1.2 times as long as apophyses posteriores; Sterigma finger-like with flared base, strongly sclerotized and spinulate, with wrinkled appearance, anterior margins fusing with membranous pouch of segment 8; ostium oriented posteriorly; ductus bursae ca. 1.0 times as long as corpus bursae; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with paired long, shallow signum consisting of thickened cells, lacking accessory sacs.

Syntype(s). Valais, Switzerland, not examined.

Additional specimens examined. **Austria**, J. Klimesch, 14 October 1959 (1 ♂, slide HRR 048; 1 ♀, slide HRR 047, USNM); Location unknown: Coll. Heylaerts (1 ♂, USNM); (1 ♂, slide 145686, USNM); (1 ♀, slide HRR 046, USNM).

Distribution and biology. The distribution for *P*. *andereggiana*, according to collection data, spans several central and southern European countries: Austria, Croatia, Romania, Slovakia, Slovenia, and Switzerland (Aarvik 2013). A single male specimen was collected in central Italy (Trematerra & Colacci 2016).

Discussion. The type was “received from Anderegg, probably from Wallis” (Herrich-Schäffer 1851), referring to the Canton of Valais in southern Switzerland. We

are unaware of the location or existence of any type material for this species. Herrich-Schäffer's collection was divided and sold after his death and many of his type specimens are lost (Häuser et al. 2003). Ragonot (1894) pointed out the similarity in spelling with *P*. *andereggiana* and *Aterpia anderreggana* Guenée. He proposed that the name *anderreggi* (shortened from *anderreggiana*, a misspelling of *andereggiana*) be used to avoid confusion; we treat this name as an unjustified emendation. His concerns were valid, however, and we have observed *P*. *andereggiana* and *A*. *anderreggana* mixed in collections. We were unable to locate specimens of *P*. *glebifera* and *P*. *crimea* but can confidently place these and *P*. *andereggiana* in *Paralobesia* as they all possess the third spine cluster at the base of the sacculus, one of the major defining generic characters for this group.

DNA sequence data. No sequence data were obtained for any of the three European species.

Paralobesia parsaurum **Royals and Gilligan, sp.n.**

Figs. 45–48, 159, 191

Diagnosis. *Paralobesia parsaurum* is unique in wing pattern. The forewing is divided from diagonally from the anal angle to costa by different ground colors, the more basal being a dusky grey and the apical a golden orange. The genitalia are most easily confused with *P*. *magnoliana* and *P*. *liriodendrana*. However, the males of *P*. *parsaurum* can be separated by the cucullus being very wide in the center, about 1.5 times the width of the base, Spc_1 being rounded apically and a phallus that is no longer than the

cucullus. In *P*. *magnoliana*, the cucullus is somewhat distended medially, but never more than 1.2 times the width of the base. The cucullus of *P*. *liriodendrana* is narrow and nearly parallel sided. Both *P*. *liriodendrana* and *P*. *magnoliana* have a Spc_1 that is narrow and not distally expanded and a phallus longer than the cucullus. Females of *P*. *parsaurum* can be differentiated by the shape of the sterigma and signa. The sterigma in *P*. *parsaurum* is more conical, with the ostium oriented posteriorly. In both *P*. *liriodendrana* and *P*. *magnoliana* the sterigma has a pinched appearance at the top, creating an ostium opening ventrally and a wrinkled appearance dorsally. The paired signa in *P*. *parsaurum* is teardrop shaped while those in both *P*. *liriodendrana* and *P*. *magnoliana* are thin and linear.

Description. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.6 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled brown; posterior crest mottled red brown; fore- and mid-legs brown with white annulations on tibia and tarsal segments, hind-legs mostly pale brown. Forewing length 4.7–5.9 mm (mean 5.3 mm; n = 17); ground color leaden grey in the basal-costal half, golden pale brown in the apical dorsal half, wing markings mostly dark brown and brown; costal strigulae pairs 3–9 expressed as pale brown and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing slightly from cubitus to dorsum; median fascia dark brown in costal half, pale yellow brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot usually present as patch of pale scales, blending with pale brown ground color; postmedian

fascia divided into two sections, an oval patch at costa and a triangular pretornal patch, nearly indiscernable against pale ground color; postmedian band a large, long semioval patch extending to termen, usually with notch originating from termen near M_3, dorsal edge often blending into pale ground color so spot appears small; preterminal fascia a small dark patch near apex; fringe scales lightly mottled. Hindwing brown with paler scales at base; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Pale brown. Genitalia with uncus slightly bilobed and curved marginally posteriorly, setae from apex of uncus absent; socius paired small lobes, not reaching centerline of tegumen, with short flattened setae as long as socius; gnathos a thin, weakly sclerotized band, fused with membranous subscaphium; cucullus medially dilated, costal margin weakly concave, apex narrowly rounded, ventral margin strongly convex, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; sacculus with two distinct clusters of spine-like setae, one on padlike lobe proximal to cucullus and a second at base; Spc_1 separated from cucullus by moderate narrow emargination, extending ventrally beyond cucullus so all spines are nearly past ventral margin of cucullus, spines short, widely spaced; Spc_2 absent; Spc_3 at base, spines on Spc_3 long and feathery, extending past edge of Spc_1 almost to apex of cucullus. Phallus tapering distally, strongly curved, length ca. 1.0 that of the cucullus, lacking any projection.

Female. *Head:* As in male. *Thorax*: As in male, except forewing length 5.6–6.7 mm (mean 6.1; n = 7) and hindwings solid brown to base. *Abdomen*: Dark brown. Genitalia with apophyses anteriores ca.1.2 times as long as apophyses posteriores; sterigma widely conical, strongly sclerotized and strongly microtrichiate, dorsal margin

merging with pleural membrane; ostium narrow, oriented posteroventrally; ductus bursae ca. 2.6 times as long as corpus bursae; colliculum strongly sclerotized and extending nearly half the ductus bursae; ductus seminalis near center of ductus bursae; corpus bursae with paired teardrop signum of thickened cells 0.2 the length of corpus bursae and two accessory sacs, ca.0.2 the length of corpus bursae.

Holotype. ♂, "ALA: Baldwin Co. Weeks Bay NERS, pitcher plant bog, 21 June 2008, 43', leg. D. J. Wright; 30º24.971'N 87º49.144'W; Specimen ID CNCLEP00155973; Barcode of life project, leg(s) removed, DNA extracted; ♂ genitalia on slide HRR 384; *Polychrosis parsaurum*, Royals and Gilligan, Holotype" (CNC).

Paratypes. **USA**: Alabama: Baldwin Co., Weeks Bay NER Reserve, R. L Brown, 20 June 2001 (1 ♂, 77962, slide HRR 626, MEM); 22 June 2001 (1 ♂, 77945, MEM); 24 June 2001 (1 ♀, 77946, MEM); J. A. MacGown, 3 August 2000 (1 ♀, 77846, MEM); D. J. Wright, 2 June 2008 (1 ♂, CNCLEP00155972, slide TOR 5176, CNC); Florida: Alachua Co., Alvah Peterson, at *Magnolia grandiflora*, (1 ♂, slide HRR 531, FSCA); Volusia Co., S. V. Fuller, 16 September 1962 (1 ♂, slide HRR 516, FSCA); Gainesville, Alvah Peterson, from *Magnolia*, 10 July 1958 (1 ♂, slide HRR 660, FSCA); Lake Placid, Archbold Bio. Sta., R. W. Hodges, 16-22 May 1964 (1 ♂, slide HRR 125, USNM); Mississippi: Claiborne Co. Natchez Trace Pkwy mile 54, Ricky Patterson, 2 November 2003 (1 ♀, 77990, slide HRR 323, MEM); George Co., 3 mi north of Lucedale, Charles T. Bryson, 19 August – 17 September 1996 (1 ♂, 98040, slide HRR 603, MEM); Harrison Co. R. Kergosien, 27 May 1991 (1 ♀, 98282, slide HRR 591, MEM); 6 June 1995 (1 ♂, 77828, MEM); 11 June 1996 (1 ♂, 77829, MEM); 25 June 1996 (1 ♀, 77899, slide MS 97095, MEM); 15 September 1996 (1 ♂, 77967, MEM); 30 March 1997 (1 ♂,

77969, MEM); 1 June 1997 (1 ♀, 77971, MEM); 4 June 1997 (1 ♂, 77830, MEM); 6 June 1997 (1 ♂, 77831, slide HRR 320, MEM); 9 June 1997 (1 ♂, 77832, slide HRR 334, MEM); Jackson County, Shepard State Park, R. Kergosien, 25–31 May 1995 (1 ♂, 77859, MEM); 12–18 September 1995 (1 ♂, 77833, slide HRR 610, MEM); Warren Co., Vicksburg, Bryant Mather, 7 August 1980 (1 ♂, 77867, slide HRR 317, MEM); Ricky Patterson, 6 May 2001 (1 ♀, 77978, MEM); North Carolina: Craven Co., Croatan National Forest Road 3046, J. Bolling Sullivan, 31 March 1998 (1 ♀, slide HRR 144, USNM); Croatan National Forest Road 121-D, J. Bolling Sullivan, 7 September 1999 (1 ♀, slide HRR 142, USNM); Moore Co., Waymouth Woods, Beaver Pond, J. Bolling Sullivan 24 April 2001 (1 ♀, slide HRR 143, USNM); Pender Co., Holly Shelter gamelands, J. Bolling Sullivan, 26 August 1997 (1 ♂, slide HRR 109, USNM).

Distribution and biology. Collection data for *P*. *parsaurum* indicate a range across the southeastern region of the U.S. from coastal North Carolina, south to the Florida panhandle, west to Mississippi. Two of our examined specimens had recorded host data. One was associated with an unnamed *Magnolia* species and the other on *M*. *grandiflora*. Two other species in this group – *P*. *liriodendrana* and *P*. *magnoliana*, also apparently utilize *Magnolia* as a host plant.

Etymology. The specific epithet *parsaurum* comes from the latin words '*pars'*, meaning 'part', and '*aurum'* meaning 'gold' to describe the bright golden brown wing coloration on the one half of the forewings of this distinctive moth.

DNA sequence data. This species is a well-supported group (92% BS) sister to *P*. *liriodendrana* (Fig. 24).

Paralobesia magnoliana (Kearfott, 1907), stat.rev.

Figs. 49–52, 160, 192

Polychrosis magnoliana Kearfott 1907:6; Barnes & McDunnough 1917; Forbes 1923:473.

Polychrosis magnoliana Heinrich 1926:89; McDunnough 1939:40. [synonym of *P. liriodendrana*]

Paralobesia magnoliana; Obraztsov 1953:92; Brown 2005:472. [synonym of *P. liriodendrana*]

Endopiza magnoliana; Powell 1983:31. [synonym of *P. liriodendrana*]

Diagnosis. With variable wing coloration in both species, *Paralobesia magnoliana* is difficult to distinguish from *P. liriodendrana*. While *P. liriodendrana* has a tawnier and even-colored in overall appearance, coloration is similar in both species and genitalia dissection is necessary to separate these two. While these and *P. parsaurum* have similar genitalia, both male and female genitalia have characters that can be used to separate *P. magnoliana*. In *P. magnoliana*, the male cucullus is slightly dilated in the center but less than 1.5 times the base, Spc_1 extends roughly 0.6 times its length past the ventral magin of the cucullus, and the female sterigma has a conical, slightly pinched appearance, and the dorsal face is merged with the pleural membrane in strongly microtrichiate plates. In *P. liriodendrana*, the males have a narrow cucullus that is parallel sided and Spc_1 extends halfway past the ventral margin of the cucullus. The female sterigma appears as a cone that has been strongly pinched near the top, giving a strongly wrinkled appearance, particularly on the dorsal side. In *P. parsaurum*,

the male cucullus is strongly dilated in the center, 1.5 times as wide as the base, Spc_1 extends far past the base of the cucullus, and the female sterigma is more conical, not appearing pinched, with a moderately microtrichate dorsal face.

Redescription. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.6 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales with transverse band of dark brown scales; posterior crest mottled dark brown; legs brown with white annulations on tibia and tarsal segments. Forewing length 5.4–6.1 mm (mean 5.6 mm; n = 9); ground color blue grey and tawny brown, wing markings uniformly dark brown, outlined in pale brown scales; costal strigulae pairs 3–9 expressed as pale brown and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing slightly from cubitus to dorsum, wider at dorsum; median fascia uniformly dark brown or brown outlined in tawny scales, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot usually present as faint patch of pale scales; postmedian fascia divided into two sections, an irregular oval at costa with a streak of dark brown and pale scales between discal spot and apex of wing, and a triangular pretornal patch; postmedian band a large, long semioval patch extending to termen, usually with notch originating from termen near M_3 separating dorsal half from termen; preterminal fascia a small indistinct patch near apex; fringe scales mottled brown. Hindwing uniform brown to dark brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Dark brown dorsally, pale brown to white ventrally. Genitalia with uncus weakly bilobed

and curved posteriorly, without patch of setae from apex; socius small lobes, not extending to centerline of tegumen; gnathos a weakly sclerotized band, not microtrichiate medially, fused with membranous subscaphium; cucullus narrow, slightly dilated in center, costal margin broadly concave, apex rounded, ventral margin convex, ventral half covered in long, thick, blunt peglike setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, extending ventrally beyond cucullus ca. 0.5-.7 times its length spines thick, short and spaced apart; Spc_2 absent; Spc_3 at base, spines on Spc_3 long and feathery, extending past Spc_1 often reaching apex of cucullus. Phallus tapering distally, curved, length variable, usually ca. 1.0 that of the cucullus, lacking any projections or teeth. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.8–6.5 mm (mean 5.7; n = 10). *Abdomen*: Coloration variable, mostly brown with darker scaling on posterior segments, pale brown on ventral surface. Genitalia with apophyses anteriores ca.1.2 times as long as apophyses posteriores; ductus bursae ca. 2 times as long as corpus bursae; sterigma conical, strongly sclerotized and strongly microtrichiate, slightly pinched appearance at apex, with lateral projections from posterodorsal margin fused with pleural membrane strongly microtrichiate; ostium oriented posteroventrally; colliculum strongly sclerotized, narrow, occupying posterior 0.3 of ductus bursae; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with paired long, shallow, signum of thickened cells 0.3 times the length of corpus bursae and two accessory sacs, ca. 0.4 times the length of corpus bursae.

Lectotype. ♂, “*Magnolia*, iss[ued]. VIII.4, D.C.; TYPE collection of W. D. Kearfott; *Polychrosis magnoliana* ♂ Type, Kearf.; Kearfott Col. Ac. 4667” (AMNH).

Paralectotypes. **USA**: D.C., on Magnolia, W. D. Kearfott, 4 August (1 ♀, AMNH); 15 August 1901 (1 ♀, AMNH); New Jersey, Moorestown on Magnolia, 10 August 1906 (1 ♀, USNM).

Additional specimens examined. **USA**: Florida: Liberty Co. Torreya St. Pk, H.D. Baggett, 30 March 1988 (2 ♂, 77841, slide HRR 292, 77842, slide HRR 332, MEM); Maryland, Cabin John Bridge, Aug[ust] Busck, 2 July 1923 (1 ♀, slide HRR 036, USNM); Prince Geroge's Co. Spice Cr. NRMA, J. Glaser, 10 August 2003 (1 ♂, slide HRR 402, USNM); Mississippi, Winston Co., Tombigbee Nat. Forest, J. A. MacGown, 18 March 1999 (1 ♂, 77957, slide HRR 620, MEM); 2 August 1999 (1 ♀, 77958, slide HRR 622, MEM); New Jersey, Essex Co., from *Liriodendron*, 8 May (1 ♀, AMNH); North Carolina: Black Mountain, W. Beutenmuller, 12 June (1 ♀, AMNH); Avery Co., Moore Mountain, J. Bolling Sullivan, 5–6 June 2002 (1 ♂, slide HRR 163, 3 ♀, slides HRR 147, HRR 157, HRR 162, USNM); Craven Co., Croatan National Forest Rd. 3046 Gum Branch Road, J. Bolling Sullivan, 7 April 1998 (1 ♂, slide HRR 178, USNM); Virginia: Falls Church, C. H. Heinrich, on Tulip, 25 June 1913 (1 ♂, slide HRR 377, 1 ♀, slide HRR 392, USNM); 28 June 1913 (1 ♂, slide 71752, USNM); 30 June 1913 (1 ♀, slide HRR 403, USNM); Fairfax Co., Alexandria (Rose Hill), P. A. Opler, 1 June 1977 (1 ♂, slide 11832, USNM); No locality information, 10 August (1 ♀, slide 97881, USNM); 7 August (1 ♀, slide 124985, USNM); 12 August (1 ♂, USNM).

Distribution and biology. Collection data for *P. magnoliana* indicate a flight period from late March to mid-August. The range for this species extends across the southeastern U.S. from the southwestern border of Mississippi northeast to central and

coastal New York. *Paralobesia magnoliana* has only been reared from host plants in the family Magnoliaceae: *Liriodendron tulipifera* L. and *Magnolia* sp.

Discussion. There were five specimens in Kearfott's original description from Bennings Station, D.C. and Moorsetown, New Jersey. Heinrich (1926) states that the lectotype is in AMNH from D.C. As only one male *P*. *magnoliana* from D.C. was found, the designation is valid. One paralectotype could not be found.

DNA sequence data. *Paralobesia magnoliana* is not represented in our phylogenetic tree.

***Paralobesia liriodendrana* (Kearfott, 1904)**

Figs. 53–56, 161, 193

Polychrosis liriodendrana Kearfott 1904:293; Barnes and McDunnough 1917:167; Forbes 1923:473 Heinrich 1926:89; McDunnough 1939:40.
Paralobesia liriodendrana; Obraztsov 1953:93; MacKay 1959:134; Brown 2005:472; Gilligan et al. 2008:46.
Endopiza liriodendrana; Powell 1983:31.

Diagnosis. *Paralobesia liriodendrana* is difficult to distinguish from *P*. *magnoliana* by wing pattern. Whereas the latter often has a darker overall appearance, especially near the apex of the forewing, coloration overlaps in both species and genitalia dissection is necessary to separate these two. While these and *P*. *parsaurum* have similar genitalia, both male and female genitalia have characters that can be used

to separate *P*. *liriodendrana*. In *P*. *liriodendrana*, the males have a narrow cucullus that is parallel sided and Spc_1 extends halfway past the ventral margin of the cucullus. The female sterigma appears as a cone that has been strongly pinched near the top, giving a strongly wrinkled appearance, particularly on the dorsal side. In *P*. *magnoliana*, the male cucullus is slightly dilated in the center but less than 1.5 times the base, and Spc_1 extends roughly 0.6 times its length past the ventral magin of the cucullus, and the female sterigma has a less wrinkled appearance, and the dorsal face is merged with the pleural membrane in strongly microtrichiate plates. In *P*. *parsaurum*, the male cucullus is strongly dilated in the center, 1.5 times as wide as the base, Spc_1 extends far past the base of the cucullus, and the female sterigma is more conical, not appearing pinched, with a moderately microtrichate dorsal face.

Redescription. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.75 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales; posterior crest mottled dark brown; legs brown with white annulations on tibia and tarsal segments. Forewing length 4.5–6.3 mm (mean 6.6 mm; n = 61); ground color variable grey and tawny brown, wing markings variable, uniformly brown or dark brown, outlined in pale brown scales; costal strigulae pairs 2–9 expressed as pale brown and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing slightly from cubitus to dorsum, wider at dorsum; median fascia uniformly dark brown or brown outlined in tawny scales, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot usually present as faint

patch of pale scales; postmedian fascia divided into two sections, an irregular oval at costa with a streak of brown and pale scales between discal spot and apex of wing, and a triangular pretornal patch; postmedian band a large, long semioval patch extending to termen, usually with notch originating from termen near M_3 separating dorsal half from termen; preterminal fascia a small indistinct patch near apex; fringe scales brown. Hindwing uniform brown to dark brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Grey brown dorsally, pale brown to white ventrally. Genitalia with uncus weakly bilobed and curved posteriorly, without patch of setae from apex; socius small lobes, not extending to centerline of tegumen; gnathos a weakly sclerotized band, not microtrichiate medially, fused with membranous subscaphium; cucullus narrow, parallel sided, costal margin broadly concave, apex rounded, ventral margin convex, ventral half covered in long, thick, blunt peglike setae, apex and dorsal half covered in finer setae; sacculus with only two distinct clusters of spine-like setae, one on padlike lobe proximal to the cucullus (Spc_1) and second at base (Spc_3); Spc_1 separated from cucullus by narrow emargination, extending ventrally beyond cucullus ca. 0.5 times its length spines thick, short and spaced apart; Spc_2 absent; Spc_3 at base, spines on Spc_3 long and feathery, extending past Spc_1 often reaching apex of cucullus. Phallus tapering distally, curved, length variable, usually ca. 1.0 times that of the cucullus, lacking any projections or teeth. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 5.2–6.3 mm (mean 5.8; n = 31). *Abdomen*: Coloration variable, mostly brown with darker scaling on posterior segments, pale brown on ventral surface. Genitalia with apophyses anteriores ca.1.2 times as long as apophyses posteriores; sterigma conical, strongly sclerotized and moderatly

microtrichiate, pinched appearance at apex, wrinkled on dorsal face; ostium oriented posteroventrally; ductus bursae ca. 1.3 times as long as corpus bursae; colliculum strongly sclerotized, occupying posterior 0.3 of ductus bursae; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with paired long, shallow, signum of thickened cells 0.3 the length of corpus bursae and two accessory sacs, ca. 0.25 times the length of corpus bursae.

Lectotype. ♂, "Aug Busck Collector; on Tulip tree, iss[ued] July 10, 1902; TYPE collection of W. D. Kearfott; *Polychrosis liriodendrana*, Type. Kearf.; Kearfott Col. Ac. 4667; LECTOTYPE" (AMNH).

Paralectotypes. **USA**: New Jersey, Essex Co., W. D. Kearfott, 8 May (1 ♀, AMNH); Montclair, W. D. Kearfott, 21 July 1903 (1 ♂, 1 ♀, AMNH); 7 May (2 ♂, USNM); 10 May (1 ♂, USNM); from *Liriodendron*, 20 May (1 ♀, AMNH).

Additional specimens examined. **USA**: Alabama: Cleburne Co., Talladega Natl. Forest, R. L. Brown & J. MacGown, 19 May 1998 (1 ♂, 77963, MEM); DeKalb Co., DeSoto St. Pk., R. Brown & D. Pollock, 19 May 1990 (1 ♂, 77844, MEM); Monroe Co. Maines Island Park, J. A. MacGown, 4-5 April 1995 (1 ♂, 77845, MEM); Washington D.C., on *Magnolia*, Chittenden, 14 February 1908 (1 ♂, slide HRR 391, USNM); 10 March 1908 (1 ♂, slide HRR 042, USNM); Florida: Liberty Co., Torreya St. Park, H. D. Baggett, 1 October 1983 (1 ♀, 77843, slide HRR 615, MEM); Georgia: Clarke Co., Athens, R. H. Turnbow, 23 April – 2 May 1979 (1 ♂, slide HRR 517, FSCA); Fulton Co., Silver Lake, 10 August 1913 (1 ♂, CUIC); Kentucky: Laurel Co., D. J. Wright, Bolton Branch, 18 may 1996 (1 ♂, CNCLEP00157861; 1 ♀, CNCLEP00157859, slide TOR 5156, CNC); For. Serv. Rd 615a, 4 May 1996 (1 ♀, CNCLEP00157865, CNC); Jct.

Forest Serv. Rds 121 and 4158, 18 May 1996 (1 ♂, CNCLEP00157867, slide TOR 5157, CNC); Maryland: Balt[imore] Co., Townson, J. Glaser, 1 May 2002 (1 ♂, slide 124984, USNM); Calvert Co., Scientists Cliffs, 2179 Bluebell Road, J.-F. Landry, 6 August 2005 (1 ♀, CNCLEP00017599, CNC); 31 July 2006 (1 ♂, CNCLEP00026904; 1 ♀, CNCLEP00026905, slide TOR 5068, CNC); 1 August 2006 (1 ♂, CNCLEP00026917, CNC); 4 July 2006 (1 ♀, CNCLEP00027001, CNC); 31 July 2007 (1 ♂, CNCLEP00042304, slide TOR 5067, CNC); 8 August 2007 (1 ♂, CNCLEP00042595, CNC); Cecil Co., Pleasant Hill, W. E. Steiner & J. M. Swearingen, 14-16 July 1989 (1 ♂, USNM); Montgomery Co., Colesville, D. C. Ferguson, 13 August 1976 (1 ♂, slide HRR 039, USNM); Prince George's Co., Spice Cr. NRMA, J. Glaser, 4 August 2003 (1 ♀, slide 124983, USNM); 15 August 2003 (1 ♀, USNM); Elkton, on Tulip Tree, 9 March 1985 (1 ♂, slide HRR 038, USNM); 14 March 1985 (1 ♂, slide HRR 404, USNM); 25 April 1985 (1 ♀, USNM); Mississippi: Choctaw Co., Jeff Busby Park, R. L. Brown & S. M. Lee, 9-10 June 2003 (1 ♀, 24646, slide HRR 322, MEM); Forest Co., Brooklyn, R. Kergosien, 30 March – 12 April (1 ♀, 77950, MEM); George Co., 3mi North of Lucedale, R. Kergosien, 3-8 June 1996 (1 ♂, 77989, slide HRR 593, MEM); Grenada Co., T21N R2E, Sec 12,13N& R3E, Sec 7S,18N, R. L. Brown, 7 – 13 August 1991 (1 ♀, 77835, slide HRR 609, MEM); Harrison Co., Gulfport, C.-T. Nature Area, T. L. Schiefer, 9 May 2000 (1 ♂ 77975, slide HRR 274, MEM); Lizana, R. Kergosien, 9 June 1992 (1 ♂, 77857, slide HRR 316, MEM); Long Beach, R. Kergosien, 25 May 1997 (1 ♂, 77970, slide HRR 631, MEM); Lee Co., Tombigbee State Park, R. Kergosien, 9–19 July 1994 (1 ♂, 77959, MEM); 8–30 April 1995 (1 ♂, 77860, MEM); Tishomingo Co., J. P. Coleman St. Park, R. Kergosien, 1–8 August 1994 (1 ♂, 77985, MEM); 22 July–13

August 1995 (1 ♀, 77953, MEM); Tishomingo St. Pk., J. R. MacDonald, 11–12 April 1986 (1 ♂, 77840, slide MS 1587, MEM); Warren Co., Vicksburg, Bryant Mather, 30 July 1991 (1 ♂, 98044, slide HRR 598, MEM); Wilkinson Co., Clark Creek Nat. Area, R. L. Brown, 12 July 1997 (1 ♂, 77836, slide HRR 436, MEM); Winston Co., Tombigbee Nat. Forest, D. M. Pollock, 5 April 1999 (1 ♂, 77834, MEM); New York: Chautauqua Co., nr. Fredonia, Tashenberg, 1 October 1983 (1 ♂, 77856, MEM); The Bronx, Van Cortland Park, E. Jäckh, 22 May 1970 (1 ♀, slide HRR 381, USNM); New Jersey: Anglesea, W. D. Kearfott, May 1880 (1 ♀, USNM); North Carolina: Alleghany Co., New River State Park, Oliver Farm, 2600', J. Bolling Sullivan, 2–4 May 2000 (1 ♂, slide HRR 264, USNM); 20–21 July 2000 (1 ♂, slide HRR 181, USNM); Ashe Co., US 221 Access Rd. new River State Park, J. Bolling Sullivan, 31 August 2000 (2 ♂, slides HRR 155, HRR 188, 1 ♀, slide HRR 182, USNM); Avery Co., J. Bolling Sullivan, 22–23 June 2001 (1 ♂, slide HRR 149, USNM); 19–20 August 2001 (1 ♂, slide HRR 180, USNM); 5–6 June 2002 (1 ♂, slide HRR 148, USNM); Haywood Co., 155 Mt. Pisgah Rd., J. Bolling Sullivan & L. Deutschman, 17–18 August 2001 (1 ♂, slide HRR 184, 1 ♀, slide HRR 150, USNM); Jackson Co., Balsam, D. C. Ferguson, 21 June 1974 (1 ♀, slide HRR 515, USNM); 23 June 1974 (1 ♂, slide HRR 514, USNM); Macon Co., Highlands, J. G. Franclemont, 4 July 1958 (1 ♂, slide HRR 103, USNM); Stokes Co., Hanging Rock State Park, J. Bolling Sullivan 1 –19 August 1998 (6 ♀, slides HRR 176, HRR 170, HRR 177, HRR 159, HRR 174, HRR 145, USNM); 20-21 October 1998 (1 ♀, slide HRR 158, USNM); Swaine Co., Great Smoky Mt Nat. Pk. Big Cove rd., J. Bolling Sullivan & L. Deutschman, 22 April 2001 (1 ♂, slide HRR 161, 1 ♀, slide HRR 160, USNM); GSMNP Ranger Station, Deep Creek, J. Bolling Sullivan, 23–25 July 2000 (1 ♂, slide HRR 179,

USNM); Watauga Co., Zionville, J. M. Lynch, 28 July 2014 (1 ♂, slide HRR 236, CUIC); Tryon, Fiske, 8 August 1904 (1 ♀, USNM); Ohio: Adams Co., 1 mi. S. E. of Lynx, D. J. Wright, 16 July 1990 (1 ♂, CNCLEP00157855, TOR 5155, CNC); Cincinnati, Annette F. Braun, 4 July 1905 (1♂, slide HRR 385, USNM); 21 August 1905 (1 ♀, slide HRR 041, USNM); Pennsylvania: Dauphin, 5 July 1917 (1 ♀, slide 71750, USNM); South Carolina: Oconee Co., Cherry Hill Recreation Area. Rte 107, J.G. Franclemont, 5 September 1958 (1 ♂, slide HRR 668, USNM); Tennessee: Blount Co., Cades Cove, R. L. Brown, 18 July 2004 (2 ♂, 29103, 29104, slide HRR 332, MEM); Cocke Co., Great Smoky Mountain National Park, R.L. Brown & S.M. Lee, 9 June 2002 (1 ♂, 20186, slide HRR 291, MEM); Sevier Co., Gatlinburg, Cobbly Nob (Greenbrier Resort), J.F. Landry & P. Hebert, 19 May 2005 (1 ♂, CNCLEP00016141, slide HRR 309, 1 ♀, CNCLEP00016143, slide HRR 308, CNC); Great Smoky Mountain National Park, Chimneys, R.L. Brown, 30 August 1986 (4 ♂, 77851, 77852, slide MS 1693, 77849, slide HRR 614, 77848, slide HRR 333, 2 ♀, 77850, slide HRR 337, 77853, slide MS 1694, MEM); Virginia: Fairfax Co., Alexandria (Rose Hill), P. A. Opler, 2 June 1976 (1 ♂, slide 118775, USNM); 1km E of Fairfax city, J. Brown, 18 May 2012 (1 ♀, slide HRR 393, USNM); Burke, Cove Landing Road; J. Brown, 12 May 2015 (1 ♂, USNM); 19 May 2015 (1 ♂, USNM); 24 May 2015 (1 ♂, USNM); 26 May 2015 (1 ♀, USNM); 6 June 2015 (2 ♂, TOR-DNA-1016, USNM); 10 June 2015 (1 ♀, USNM); 26 April 2016 (1 ♀, USNM); 28 May 2016 (1 ♂, slide HRR 398, USNM); 7 June 2016 (4 ♂, slides HRR 025, HRR 031, 1 ♀, slide HRR 395, USNM); 12 June 2016 (2 ♂, slides HRR 026, HRR 028, 3 ♀, slides HRR 027, HRR 029, HRR 030, USNM); West Springfield, J. B. Heppner, 23 June 1979 (1 ♂, 2 ♀, FSCA); Floyd Co., Buffalo Mtn. Natural Area Preserve, S. M.

Roble, 9 July 2010 (1 ♂, slide HRR 389, 1 ♀, slide HRR 394, USNM); 20 May, from *Liriodendron* (1 ♂, slide HRR 396, USNM).

Distribution and biology. Collection data for *P*. *liriodendrana* indicate a lengthy flight period from late February to mid-October. The range for this species extends across the southeastern U.S. from the southwestern border of Mississippi northeast to central and coastal New York. *Paralobesia liriodendrana* has only been reared from host plants in the family Magnoliaceae: *Liriodendron tulipifera* L. and *Magnolia* L.

Discussion. We are unsure of how many specimens were in the original syntype series. *Klots*' designation of a lectotype attributed to Heinrich was invalid because he did not designate a single type specimen from the AMNH. We here designate a specimen as the lectotype.

DNA sequence data. This species is a well-supported clade (88% BS) in our phylogenetic tree, sister to *P*. *parsaurum* (Fig. 24).

Paralobesia albiterminana **Royals & Dang, sp.n.**

Figs. 57–60, 162, 194

Diagnosis. Most likely to be confused with *P*. *cyclopiana*, *P*. *albiterminana* can be separated by wing pattern and female genitalia. Male genitalia are impossible to distinguish. In *P*. *albiterminana*, the forewing has a large pale, yellowish, circular spot, occupying the apical third of the wing. This pale spot has a nearly straight basal margin, from the costa to nearly the center of the dorsum, encompassing the entire tornal spot.

Dark scaling in the center of this pale spot may be present or absent. In *P*. *cyclopiana*, this pale spot never encompasses the tornal patch, though often touches the dorsal margin. A large dark spot in the center of the pale scaling may be present or absent in this species. Female genitalia can be differentiated by the shape of the sterigma. In *P*. *albiterminana*, the sterigma is sub-rectangular, and flattened, almost platelike against the ventral surface of the abdomen, with the ostium occupying about one half of the surface. In *P*. *cyclopiana*, the sterigma is well rounded in shape, protruding from the ventral surface of the abdomen, with a wide ostium, encompassing nearly the entire posterior end of the sterigma.

Description. **Male**. *Head*: Vertex pale brown; frons scaling uniformly white; labial palpus pale brown, length ca. 1.9 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum pale to dark brown; posterior crest dalk brown; fore- and mid-legs mottled dark brown with white annulations on tibia and tarsal segments, hind legs pale. Forewing length 5.9–8.0 mm (mean 6.7 mm; n = 12); ground color grey, most fasciae and striae indiscernable; costal strigulae pairs 2–9 expressed as grey dashes along costa; subbasal fascia a narrow mottling of brown scales, difficult to discern against grey base; postmedian fascia reduced to a triangular dark brown pretornal patch; postmedian band a large patch extending to termen and encompassing tornal patch, pale yellowish brown with dark brown scaling in center present or absent; preterminal fascia a thin dark streak near apex; fringe scales darkly mottled. Hindwing uniformly brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten pale brown. *Abdomen:* Greyish brown, pale elongate scales from terminal segment. Genitalia with uncus absent; socius

large lobes, occupying nearly entire area above sclerotized tegumen, covered in dense fine setae 1.5 times as long as socius; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus enlongate, narrow, parallel sided, costal margin broadly concave, apex rounded, ventral margin weakly convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, not extending beyond ventral cucullus margin, Spc_2 ca.1.0 times as large as Spc_1, spines on both Spc_1 and Spc_2, thick and spikelike, sparse and widely spaced; Spc_2 and Spc_3 separated by shallow emargination ca. 0.25 times as deep as emargination between Spc_1 and Spc_2, spines on Spc_3 thin and short, not reaching Spc_1, with small barb at apex. Phallus tapering distally, curved, sclerotized along one side entirely, the other about 0.5 the length, length ca. 0.5 that of the cucullus, with a strongly sclerotized ventral tooth, keel-like in shape. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 5.5–8.8 mm (mean 7.3; n = 10) and hindwings dark brown. *Abdomen*: Dark brown. Genitalia with apophyses anteriores ca. same length as apophyses posteriores; sterigma flattened, sub-rectangular, moderately sclerotized, with spiculated anterior surface; ostium oriented posteroventrally, occupying 0.5 of posterior face; ductus bursae ca. 1.3 times length of corpus bursae, colliculum occupying posterior 0.25; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with paired long, shallow, signum consisting of thickened cells, ca. 0.3 times the length of corpus bursae, and two accessory sacs.

Holotype. ♂, “FL, Marion Co., East Silver Springs Shores, Malauka Rd. nr. Meadow Lake; John S. Kutis, 8-IV-1991; Collected at MV light; W. L. Adair Collection – 2003; ♂ genitaia on slide HRR 409” (FSCA).

Paratypes. **USA**: Florida, Collier Co., Collier Seminole State Park, Linwood C. Dow, 2 May 1987 (3 ♂, slide HRR 021, FSCA); Highlands Co., Archbold Biological Station, Lake Placid, J. G. Franclemont, 4 April 1959 (1 ♀, slide 17799, USNM); Archbold Biol. Station 10 mi. S. Lake Placid, J. B. Heppner, 2 May 1975 (1 ♀, slide HRR 535, FSCA); 6 May 1975 (1 ♂, slide HRR 534, FSCA); Hammock State Park, Linwood C. Dow, 7 March 1988 (1 ♂, slide HRR 411; 3 ♀, slides HRR 020, HRR 022, FSCA); Leon Co., Tall Timbers Res. Sta. Lk. Iamonia, J. B. Heppner, 19-21 May 1986 (1 ♀, slide HRR 536, FSCA); Marion Co., Ocala National Forest, Salt Springs Trl., J. J. Dombroskie et al., 20 June 2006 (2 ♀, slide HRR 226, CUIC); Pinellas Co., Hammock Park, Dunedin, Linwood C. Dow, 9 March 1978 (2 ♂, slide HRR 023, FSCA); 23 April 1987 (1 ♂, slide HRR 410, FSCA); Putnam Co., Ocala National Forest, intersection of SR 19 and Oklawaha River Swamp Forest, Terhune S. Dickel, 21 March 2004 (1 ♂, 00718023, slide 126405, USNM); nr. Interlachen, intersection of 310 and 19, P. Hebert, K. Pickthorn & J. deWaard, 16 June 2006 (1 ♂, slide HRR 538, CBG); Brooker, on *Magnolia grandiflora*, A. N. Tissott, 11 May 1949 (1 ♂, slide 72304, USNM); Lake Placid, R. W. Hodges, 30 April 1964 (1 ♀, slide 17800, USNM); Georgia, Emanuel Co., Ohoopee Dunes Natural Area, R. L. Brown & S. M. Lee, 17 June 2002 (1 ♀, 21959, slide HRR 405, MEM).

Distribution and biology. Collection data limits the known range of *P. albiterminana* to the south eastern states of the U.S. primarily Florida and Georgia. This

southerly range allows for early fliers, with a flight period from early March through late June. Only a single specimen from the examined material had a host recorded – *Magnolia grandiflora* L. (Magnoliaceae), a perennial tree native to the southeast U.S.

Etymology. The name *P*. *albiterminana* was listed by P. T. Dang in an unpublished manuscript for this *P*. *cyclopiana* look-alike.

DNA barcode data. This species forms a well-supported clade (95% BS) in our phylogenetic tree (Fig. 24).

***Paralobesia cyclopiana* (Heinrich, 1926)**

Figs. 61–64, 163, 195

Polychrosis cyclopiana Heinrich 1926:93; McDunnough 1939:40; Brower 1983:24. *Paralobesia cyclopiana*; Obraztsov 1953:94; Brown 2005:472; Gilligan et al. 2008:49. *Endopiza cyclopiana*; Powell 1983:31.

Diagnosis. This is one of the most easily recognized moths of *Paralobesia* in terms of wing pattern. Most likely to be confused with *P*. *albiterminana*, *P*. *cyclopiana* can be separated by wing pattern and female genitalia. Male genitalia are impossible to distinguish. The forewing of *P*. *cyclopiana* has a large pale, yellowish, circular spot, occupying the apical third of the wing. This pale spot never encompasses the tornal patch, though often touches the margin. A large dark spot in the center of the pale scaling may be present or absent in this species. In *P*. *albiterminana*, this pale spot has a nearly straight basal margin, extending from the costa to the center of the dorsum,

encompassing the entire tornal spot. Dark scaling in the center of this pale spot may be present or absent. Female genitalia can be differentiated by the general shape of the sterigma. In *P*. *cyclopiana*, the sterigma is well rounded, protruding from the ventral surface of the abdomen, with a wide ostium, encompassing nearly the entire posterior end of the sterigma. In *P*. *albiterminana*, the sterigma is sub-rectangular, and flattened, almost platelike against the ventral surface of the abdomen, with the ostium occupying about one half of the surface.

Redescription. **Male**. *Head*: Vertex pale brown; frons scaling uniformly white; labial palpus pale brown, length ca. 1.7 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum pale to dark brown; posterior crest dalk brown; fore- and mid-legs mottled dark brown with white annulations on tibia and tarsal segments, hind legs pale. Forewing length 5.9–7.7 mm (mean 7.0 mm; n = 24); ground color grey, most fasciae and striae indiscernable; costal strigulae pairs 2–9 expressed as grey dashes along costa; subbasal fascia a narrow mottling of brown scales, difficult to discern against grey base; postmedian fascia a triangular dark brown pretornal patch; postmedian band a large circular patch extending to termen, pale yellowish brown with dark brown scaling in center present or absent; preterminal fascia a thin dark streak near apex; fringe scales darkly mottled. Hindwing uniformly brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten pale brown. *Abdomen:* Greyish brown, pale elongate scales from terminal segment. Genitalia with uncus absent; socius large lobes, occupying nearly entire area above sclerotized tegumen, covered in dense fine setae 1.5 times as long as socius; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous

subscaphium; cucullus enlongate, narrow, parallel sided, costal margin broadly concave, apex rounded, ventral margin weakly convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, not extending beyond cucullus margin, Spc_2 ca.1.0 times as large as Spc_1, spines on both Spc_1 and Spc_2, thick and spikelike, sparse and widely spaced; Spc_2 and Spc_3 separated by shallow emargination ca.0.25 times as deep as emargination between Spc_1 and Spc_2, spines on Spc_3 thin and short, not reaching Spc_1, with small barb at apex. Phallus tapering distally, curved, sclerotized along one side entirely, the other about 0.5 the length, length ca. 0.5 that of the cucullus, with a strongly sclerotized ventral tooth, keel-like in shape. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 7.4–8.2 mm (mean 7.7; n = 7). *Abdomen*: Dark brown. Genitalia apophyses anteriores ca. same length as apophyses posteriores; sterigma doughnut-like, circular, moderately sclerotized, with spiculated anterior surface; ostium oriented posteriorly, occupying entire posterior surface; ductus bursae ca. 1.3 times length of corpus bursae, colliculum occupying posterior 0.25; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with a long, shallow, signum consisting of thickened cells, .25 times length of corpus bursae, and two accessory sacs.

Holotype. ♀, “Seed pods swamp magnolia; July 1920; Burnt Mills N[ew].J[ersey].; H. B. Weiss Coll.; Type No 28032 U.S.N.M.; ♀ genitalia on slide, 3 Nov. 1923, #3, C. H.; *Polychrosis cyclopiana* Hein., TYPE; ♀ genitalia slide By C. H., USNM 72855” (USNM).

Paratype. **USA**: Pennsylvania, vicinity of Philadelphia, J. McDunnough, 20 July 1924 (1 ♂, CNCLEP00132133, slide TOR 441, CNC).

Additional specimens examined. **USA:** Alabama, Baldwin Co., Bon Secour NWR, in imported *Magnolia glauca*, R. L. Brown & D. M. Pollock, 7-9 August 1994 (1 ♂, 77902, MEM); Weeks Bay NER Reserve, E. Martinez, 13-15 April 2007 (1 ♀, 42565, MEM); R. L. Brown, 13 April 2001 (1 ♀, 77903, MEM); 25 June 2001 (1 ♂, 77905, MEM); 13 April 2007 (1 ♀, 38070, slide HRR 407, MEM); R. L. Brown & J. MacGown, 23 June 2001 (1 ♂, 77904, MEM); Louisiana, La. St. Tam. Par., 4.2 mi NE Abita Springs, V. A. Brou, 26 April 1983 (1 ♂, slide 25537, USNM); Maryland, Dorchester Co., 3 mi east of Hurlock, J. Glaser, 9 May 2002 (1 ♂, slide HRR 043, USNM); 10 May 2004 (1 ♂, USNMENT00718024, USNM); Mississippi, George Co., Mixon Lakes, J. A. MacGown, 9-10 April 1999 (1 ♂, 77925, MEM); Hancock Co., Bayou LaTerre, R. Kergosien, 4 July 1977 (1 ♀, 77927, slide 917824, MEM); Harrison Co., Long Beach, R. Kergosien, 3 May 1993 (1 ♂, 77906, slide HRR 406, MEM); 5 April 1995 (1 ♂, 77907, MEM); 24 April 1995 (1 ♂, 77908. slide HRR 339, MEM); 28 April 1995 (1 ♂, 77909, slide HRR 340, MEM); 16 May 1995 (1 ♂, 77910, MEM); 19 June 1995 (1 ♂, 77911, MEM); 21 June 1995 (1 ♀, 77912, slide HRR 341, MEM); 21 April 1996 (1 ♂, 77913, MEM); 27 April 1996 (1 ♂, 77914, slide HRR 412, MEM); 30 April 1996 (1 ♂, 77915, MEM); 9 June 1996 (1 ♂, 77917, slide HRR 408, MEM); 21 July 1996 (1 ♀, 77918, slide HRR 342, MEM); 30 April 1997 (1 ♂, 77919, MEM); 10 April 1998 (1 ♂, 77920, MEM); 13 April 1998 (1 ♂, 77921, MEM); Jackson Co., Moss Point, E. C. Knudson & Bordelon, 23 June 2013 (1 ♀, slide HRR 537), FSCA); Winston Co., Tombigbee Nat. Forest, M. L.

Heddle, 18 march 1999 (1 ♂, 77926, MEM); J. A. MacGown, 17 May 1999 (1 ♂, 77923, MEM); D. M. Pollock, 17 May 1999 (1 ♂, 77924, MEM).

Distribution and biology. Collection data marks the range for *P*. *cyclopiana* as primarily a deep southern species, with most collections from Mississippi, Alabama, and Louisiana. A handful have been collected in Maryland.

Discussion. Heinrich listed the female type as being deposited in the CNC. This specimen resides in the USNM, whereas the male paratype is at the CNC.

DNA sequence data. In a phylogenetic analysis using COI, *P*. *cyclopiana* comes out as a polytomy, but related to *P*. *albiterminana* (Fig. 24).

***Paralobesia carduana* (Busck, 1907)**

Figs. 65–68, 164, 196

Polychrosis carduana Busck 1907:134; Barnes and McDunnough 1917:167; Forbes 1923: 472; Heinrich 1926: 96; Brower 1983:24.
Lobesia carduana; Obraztsov 1953:91; MacKay 1959:134; Powell 1983:31; Miller 1987:17.

Diagnosis. *Paralobesia carduana* has variable coloration of wing markings and is superficially similar to many other *Paralobesia* species. Female genitalia may be confused with those of *P*. *cyclopiana*. In *P*. *carduana*, the female sterigma is distinctly rounded and donut-shaped, with the ostium taking up no more than one half of the posterior surface, while in *P*. *cyclopiana*, the sterigma is rounded anteriorly, but the

posterior surface tapers to an edge, and the ostium encompasses nearly the entire posterior surface. Male genitalia are unlikely to be confused with any other species in *Paralobesia*. The spines of Spc_2 are splayed across the wide, rounded lobe and Spc_3 is a very short tuft of spines in the back at the base of the sacculus, quite difficult to observe in a ventrally slide mounted genitalia preparation. Other males of *Paralobesia* either do not possess this rounded, splayed Spc_2, or have Spc_3 at least extending visibly past Spc_2.

Redescription. **Male**. *Head*: Vertex brown to dark brown; frons scaling uniformly white; labial palpus pale brown, all segments combined ca. 1.9 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna brown. *Thorax:* Dorsum with alternating bands of reddish brown and dark brown scales; posterior crest dark brown; legs dark brown with white annulations on tibia and tarsal segments. Forewing length 5.4–5.5 mm (n = 2); ground color grey, wing markings reddish and dark brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; dorsal half of interfascial area between subbasal fascia and median fascia pale yellowish brown; median fascia dark brown to black in costal half, brown to pale brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, an irregular oval patch at costa and a triangular, dark brown pretornal patch; postmedian band a large semioval patch extending to termen, usually with notch originating near tornus and reaching center of wing; preterminal fascia a small dark patch near apex; fringe scales darkly

mottled. Hindwing brown; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus weakly bilobed, with patches of setae from either side of apex, extending ventrally, as long as uncus; socius absent; gnathos a weakly sclerotized band, fused with membranous subscaphium, microtrichiate medially; cucullus weakly clavate, costal margin concave, apex widely rounded, ventral margin weakly concave, nearly straight, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate emargination, lobe extending ventrally so spine cluster is entirely past the ventral margin of the cucullus; Spc_2 on a very widely rounded lobe, spines splayed; Spc_3 from backside of base, spines on Spc_3 very short and thin, barely extending past Spc_2. Phallus tapering distally, curved, length ca. 0.8 times that of the cucullus, with 1-2 teeth near apex. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 5.5–5.6 mm (n = 2). *Abdomen*: Dark brown. Genitalia with apophyses anteriores ca.1.2 times as long as apophyses posteriores; Sterigma donut-like with margins rounded, strongly sclerotized and spinulate; ostium oriented posteroventrally, occupying < 0.5 of the posterior surface; ductus bursae ca. 0.5 times as long as corpus bursae; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with paired long, shallow signum consisting of thickened cells, and two accessory sacs, ca. 0.2 times the length of corpus bursae.

Holotype. ♀ “Hyattsville, Aug.06 Md., on thistle; Aug. Busck Collector; Type No. 10159., U.S.N.M.; *Polychrosis carduana* Type, Busck; ♀ genitalia on slide HRR 683” (USNM).

Paratypes. not examined

Additional specimens examined. **USA**. Illinois, Putnam Co., M. O. Glenn, 18 July 1958 (1 ♂, slide HRR 492, INHS); Iowa, Muscatine, C. E. Smith, 7 May 1917 (1 ♀, slide HRR 094, USNM); Ohio, Greene Co., Bath Township, Wright-Patterson AFB Huffman Prairie, Eric H. Metzler, 14 July 1995 (1 ♂, slide HRR 426; 1 ♀, slide HRR 415, USNM).

Distribution and biology. Distribution according to limited collection records indicate a range throughout the midwestern U.S.

DNA sequence data. This group is a well-represented clade (98% BS) in our phylogenetic tree (Fig. 24).

Paralobesia crassus Royals and Gilligan, sp.n.

Figs. 69–72, 166, 197

Diagnosis. *Paralobesia crassus* appears to have a spring and summer form. While the spring form is distinguishable by wing pattern, the summer form is superficially similar to *P*. *monotropana* but can be distinguished by genitalia. In the spring form, the median fascia is outlined in the costal two thirds by a thick border of pale brown scales extending towards the apex of the wing and blending with the pale discal spot. Male and female genitalia are unmistakable in this species. The large cucullus in the male is widest at the center and almost triangular in shape separate this from males of other *Paralobesia* species. The sterigma in the female is sub-rectangular and smooth surfaced, clearly separating it from other females in this group.

Description. **Male**. *Head*: Vertex pale reddish brown; frons scaling uniformly white; labial palpus pale brown, all segments combined ca.1.7 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with brown and tan scales with a transverse band of dark brown scales; posterior crest mottled with dark brown scales; Fore- and mid-legs dark brown with white annulations on tibia and tarsal segments, hind-legs pale brown. Forewing length 4.0–5.0 mm (mean 4.6 mm; n = 11); ground color blue grey, wing markings a mix of red-brown and dark brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown on costal edge; median fascia dark brown in costal half with a mix of pale brown in dorsal half, dorsal half outlined in pale brown scales, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, an irregular patch at costa and a triangular pretornal patch with dark center; postmedian band a large semioval patch extending to termen and meeting costa, usually with notch originating from termen near M_3; preterminal fascia a small indistinct patch near apex; fringe scales darkly mottled. Hindwing uniformly dark brown with paler scales at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. (In the summer form, the pale outline of the median fascia is lacking and the hind wings are a darker brown.) *Abdomen:* Pale to dark brown. Genitalia with uncus curved posteriorly, with patch of setae as long as uncus extending ventrally from sides of apex; socius absent; gnathos a weakly sclerotized band, strongly microtrichiate medially, fused with membranous

subscaphium; cucullus broad in center, stout, costal margin broadly concave, apex rounded, ventral margin strongly convex, ventral two thirds covered in thick spine-like setae, apex and dorsal edge covered in finer setae;; Spc_1 separated from cucullus by very narrow emargination often obscured by Spc_1; extending ventrally beyond cucullus ca. 0.25 times its length, Spc_2 1.2 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by emargination 0.5 times the depth of that between Spc_1 and Spc_2; Spc_3 on a raised lobe, spines on Spc_3 thick and feathery, extending past Spc_1 to center of cucullus. Phallus tapering distally, curved, length ca. 0.3 times that of the cucullus, with a single tooth along ventral curvature near apex.

Female. *Head:* As in male. *Thorax*: As in male, except forewing length 4.1–5.1 mm (mean 4.6; n = 9). *Abdomen*: Coloration brown. Genitalia; apophyses anteriores ca.1.2 times as long as apophyses posteriores; sterigma sub-rectangular, moderately sclerotized and smooth surfaced; ostium one half of posterior margin, oriented posteriorly; ductus bursae ca. 2.0 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with a short, shallow signum of thickened cells, 0.2 times the length of corpus bursae, lacking paired accessory sacs.

Holotype. ♂, “USA: VA: Fairfax Co. Burke, Cove landing Road, 38.784, -77.281, 11 May 2015, J. Brown; Legs removed for sequencing TOR-DNA-103; ♂ genitalia on slide, HRR 294” (USNM).

Paratypes. **USA**: Arkansas: Conway County, Petit Jean St. Park; hardwood forest in ravine, W.H. Cross Expedition, R. L. Brown, 5 August 2008 (1 ♀, 43595, slide HRR 599, MEM); Kentucky: Powell Co. Tunnel Ridge, L. Gibson, 28 April 1989 (1 ♂, CNCLEP00099649, slide TOR 2235, CNC); Louisiana: Bossier Parish, Barksdale

A.F.B., D. M. Pollock, 8 April 1996 (1 ♂, 77872, slide HRR 617, MEM); 16 April 1996 (1 ♂, 77947, slide HRR 635, MEM); Mississippi: Oktibbeha Co., 5 mi S. of Starkville, R. L. Brown,10 April 2002 (1 ♀, 98010, slide HRR 592, MEM); Miss. State. Univ(ersity)., Charles T. Bryson, 22 August 1975 (1 ♀, 97985, slide HRR 601, MEM); Noxube Co., Noxube N. W. refuge, D. M. Pollock, 14 April 1993 (1 ♀, 77956, slide HRR 619, MEM); Jackson Co. Shepard State Park, R. Kergosien, 1-5 September (19)95 (1 ♂, 77986, slide MS99505, MEM); Oklahoma: Bartlesville, Cherokee Hills Drive, Mark Dreiling, 20 August 2008 (1 ♂, MDOK-0738, slide HRR 356, CNC); 16 April 2009 (3 ♂, MDOK-1982, MDOK-1985, MDOK-2082, CNC); 23 April 2009 (1 ♂, MDOK-2158, CNC); 24 April 2009 (1 ♀, MDOK-2167, slide HRR 355, CNC); 26 April 2009 (1 ♀, MDOK-2177, slide TOR 5072, CNC); 12 August 2009 (1 ♀, MDOK-3090, slide TOR 5078, CNC); 26 August 2009 (1 ♀, MDOK-3283, slide HRR 354, CNC); Tennessee: Sevier Co. Gatlinburg, Cobbly Nob, J. F. Landry & P. Herbert; 19 May 2005 (1 ♂, CNCLEP00016138, CNC); Virginia: Fairfax Co., Burke, Cove Landing Road, J. Brown, 10 May 2015 (1 ♂, slide HRR 284, USNM); 12 May 2015 (1 ♀, slide HRR 295, USNM).

Distribution and biology. Collection data for *P*. *crassus* indicate a range across the southeastern U.S. from coastal Virginia west to Oklahoma and south to coastal Mississippi. Collection dates and difference in coloration suggest that this species has two forms: a spring form that flies from early April to late May, and a summer form that flies from early August to mid-September.

Etymology. The term ‘*crassus’* in Latin is used as an adjective for large, thick or fat. With the uniquely large cucullus and sterigma in this species, it seemed particularly fitting.

DNA sequence data. Sequences for 13 of these specimens in the BOLD database result in a well-supported clade (96% BS) (Fig. 24).

Paralobesia blandula (Heinrich, 1926)

Figs. 73–76, 166, 198

Polychrosis blandula Heinrich 1926:93; McDunnough 1939:40; Brower 1983:24. *Paralobesia blandula*; Obraztsov 1953:94; Brown 2005:472; Gilligan et al. 2008:49. *Endopiza blandula*; Powell 1983:31.

Diagnosis. This moth is easily recognized by its wing markings and characters of both male and female genitalia. Superficially it resembles *P*. *yaracana* and female genitalia may be confused with those of *P*. *wontonana*. *Paralobesia blandula* has forewings with orange-brown markings and a conspicuous creamy pale scaling in the dorsal half of the interfascial area between the subbasal fascia and median fascia, creating a pale circular spot. The forewings of *P*. *yaracana* have an overall pale brown color, lacking the orange markings and no obvious pale spot along the dorsal edge.

In females of *P*. *blandula*, the sterigma has a posterior border that is finely serrate around entire edge, and has lateral shoulders. In *P*. *wontonana*, the posterior edge of the sterigma has the appearance of gathered folds and is not entirely serrate.

Redescription. **Male**. *Head*: Vertex pale brown; frons scaling uniformly white; labial palpus pale brown, length ca. 2.4 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum pale to

dark brown; posterior crest dark brown; fore- and mid-legs mottled dark brown with white annulations on tibia and tarsal segments, hind legs pale. Forewing length 6.0–6.5 mm (mean 6.2 mm; n = 2); ground color grey and red brown; costal strigulae pairs 2–9 expressed as pale dashes along costa; subbasal fascia jagged along distal margin, widening from costa to cubitus and narrowing from cubitus to dorsum; dorsal half of interfascial area between subbasal fascia and median fascia entirely pale to white scaled; median fascia dark brown in costal half with a mix of pale brown in dorsal half, dorsal half outlined in pale brown scales, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot obvious; postmedian fascia divided into two sections, a small irregular patch at costa and a dark brown triangular pretornal patch; postmedian band a large patch with wavy margins extending to termen, pale yellowish brown to dark brown; preterminal fascia a dark spot near apex; fringe scales darkly mottled. Hindwing mostly white with dark brown scaling at apex; fringe scales long, dark brown basally, pale brown apically; cubital pecten pale brown. *Abdomen:* Greyish brown, pale elongate scales from terminal segment. Genitalia with uncus absent; socius absent; gnathos a weakly sclerotized band, strongly microtrichiate medially, fused with membranous subscaphium; cucullus enlongate, narrow, weakly clavate, costal margin broadly concave, apex rounded, ventral margin weakly convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, extending beyond cucullus margin ca. 0.5 times its length, Spc_2 ca.1.0 times as large as Spc_1, spines on both Spc_1 and Spc_2, thick and spikelike; Spc_2 and Spc_3 separated by shallow emargination ca. 0.25 times as deep as emargination

between Spc_1 and Spc_2, spines on Spc_3 thin and short, reaching past Spc_2 but not Spc_1, with small barb at apex. Phallus tapering distally, weakly curved, sclerotized along one side and ventrally, length ca. 0.6 times that of cucullus, with a strongly sclerotized ventral tooth. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 6.6 mm (n = 1). *Abdomen*: Dark brown. Genitalia apophyses anteriores ca. same length as apophyses posteriores; sterigma sub-sperical with posterior margin dorsoventrally flattened and strongly serrate, moderately sclerotized, with spiculated anterior surface; ostium oriented posteriorly,; ductus bursae ca. 1.3 times length of corpus bursae, colliculum occupying posterior 0.2; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with a long, shallow, signum consisting of thickened cells, and two accessory sacs.

Holotype. ♂, “Aweme, Man[itoba], N. Criddle, 9-VI-1921; *Polychrosis blandula*, Hein. TYPE; TYPE *Polychrosis blandula* Hein. No. 1773; ♂ genitalia on slide #1 C.H. June 4, 1924; Database # CNCLEP00019798; ♂ genitalia on slide TOR 5063” (CNC).

Additional specimens examined. CANADA. Alberta: 8km SE Sherwood Park, G. R. Pohl, 22 June 2002 (1 ♂, slide HRR 430, NFRC); Northwest Territories: Wood Buffalo National Park, Benchmark weather station, Aspen stand, Nicole Labine, 17 June 2012 (1 ♂, BIOUG05849-C03, slide TOR 5081, CNC); Ontario: Lambton Co., Port Franks, K. H. Stead, 15 May 1998 (1 ♀, CNCLEP00111930, slide TOR 5111, CNC); 27 May 2014 (1 ♂, BIOUG21233-C03, slide HRR 254, CNC).

Distribution and biology. Limited collection data suggests that *P. blandula* is one of the furthest north-ranging species of *Paralobesia*. With records from the southern border of the Northwest Territories southeast to southern Ontario. Collection dates

range from mid-May to late July. Besides being collected in an aspen forest (label data), no other host data has been recorded.

DNA sequence data. In a phylogenetic analysis using COI, these specimens group nicely (85% BS) (Fig. 24).

Paralobesia aemulana (Heinrich, 1926)

Figs. 77–80, 167, 199

Polychrosis aemulana Heinrich 1926:94; McDunnough 1939:40.

Paralobesia aemulana; Obraztsov 1953:92; Brown 2005:471.

Endopiza aemulana; Powell 1983:31.

Diagnosis. *Paralobesia aemulana* is superficially similar to both *P*. *vernoniana* and *P*. *spiraeifoliana*, but is easily identified by male genitalia. In *P*. *aemulana* Spc_1 is about flush or extending just past the ventral margin of the cucullus, while in *P*. *vernoniana* this cluster does not extend past the margin, and in *P*. *spiraeifoliana* it extends well past the cucullus margin. The characters of the phallus can differentiate the three as well. In *P*. *aemulana*, there is a distinctive slender tooth from the very apex extending further apically. *Paralobesia vernoniana* has a large tooth in the center of the phallus, while *P*. *spiraeifoliana* has a short serrated keel from the center of the dorsal curvature. Female genitalia might be confused with that of *P*. *exasperana*, however the sterigma of *P*. *aemulana* is more conical rather than cylindrical as in *P*. *exasperana* and is more densly spined.

Redescription. **Male**. *Head*: Vertex pale reddish brown; frons scaling uniformly white; labial palpus pale brown, all segments combined ca. 1.6 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales; posterior crest mottled dark brown; legs brown with white annulations on tibia and tarsal segments. Forewing length 5.0 mm (n = 1); ground color leaden grey, wing markings mostly dark brown, outlined in red brown scales; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing slightly from cubitus to dorsum, wider at dorsum; median fascia dark brown outlined in paler orange scales, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot usually present as patch of pale scales; postmedian fascia divided into two sections, an oval patch at costa and a triangular pretornal patch that reaches 0.3-0.5 the distance to costa; postmedian band a large, long semioval patch extending to termen, nearly reaching tornus, usually with notch originating from termen near M_3 separating dorsal half from termen; preterminal fascia a small indistinct patch near apex; fringe scales darkly mottled. Hindwing uniform brown with paler scales at base; fringe scales long, dark brown basally, brown apically; cubital pecten brown. *Abdomen:* Pale to dark brown. Genitalia with uncus reduced, moderately bilobed and curved posteriorly, with patch of very short setae shorter than uncus extending ventrally from apex of each lobe; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus weakly clavate, costal margin broadly concave, apex rounded, ventral margin convex, ventral half covered in spine-

like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate narrow emargination, extending ventrally beyond cucullus ca. 0.3 times its length, Spc_2 0.75 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated extremely shallow emargination, Spc_3 at base, spines on Spc_3 thick, and long, extending past edge of Spc_2 almost to apex of cucullus. Phallus tapering distally, curved, length ca. 1.0 that of the cucullus, with a narrow tooth projecting forward from apex. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.7–5.3 mm (mean 4.9; n = 3). *Abdomen*: Coloration variable, mostly brown with darker scaling on posterior segments. Genitalia apophyses anteriores ca.1.0 times as long as apophyses posteriores; sterigma conical, moderately sclerotized and strongly microtrichiate, anterodorsal margin extending past ventral, with median indentation, posterior margin serrate; ostium oriented posteriorly. Ductus bursae ca. 2.0 times as long as corpus bursae; colliculum strongly sclerotized; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with paired long, shallow, signum of thickened cells 0.25 times the length of corpus bursae and two accessory sacs, ca.0.25 the length of corpus bursae.

Holotype. ♂, “Hazleton, Pa. 7-3-05; Kearfott Col. Ac. 4667; Am. Mus. Nat. Hist. Dept. Invert. Zool. No.; ♂ genitalia on slide, C.H. 19 May 1922; *Polychrosis aemulana*, Hein. TYPE” (AMNH).

Paratypes. **USA**: Pennsylvania: Hazleton, 3 July 1905 (1 ♀, slide 71771, USNM); New Jersey: Essex Co. Pk., W. D. Kearfott, 3 June (1 ♀, slide 97885, USNM).

Additional specimens examined. **CANADA**: Nova Scotia: Halifax, Point Pleasant Park, Tyler Zemlak, 13 July 2013 (1 ♀, BIOUG07530-C06, in alcohol, slide

HRR 549, CBG); Petite Riviere, J. McDunnough, 15 June 1935 (2 ♀, CNCLEP00103637, slide TOR 1360, CNCLEP00105430, slide TOR 1359, CNC); Ontario: Pukaskwa National Park, Heron Bay, Cavan Harpur, 1 July 2013 (1 ♂, BIOUG10121-B09, in alcohol, slide HRR 551, CBG); Beamsville, W. L. Putnam, from *Eupatorium purpureum*, 27 June 1937 (1 ♂, CNCLEP00099663, slide TOR 5062, CNC) Prince Edward Island: Portage, J. McDunnough, 18 July 1940 (1 ♂, CNCLEP00105431, slide TOR 2337, 1 ♀, CNCLEP00103638, slide TOR 2234, CNC); Québec: Gatineau Park, fen near Hickory Trail, J.-F. Landry & Marilyn H.S. Light, 1 July 2013 (1 ♀, BIOUG10121-B06 – in alcohol, slide HRR 550, CNC). **USA**: Pennsylvania (1 ♂, slide HRR 530, CUIC).

Distribution and biology. *Paralobesia aemulana* collection data indicate a range through southeastern Canada and northeastern U.S., from central Ontario east to Nova Scotia, and south to Pennsylvania. Collection dates suggest a summer flight period from early June through late July. Only one of the above specimens had an associated host record, *Eutrochium* (*Eupatorium*) *purpureum* (L.) E.E. Lamont (Asteraceae). Another species, *P*. *slingerlandana* is known to feed on *Eupatorium perfoliatum*.

DNA sequence data. Three sequences are present in the BOLD database and represented as a group with a boostrap support value of 100% in our phylogenetic tree (Fig. 24).

Paralobesia viteana (Clemens, 1860)

Figs. 81–83, 168, 200

Endopiza viteana Clemens, 1860:359; Diakonoff 1973:383; Powell 1983:31; Miller 1987:15; Godfrey et al. 1987:32.

Penthina vitivorana Packard 1869:336; Riley 1869:133; Walsh and Riley 1869:177.

Lobesia viteana Razowski 1983:109.

Polychrosis botrana Ragonot 1894:208; Fernald 1903:449.

Polychrosis viteana: Kearfott 1904:292; Barnes and McDunnough 1917:167; Heinrich 1926:90; Forbes 1924:473; McDunnough 1939:40; Darlington 1947:92.

Paralobesia viteana Obraztsov 1953:93; Diakonoff 1954:10; MacKay 1959:132; Miller 1973:225; Brown 2005:472; Gilligan et al. 2008:47.

Diagnosis. *Paralobesia viteana*, with variable wing marking shapes can, at first glance, be confused with a number of different species of *Paralobesia*. However, wing coloration can be diagnostic and both male and female genitalia are unmistakable. In the forewing of *P*. *viteana*, the subbasal fascia is very faint against the gray background, giving the basal half a contrasting grey against the pale and dark brown markings of the apical half, and the costal portion of the postmedian fascia, present as an oblong patch or dash in other species, is nearly absent in *P*. *viteana*. Male genitalia of *P*. *viteana* may be instantly recognized by the protrusion of a large ‘paintbrush’-like lobe extending midway up the valve between Spc_1 and the base of the cucullus, and the highly reduced Spc_3. Neither of these features are present in other *Paralobesia*. In females of *P*. *viteana* the sterigma is shaped like a dorsal-ventrally flattened half circle, and smooth circled, and there is a large, strongly microtrichiate ‘collar’ of membrane between

segments 9 and 10. Neither of these features are present in any other female of *Paralobesia*.

Redescription. **Male**. *Head*: Vertex rough scaled, reddish brown; labial palpus pale brown, length ca. 1.7 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna brown. *Thorax:* Dorsum reddish brown; posterior crest brown; fore- and mid-legs mottled brown with white annulations on tibia and tarsal segments, hind-legs pale. Forewing length 3.9–5.6 mm (mean 5.0 mm; n = 16); ground color grey in basal half, pale brown in apical half, divided diagonally from halfway along dorsum to 0.66 the way up costa, wing markings mix of dark brown and brown scales; costal strigulae pairs 5–9 expressed as grey dashes along costa; subbasal fascia a narrow mottling of brown scales, difficult to discern against grey ground color; median fascia mostly dark brown, mottled brown near dorsum, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, a small dash at costa, and a triangular dark brown pretornal patch; postmedian band a large circular patch only touching termen by a narrow dash of dark scales, dark brown scaling in center, with notch originating from termen near M_3 separating dorsal half from termen; preterminal fascia a small dark circle near apex; fringe scales darkly mottled. Hindwing brown, paler near base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Greyish brown, pale elongate scales from terminal segment. Genitalia with uncus lacking setae from apex; socius absent; gnathos a weakly sclerotized band, strongly microtrichiate medially, fused with membranous subscaphium; cucullus short and broad, costal margin broadly concave, apex widely rounded, nearly flat in center,

ventral margin broadly convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; a large lobe with compacted brush of setae at base of cucullus in center of valve; Spc_1 at distal end of a long lobe, with spikes extending well past ventral margin of cucullus; Spc_2 ca.0.75 times as large as Spc_1, spines on both Spc_1 and Spc_2 short, thick and spikelike; Spc_2 and Spc_3 separated by shallow emargination ca. 0.5 times as deep as emargination between Spc_1 and Spc_2, spines on Spc_3 reduced to dense patch of thin elongate setae at sacculus base. Phallus tapering distally, nearly straight, sclerotized along ventral edge, with a sclerotized ventral tooth, sometimes appearing serrated, at apex. **Female**. *Head:* As in male. *Thorax*: As in male. *Abdomen*: Brown, with terminal segments dark brown to black. Genitalia with a micotrichiate inflated 'collar' of tissue between abdominal segments 9 and 10; apophyses anteriores ca. same length as apophyses posteriores; sterigma a smooth surfaced, dorso-ventrally flattened half circle with an indentation in anteroventral margin; ostium oriented posteriorly; ductus bursae ca. 1.3 times length of corpus bursae; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with paired long, shallow, signum consisting of thickened cells, .25 times length of corpus bursae, and two accessory sacs, ca. 0.4 times the length of corpus bursae.

Types. "TYPE...7204; *Endopiza viteana* Det. Fernald, Prob. Type 168. Fig. 51. Lacks left wings." "United States: Ohio, Type 15008; *Penthina vitivorana* Ohio Pack; *Penthina vitivorana* Pack. Lectotype Aes. W. E. Miller., - 14057" (MCZ).

Additional specimens examined. CANADA. Ontario Lambton, Port Franks, K. H. Stead, 23 July 2011 (1 ♀, slide HRR 443, CUIC); 5 August 2014 (1 ♀, slide HRR 116, CUIC); Nepean, Pinhey Forest, P. T. Dang, 7-8 September (1 ♀,

CNCLEP00099647, slide HRR 646, CNC); Vineland Station, on *Sambucus canadensis*, W. G. Sarlick, August 1929 (2 ♂, CNCLEP00099658, slide HRR 304; CNCLEP00099659, slide TOR 2232; 2 ♀, CNCLEP00099661, slide TOR 5061; CNCLEP00099656, slide HRR 305, CNC); **USA**: Alabama, Monroe Co., Haines Island Park, J. A. MacGown, 24-25 July 1995 (1 ♂, s77944, slide HRR 633, MEM); Arkansas, Washington, Devil's Den State Park, R. W. Hodges, 28 June 1966 (1 ♀, slide HRR 015, USNM); Fayetteville, H. N. Greenbaum, 10-19 October 1975 (1 ♂, slide HRR 522, FSCA); 29 August- 10 September (1 ♂, slide HRR 521, FSCA); Florida, Marion Co., Santor, CR 328 1mi E of CR 475, John S. Kutis, 1 April 1991 (1 ♀, 77874, MEM); Illinois, Putnam Co., M. O. Glenn, 20 May 1944 (1 ♀, slide 71765, USNM); 11 June 1948 (1 ♂, slide HRR 497, USNM); 6 June 1950 (1 ♀, slide HRR 487, USNM); 10 August 1964 (1 ♀, slide HRR 486, USNM); Maryland, Scientists Cliffs, 2179 Bluebell Road, J.-F. Landry, 4 August 2011 (1 ♀, CNCLEP00090533, CNC); Massachusetts, Barnstable, C. P. Kimball, 21 June 1951 (1 ♀, slide HRR 652, FSCA); Michigan, Paw Paw, 1 August 1921 (1 ♂, slide 71753, USNM); Mississippi, Bolivar Co., Great River Road State Park, D. M. Pollock, 23 June 1993 (1 ♂, 77955, slide HRR 618, MEM); Harrison Co., Long Beach, R. Kergosien, 31 August 1992 (1 ♀, 77861, slide 99093, MEM); 7 October 1994 (1 ♂, 77964, slide HRR 627, MEM); 23 May 1995 (1 ♂, 77887, slide HRR 335, MEM); 10 June 1996 (1 ♂, 77951, slide HRR 645, MEM); 19 September 1996 (1 ♂, 77864, MEM); 18 May 1997 (1 ♂, 77865, slide HRR 293, MEM); 25 May 1997 (1 ♂, 77866, MEM); 3 July 1997 (1 ♂, 77972, slide HRR 271, MEM); 1 April 1998 (1 ♀, 77974, slide HRR 273, MEM); Pass Christian, R. Kergosien, 24 September 1994 (1 ♂, 77862, slide HRR 466, MEM); Jackson Co., Shepard State park, R. Kergosien,

18-25 July 1995 (1 ♀, 77954, slide HRR 634, MEM); Lee Co., Tombigbee State Park, R. Kergosien, 10-21 July 1995 (1 ♂, 77981, MEM); Oktibbeha Co., Osborn, R.L. Brown & L. Koehn, 30 August 1997 (1 ♂, 77984, slide HRR 328; 1 ♀, 77982, MEM); Warren Co., Vicksburg, Ricky Patterson, 30 May 2001 (1 ♀, 77980, slide HRR 326, MEM); Washington Co., Leroy Percy State Park, R. L. Brown & D. M. Pollock, 28 April 1993 (1 ♂, 77871, slide HRR 318, MEM); Chautauqua, Fredonia, on *Vitis* species, E. F. Tashenberg, 13 June 1957 (1 ♀, USNM); 14 June 1957 (1 ♂, USNM); 15 June 1957 (1 ♂, slide 124979/TMG 346, USNM); 16 June 1957 (1 ♂, USNM); 17 June 1957, (1 ♂, 77886, MEM; 1 ♂, slide HRR 016; 2 ♀, USNM); 18 June 1957 (2 ♀, slide 124980/TMG 347, USNM); 20 June 1957 (2 ♂, 1 ♀, USNM); Chautauqua, Fredonia, E. F. Tashenberg Septermber 1983 (2 ♂, 77882; 77883, slide HRR 319; 1 ♀, 77884, MEM); 10 May 1943 (2 ♂, slides HRR 097, HRR 464; 3 ♀, slides HRR 098, HRR 465, CUIC); Tompkins Co., Danby, J. J. Dombroskie et al., 13 May 2012 (1 ♂, slide HRR 007, CUIC); Ithaca, 25 August 1904 (2 ♀, USNM); Ithaca, Snyder Heights, J. G. Franclemont, 1 June 1979 (1 ♀, 77885, slide HRR 608, MEM); Orient, Roy Latham, 1961 (1 ♂, slide HRR 659, CUIC); Vineland, E. F. Tashenberg, 24 August 1983 (3 ♂, 77878, slide 1605; 77879, 77881, 1 ♀, 77880, MEM); North Carolina, Ashe Co., Mt. jefferson State Park- offices, J. Bolling Sullivan, 2-3 May 2000 (1 ♂, slide HRR 185, USNM); Ohio, Sandusky, G. A. Runner (1 ♀, slide HRR 526, INHS); from Grape, 1936 (1 ♀, slide HRR 525, INHS); Oklahoma, Bartlesville, Mark Dreiling, 24 June 2009 (1 ♂, MDOK-2925, slide TOR 5074, CNC); 4 August 2009 (1 ♀, MDOK-3079, slide TOR 5080, CNC); Pennsylvannia: Philadelphia, Pennypack Park, J. B. Heppner, 8 August 1973 (1 ♂, slide HRR 651, FSCA); North East, on grape, R. A. Cushman, October 1916

(3 ♂, slide 71754, HRR 380; 3 ♀, slides 71755, HRR 379); Tennessee, Sevier Co., Gatlinburg, Cobbly Nob (Greenbrier Resort), J.-F. Landry & P. Hebert, 19 May 2005 (1 ♂, CNCLEP00016140, CNC); Texas, Guadalupe Co., 13.5mi E of Seguin, D. M. Pollock, 8 May 1993 (1 ♂, 77876, MEM); , Harris Co., Houston, A & M. E. Blanchard, 2 March 1970 (1 ♂, slide 90312, USNM); 9 May 1979 (1 ♂, slide 90311, USNM); 5 June 1979 (1 ♂, slide 90309, USNM); 22 June 1979 (1 ♂, slide HRR 376, USNM); Montgomery Co., Conroe, A & M. E. Blanchard, 9 March 1971 (1 ♂, slide 90310, USNM); Fort Worth, E. Jäckh jr., 18 March 1963 (2 ♂, slides HRR 017, HRR 387, USNM); 26 March 1963 (1 ♂, slide 4867 (on specimen pin), USNM); Dallas, Fernald Collection (1 ♀, slide HRR 460, USNM); Virginia, Fairfax Co., 1km E of Fairfax city; J. Brown, 26-28 May 2006 (1 ♂, slide 118544, USNM); 3 September 2007 (1 ♂, slide HRR 285, USNM); 19 May 2013 (1 ♀, slide HRR 283, USNM); West Springfield, J. B. Heppner, 2 June 1979 (1 ♂, slide HRR 650, FSCA); No Locality Data: 15 April 1896 (1 ♂, slide 71756, USNM); 20 February 1905 (1 ♂, slide HRR 262, CUIC); 30 July 1979, on Vernonia novae (1 ♀, slide HRR 662, CUIC).

Distribution and biology. *Paralobesia viteana* has a wide range across the eastern U.S. and portions of southeastern Canada, from southern Ontario and coastal New York, south to Florida and west into Texas and Oklahoma. The primary host, *Vitis* spp. L. (Vitaceae) occurs across North America (USDA-NRCS, 2018). A single specimen of *P. viteana* was recorded as feeding on *Vernonia* sp. Schreb. (Asteraceae), which has a number of species from Utah westward, and several specimens were recorded on *Sambucus canadensis* (L.) R. Bolli (Caprifoliaceae), a shrub native to most of eastern North America (USDA-NRCS, 2018).

Discussion. An image of the forewing of the lectotype may be found in Miller's (1973) publication of the Clemens types and the lectotype designation was attributed to Darlington (1947).

DNA sequence data. In a phylogenetic analysis using COI, these specimens group nicely (98% BS) (Fig. 24).

Paralobesia ridingsi **Royals and Gilligan, sp.n.**

Fig. 201

Diagnosis. *Paralobesia ridingsi* wing pattern is unknown. Female genitalia may confused with those of *P*. *palliolana*, but can be distinguished by a couple subtle features. In *P*. *ridingsi*, the ostium opening is nearly flush with the posterior margin, the posterior margin is widely rounded, and no accessory sacs are present. In *P*. *palliolana*, the ostium opening is in a depression in the posterior margin, the posterior margin is rounded but tapered, and the corpus bursae has acessory sacs present.

Description. **Female**. *Head:* Labial palpus, with all segments combined ca. 1.5 times diameter of compound eye. *Abdomen*: Genitalia with apophyses anteriores ca.1.0 times as long as apophyses posteriores; sterigma broadly widened, broader than high, with rounded posterior margin, moderately sclerotized and strongly microtrichiate; ostium oriented posteriorly, nearly flush with posterior margin; ductus bursae ca. 1.2 times as long as corpus bursae; colliculum strongly sclerotized, occupying posterior 0.25; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with paired, linear signum of thickened cells, lacking two accessory sacs.

Holotype. ♀, “ID#: BIOUG03665-E11, Canada: Manitoba, Riding Mountain N[ational] P[ark] [Lt:50.7 Ln:-99.9], Melanie Roberta Tesar, 09-Jul-2012, DNA Barcode: CNRME2989-12; BIOUG03665-E11; ♀ genitalia on slide HRR 310” (CNC).

Paratype. Same collection data as holotype (1 ♀, BIOUG3665-E10, slide TOR 5084).

Distribution and biology. *Paralobesia ridingsi* is known only from the type locality, Riding Mountain National Park in Manitoba, Canada.

Discussion. This species is known only from two specimens, which are clearly distinct in a phylogenetic analysis using COI (Fig. 24), and female genitalia. However, the specimens are in incredibly poor condition with shriveled wings lacking all scales. No wing pattern could be discerned.

Etymology. The specific epithet *ridingsi* is in reference to the type locality, Riding Mountain National Park in Manitoba, Canada.

DNA sequence data. Only two specimens are represented in our phylogenetic tree (69% BS) (Fig. 24).

Paralobesia monotropana **(Heinrich, 1926)**

Figs. 84–87, 169, 202

Polychrosis monotropana Heinrich 1926:91; McDunnough 1939:40; Clarke 1953:229.

Paralobesia monotropana; Obraztsov 1953:92; MacKay 1959:134; Brown 2005:472; Gilligan et al. 2008:47.

Endopiza monotropana; Powell 1983:31; Godfrey et al. 1987:32.

Diagnosis. *Paralobesia monotropana* is superficially similar to both *P*. *cypripediana* and *P*. *marilynae*, but the three species can be separated by features of the male genitalia. In *P*. *monotropana*, Spc_1 is ca. 1.5 times as large as Spc_2, and the pad of spines extends ca. 0.5 times its length past the ventral margin at the base of the cucullus. In *P*. *cypripediana*, Spc_1 is about the same size as Spc_2, and the pad of spines extends no more than 0.25 times its length past the ventral margin at the base of the cucullus. In *P*. *marilynae*, Spc_1 is about the same size as Spc_2, and the pad of spines extends ca. 0.5 times its length past the ventral margin at the base of the cucullus. The emargination between Spc_3 and Spc_2 is rounded and shallow in *P*. *monotropana*, rounded but deeper in *P*. *cypripediana*, and shallow but angular in *P*. *marilynae*. The phallus of *P*. *monotropana* has a series of short wide teeth on the apical 0.33. In *P*. *cypripediana* these teeth are smaller and narrower, and extend from a serrated dorsal keel near the middle of the phallus. In *P*. *marilynae* there is a single tooth near the apex of the phallus. The setae on posterior surface at the apex of the uncus are shorter than the uncus in *P*. *monotropana*, longer than the uncus in *P*. *cypripediana*, and absent in *P*. *marilynae*. Most other species of *Paralobesia* that resemble *P*. *monotropana* have long (extending past Spc_1) setae at Spc_3 versus the relatively short setae (not extending past Spc_1) in *P*. *monotropana*, and a different configuration of teeth on the phallus. In females of *P*. *monotropana*, the sterigma is bell shaped and the anterodorsal margin extends past the ventral, with a medial depression that often extends posteriorly past the anteroventral margin. That of *P*. *cypripediana* is more conical, and the anterior margins are even in length.

Redescription. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.75 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales; posterior crest mottled with dark brown and orange scales; legs pale brown with white annulations on tibia and tarsal segments. Forewing length 4.2–5.2 mm (mean 4.6 mm; n = 9); ground color blue grey, wing markings varying from dark reddish brown to mottled pale brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum; median fascia dark brown in costal half with a mix of pale brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, an oval patch at costa and a triangular pretornal patch; postmedian band a large semioval patch extending to termen, usually with notch originating from termen near M_3; preterminal fascia a small indistinct patch near apex; fringe scales darkly mottled. Hindwing uniform dark brown with paler scales at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Pale to dark brown. Genitalia with uncus reduced, weakly bilobed and curved posteriorly, with patch of setae shorter than uncus extending ventrally from apex of each lobe; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus clavate, stout, costal margin broadly concave, apex narrowly rounded, ventral margin convex with slight medial concavity, ventral half covered in stout spine-like setae, apex and dorsal half covered in fine setae; spc_1 separated from cucullus by moderate narrow

emargination, extending ventrally beyond cucullus ca. 0.5 times its length, Spc_1 and Spc_2 separated by deep U-shaped emargination, Spc_2 0.75 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by shallow emargination, Spc_3 on a raised lobe, spines on Spc_3 stout and spikelike, extending past edge of Spc_2. Phallus tapering distally, curved, length ca. 0.66 that of the cucullus, with 3–5 short broad teeth along dorsal margin near apex. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.5–5.5 mm (mean 4.9; n = 10). *Abdomen*: Coloration variable, mostly brown with darker scaling on posterior segments. Genitalia with apophyses anteriores ca.1.5 times as long as apophyses posteriores; sterigma bell-like, moderately sclerotized and smooth, with a slight indentation along the dorsal anterior margin, posterior margin serrate; ostium oriented posterodorsally. Ductus bursae ca. 2.0 times as long as corpus bursae; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with a long, shallow, platelike signum and two accessory sacs, less than 0.1 times length of corpus bursae.

Holotype. ♂, “Cincinnati, O[hio]., Annette F. Braun, VIII-24-07, on *Monotropa uniflora*; 227; Am. Mus. Nat. Hist. Dept. Invert. Zool. No.; ♂ genitalia on slide, CH. 19 May 1922; *Polychrosis monotropana* Hein. TYPE” (AMNH).

Paratype. **USA**: Maryland, Cabin John Bridge, R. M. Fouts, “seed capsules of *Monotropa*,” 22 Aug 1923 (1 ♀, USNM).

Additional specimens examined. **CANADA**: Ontario, Vineland Station, W. L. Putman, 4 Jul 1942 (1 ♂, CNCLEP 00105123, slide TOR 5116, CNC); 20 Jul 1942 (1 ♀, CNCLEP00105122, slide TOR 5117, CNC). Québec: Gatineau Park, Marilyn H. S. Light; pupa from *Monotropa uniflora*, 16 Sep 2014 (1 ♀, CNCLEP 00132701, slide TOR

5115, CNC); Ramsay Lake, eggs collected 27 Jul 2015, pupated 6 Aug 2015, emerged 22 Aug 2015 (1 ♂, CNCLEP00138308, slide HRR 244, CNC); Eardley-Masham Road, Trail 56, larvae collected 30 Jul [2016], pupated 6–8 Aug [2016]; emerged 25 Aug 2016 (1 ♂, CNCLEP00141700, slide HRR 246, CNC); emerged 26 Aug 2016 (1 ♀, CNCLEP00141702, slide HRR 244, CNC); emerged 27 Aug 2016 (1 ♂, CNCLEP 00141703, slide HRR 245, CNC); emerged 28 Aug 2016 (1 ♀, CNCLEP00141704, slide HRR 247, CNC); larva from *Rhus typhina*, 5 Aug [2016], pupated 7 Aug [2016], emerged 29 Aug 2016 (1 ♂, CNCLEP00141697, slide HRR 248, CNC); **USA**: Maryland, Washington Co., N.E. Boonsboro Greenbrier St. Park, W. E. Steiner *et al*., 8–10 Aug 1986 (1 ♂, slide HRR 037, USNM; 1 ♀, slide HRR 034, USNM); Wheaton, Homerleigh Rd., woods, K. Sommerman, 23 Aug 1950, from *Monotropa uniflora* (4 ♂, slides HEE 033, HRR 035, USNM 124982 [slide missing], USNM), (3 ♀, slides HRR 032, USNM 124981 [slide missing], USNM).

Distribution and biology. *Paralobesia monotropana* has been recorded from the northeastern U.S. (Maryland) and southeastern Canada (Ontario, and Québec). Rearing records indicate that *Monotropa uniflora* (Ericaceae) is the primary larval host, although a few specimens have been reared from *Rhus typhina* (Anacardiacae). Observations indicate that this is not an occurrence of accidental oviposition (M. Light, pers. comm). Females deposit eggs on floral bracts or flower petals, rarely on stems. First instar larvae enter the developing ovary through the pistil. Larvae feed on the interior ovary tissue, but do not feed on seeds; larvae will feed on stem pith if ovary tissue is completely consumed. Collection dates indicate a flight period from early June to late August.

Discussion. Heinrich (1926) listed two female paratypes with identical collection data (USNM), but we were able to locate only one of them.

DNA sequence data. *Paralobesia monotropana* has moderate support as a clade (68% BS) (Fig. 25).

***Paralobesia spiraeifoliana* (Heinrich, 1923)**

Figs. 88–91, 170, 203

Polychrosis spiraeifoliana Heinrich 1923:106; Forbes 1923:472; Heinrich 1926:93; McDunnough 1939:40; Brower 1983:24.
Paralobesia spiraeifoliana; Obraztsov 1953:93; Brown 2005:472; Gilligan et al 2008:48.
Endopiza spiraeifoliana; Powell 1983:31; Godfrey et al. 1987:32; Miller 1987:16.

Diagnosis. *Paralobesia spiraeifoliana* is superficially similar to *P*. *vernoniana* and *P*. *aemulana* but is easily identified by male genitalia. In *P*. *spiraeifoliana* Spc_1 extends well past the ventral margin of the cucullus. In *P*. *aemulana* Spc_1 is about flush or extending just past the ventral margin of the cucullus, while in *P*. *vernoniana* this cluster does not extend past the margin. The characters of the phallus can differentiate the three as well. That of *P*. *spiraeifoliana* has a short serrated keel from the center of the dorsal curvature. In *P*. *aemulana*, there is a distinctive slender tooth from the very apex extending further apically and *P*. *vernoniana* has a large tooth in the center of the phallus

Redescription. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.9 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum tan scaled; posterior crest dark brown; legs mostly pale brown on femora, dark brown with white annulations on tibia and tarsal segments. Forewing length 4.3–5.1 mm (mean = 4.7 mm; n = 9); ground color pale brown to light grey, wing markings reddish brown and dark brown; costal strigulae pairs 3–9 expressed as white and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; median fascia mostly uniform brown or dark brown, with paler scaler against costal edge, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, meeting postmedian fascia and angling back to the dorsum; postmedian fascia divided into two sections, an irregular triangular patch at costa, dark to light brown, and a triangular dark brown pretornal patch, sometimes meeting costal patch via a thin line of dark scales; postmedian band a large semioval patch extending to termen and often meeting costa with a thin band of scales, with deep notch originating from termen near M_3, red-brown with dark brown scaling; preterminal fascia a small circular patch near apex, red-brown with dark brown center; fringe scales darkly mottled. Hindwing tawny brown, paler at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Genitalia with uncus weakly bilobed, curved posteriorly, with two patches of setae shorter than uncus extending ventrally from each side of apex; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus narrow, tapering slightly to apex, costal margin broadly concave, apex narrowly

rounded, ventral margin convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, extending ventrally 0.5 times its length beyond cucullus, Spc_2 ca. 0.6 times the size of Spc_1, Spc_2 and Spc_3 separated by moderate emargination ca. 0.3 times the depth of emargination between Spc_1 and Spc_2, Spc_3 on flattened lobe at base, spines on Spc_3 elongate, nearly reaching apex of cucullus, with short barb near apex. Phallus tapering distally, curved, sclerotized along ventral curvature, length ca. 0.5 times that of the cucullus, fully sclerotized along one side, with a serrate, sclerotized flap curving over dorsal face from center. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.6–5.6 mm (mean = 4.8; n = 8). *Abdomen*: Genitalia with apophyses anteriores ca. 1.0 times as long as apophyses posteriores; sterigma conical, rounded out at base; ostium encompassing entirety of posterior surface, oriented posteriorly; ductus bursae ca. 1.6 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with paired linear, shallow, signum consisting of thickened cells, lacking two accessory sacs from anterior end.

Holotype. ♂ “Reared from *Spiraea salicifolia* 5/29 19c; TYPE collection of W.D. Kearfott; *Polychrosis spiraeifoliana* Cotype, Kearf.; Barnes Collection; ♂ genitalia on slide, 7 April 1923, N.P. *Polychrisis spiraeifoliana* TYPE. Heinrich; ♂ genitalia slide by N.P. USNM 72820” (USNM)

Paratypes. **USA**. Pennsylvania, Hazleton, from *Spiraea salicifolia*, 5/29 19c (1 ♂, slide 10 April 1932, AMNH) (2 ♀, slides HRR 433, 97880, USNM); 5/30 19c (1 ♀, AMNH); New Hampshire, Hampton, S. A. Shaw, 9 August 1905 (1 ♀, slide 71770, USNM);

Additional specimens examined. **CANADA**. Nova Scotia, Halifax, Armdale, D. C. Ferguson, 29 July 1967 (1 ♂, slide HRR 133, USNM); Petite Riviere, J. McDunnough, 13 July 1935 (1 ♂, CNCLEP00105437, slide TOR 1377, CNC); 23 July 1935 (2 ♂, CNCLEP00105435, slide TOR 1374; CNCLEP00105132, slide TOR 1368, CNC); Queens, White Point Beach, J. McDunnough, 20 July 1934 (1 ♂, CNCLEP00105133, slide TOR 1369, CNC); 22 July 1934 (1 ♂, CNCLEP00105131, slide TOR 1366, CNC); Prince Edward Island, Brackley Beach, Can. Nat. Park, G. S. Walley, 30 July 1940 (1 ♀, CNCLEP00105130, slide TOR 1379, CNC); Québec, Gatineau, Aylmer, Ch. Boucher, B. Landry, 12 July 1995 (1 ♂, CNCLEP00099650, slide HRR 250, CNC); Knowlton, J. McDunnough, 26 July 1929, CNCLEP00099667, slide TOR 1390, CNC); Pontiac, Les-Collines-de-l'Outaouais, Breckenridge, Aldred's property, J.-F. Landry, 14 July 1999 (1 ♂, CNCLEP00101700, slide TOR 5082; 1 ♀, CNCLEP00101699, slide TOR 5083, CNC); **USA**. Maine, Kennebkpt, G.H. Clapp, August (1 ♀, AMNH); Lincoln, 14 July (1 ♂, slide HRR 647, USNM); Marion, 15 July (1 ♀, slide HRR 088, USNM); Sebec Lake, 24 July 1931 (1 ♂, slide HRR 139, USNM); New Jersey, Ess. Co. Pk., W. D. Kearfott (1 ♀, slide C.H. #45, AMNH).

Distribution and biology. Collection locality information places the range of *P. spiraeifoliana* primarily in extreme northeast of the U.S. (Maine) and the far southeastern regions of Ontario and Nova Scotia, Canada. Host plant records include *Spiraea salicifolia* L. (Rosaceae) and *Eupatorium purpureum*, now a synonym of *Eutrochium purpureum* (L.) E.E. Lamont (Asteraceae).

DNA sequence data. *Paralobesia spiraeifoliana* is well represented and supported (72% BS) in our phyologenetic tree, sister to the *P*. *rhoifructana* + *P*. *cypripediana* group (Fig. 25).

***Paralobesia cypripediana* (Forbes, 1923)**

Figs. 92–95, 171, 204

Polychrosis cypripediana Forbes 1923:473; Heinrich 1926:92; McDunnough 1939:40.
Paralobesia cypripediana; Obraztsov 1953:92; Brown 2005:472.
Endopiza cypripediana; Powell 1983:31.

Diagnosis. *Paralobesia cypripediana* is superficially similar to both *P*. *monotropana* and *P*. *marilynae*, but the three species can be separated by the arrangement of the spine clusters, the teeth on the phallus, and the setae on the uncus in male genitalia. These differences are detailed in the diagnosis of *P*. *monotropana*. Most other species of *Paralobesia* that resemble *P*. *cypripediana* have long (extending past Spc_1) setae at Spc_3 versus the relatively short setae (not extending past Spc_1) in *P*. *cypripediana*, and a different configuration of teeth on the phallus. Female genitalia are indistinguishable from those of *P*. *rhoifructana* (Kearfott, 1904) and *P*. *yaracana* (Kearfott, 1907).

Redescription. **Male**. *Head*: Vertex rough scaled, pale brown; labial palpus pale brown, all segments combined ca.1.75 times diameter of compound eye, segment II rough scaled with dash of black scales laterally, segment III smooth scaled; antenna

dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales with transverse band of dark scales; posterior crest mottled with dark brown and orange scales; fore- and mid-legs dark brown with tan annulations on tibia and tarsal segments, hind legs mostly pale brown with white annulations on tarsal segments. Forewing length 4.4–5.4 mm (mean 4.7 mm; n = 11); ground color blue grey, wing markings varying from dark reddish brown to mottled pale brown; costal strigulae pairs 2–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, and narrowing from cubitus to dorsum; median fascia dark brown in costal half, mixed with pale brown in dorsal half, broad from costa to cubitus, distal margin extending towards termen along cubitus, and angling back to dorsum; postmedian fascia divided into two sections, an oval patch at costa and a triangular pretornal patch; postmedian band a large semioval patch extending to termen, usually with notch originating from termen near M_3, coloration variable; preterminal fascia a small circular patch near apex, center dark; fringe scales darkly mottled. Hindwing uniform dark brown with paler scales at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Coloration pale to dark brown. Genitalia with uncus a short rounded lobe, curved posteriorly, with patch of setae longer than uncus extending ventrally from apex of each side of lobe; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus clavate, stout, costal margin broadly concave, apex narrowly rounded, ventral margin convex, ventral half covered in stout spine-like setae, apex and dorsal half covered in fine setae; Spc_1 separated from cucullus by moderate narrow emargination, extending ventrally beyond cucullus ca. 0.25 times as its length, Spc_1 and Spc_2

separated by deep U-shaped emargination, Spc_2 ca. same size as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by deep rounded emargination, Spc_3 on a raised lobe, spines on Spc_3 stout and spikelike, extending past edge of Spc_2. Phallus tapering distally, curved, length ca. 0.5 that of cucullus, with 2–5 teeth of variable size situated on keel near center. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.1–5.5 mm (mean 5.0 mm; n = 5). *Abdomen*: Coloration variable, mostly brown with darker scaling on posterior segments. Genitalia with apophyses anteriores ca.1.3 times as long as apophyses posteriores; sterigma conical, moderately sclerotized, and microtrichiate on anterior 0.25, posterior margin serrate; ostium oriented posterodorsally; posterior 0.25 of ductus seminalis moderately sclerotized; ductus bursae ca. 2.0 times as long as corpus bursae; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with faint, shallow signum and two small accessory sacs, sacs less than 0.2 length of corpus bursae.

Lectotype. ♂, “Aweme, Manitoba, N. Criddle, Jan. 14. 09; Am. Mus. Nat. Hist. Dept. Invert. Zool. No.; Kearfott Col. Ac. 4667; Reared from *Cypripedium spectabile* seed pods; ♂ genitalia on slide, CH 19-May 1922; *Polychrosis cypripediana* Forbes. TYPE; LECTOTYPE” (AMNH).

Paralectotypes. **CANADA**: same data as lectotype, “reared from *Cypripedium spectabile* seed pods,” “larva found 25 Aug 1905” [Jan 1906] (1 ♀ [unconfirmed, hindwings and abdomen missing], AMNH); 14 Apr 1907 (1 ♀ [unconfirmed, only thorax and left forewing], USNM); 24 Apr 1907 (1 ♀, slide HRR 091, USNM); 14 Jan 1909 (1 ♂, slide 71760, CH wing slide, USNM); 14 Jan 1909 (1 ♀, slide 97884, wing slide 71761, USNM); 14 Jan 1909 (1 ♂, slide TOR-1355, CNC).

Additional specimens examined. **CANADA**: Manitoba: Aweme, N. Criddle; 22 Feb 1909 (1 ♀, CNCLEP00103641, slide TOR 5118, CNC); 15 Nov 1910 (1 ♂, CNCLEP00103642, slide TOR 1357, CNC; 1 ♀, CNCLEP00103643, slide TOR 5119, CNC). New Brunswick: Queens, Akerlery, from Sumac, 15 Mar 1968 (1 ♂, CNCLEP00105128, slide TOR 5085, CNC; 1 ♀, CNCLEP00099640, slide HRR 299, CNC); 20 Mar 1968 (1 ♂, CNCLEP00099639, slide TOR 5129, CNC; 1 ♀, CNCLEP00105129, slide TOR 5086, CNC). Ontario: Renfrew, Richards Twp., J. J. Dombroskie, L. M. Gilines, & R. A. St. Laurent, 22 Jun 2015 (1 ♂, TOR-DNA-1037, slide HRR 120, CUIC). Québec: Gatineau Park, edge of Gatineau Parkway, Marilyn H. S. Light, larva collected from *Rhus typhina* 31 Jul 2015, pupated 19 Aug 2015, overwintered until 31 Mar 2016, emerged 30 Apr 2016 (1 ♀, CNCLEP00141503, slide HRR 239, CNC); Kazabazua, J. McDunnough, 3 Mar 1923 from Sumac (1 ♂, CNCLEP00099638, slide HRR 262, CNC; 1 ♂, CNCLEP00099636, slide TOR 1356, CNC; 1 ♂, CNCLEP00099637, slide TOR 5128, CNC; 1 ♀, CNCLEP00099634, slide HRR 263, CNC; 2 ♀, CNCLEP00099633, CNCLEP00099635, CNC); Gatineau Park, Folly Bog (fen), near Hickory Trail, Marilyn H. S. Light, from *Rhus typhina*, larva collected 24 Jul [2016], transferred to feed on *Cypripedium reginae*, pupated 30 Jul [2016], emerged 18 Aug 2016 (1 ♂, CNCLEP00141694, slide HRR 238, CNC); **USA**: Tennessee: Chester Co., near Henderson, K. Childs, 8-12 Apr 2015, (1 ♀, TOR-DNA-1046, slide HRR 008, CUIC). Virginia: Falls Church, C. Heinrich, reared 25 May 1915, on *Rhus copalina* [= *copallinum*] (1 ♂, CNCLEP00099632, slide TOR 5127, CNC). New York: Lake Ontario, near Roch[ester], 17, Jul 1893 (1 ♂, slide HRR 300, wing slide, USNM 71761, USNM).

Distribution and biology. *Paralobesia cypripediana* is recorded from southern Manitoba east across southern Ontario and Québec to New Brunswick, south to Virginia and Tennessee. As its name suggests, *P*. *cypripediana* is often found in association with one of its larval hosts, *C*. *reginae* (Orchidaceae) (listed as *C*. *spectabile* on older labels). However, more specimens have been reared from *Rhus* (Anacardiaceae) (including *R*. *typhina* L. and *R*. *copallinum* L.) than *Cypripedium*, suggesting that larvae are at least oligophagous on plants in similar habitats. Collection dates suggest a flight period from early March to late August. The midwinter emergence dates listed by Criddle are likely due to indoor rearing (Heinrich 1926).

Discussion. The lectotype designation attributed to Heinrich (1926) by Klots (1942) is valid; there is only one male specimen in the AMNH. We located six labeled paratypes as listed by Heinrich (1926); however, dates for two do not match those given in the original description. We assume that the date for the male listed as “Jan. 1-09” is actually 14 Jan 1909, and that the date for one of the females cited as “14-IV-07” is actually 24 Apr 1907.

In his monograph on the Lepidoptera of New York and neighboring states, Forbes (1923) included a brief description of the wing pattern of *P*. *cypripediana*. He credited the name to Kearfott, who had used *cypripediana* as a manuscript name for a series of specimens reared from the seeds of *Cypripedium* in Aweme, Manitoba by Criddle. As such, Forbes (1923) did not designate any types or provide any specimen data. Heinrich (1926) examined these specimens, which consisted of three males and four females, and designated a male as the lectotype, attributing the name to Forbes.

DNA sequence data. In the phylogenetif analysis, *Paralobesia cypripediana* is indistinguishable from *P*. *rhoifructana* (Fig. 25). DNA sequencing of COI alone is not sufficient for identification.

***Paralobesia rhoifructana* (Kearfott, 1907)**

Figs. 96–99, 172, 205

Polychrosis rhoifructana Kearfott 1904:296; Barnes and McDunnough 1917:167; Forbes 1923: 472; Heinrich 1926: 96; McDunnough 1939:40; Brower 1983:24.
Paralobesia rhoifructana; Obraztsov 1953:93; Miller 1987:17; Gilligan et al. 2008: 47.
Endopiza rhoifructana; Powell 1983:31.

Diagnosis. *Paralobesia rhoifructana* is superficially similar to *P*. *slingerlandana*, but can be differentiated by the mostly white hindwings in the males, and characters of both the male and female genitalia. In *P*. *rhoifructana*, males have a very long Spc_3, and a few short teeth near the center of the phallus, in females, the sterigma is conical and rounded near the base. In *P*. *slingerlandana*, males have a very short Spc_3, and a large flat projection from the apex of the phallus, while in females, the sterigma is cylindrical.

Redescription. **Male**. *Head*: Vertex brown; labial palpus pale brown, all segments combined ca.1.6 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna brown. *Thorax:* Dorsum with dark transverse band across mesonotum; posterior crest dark brown; fore- and mid-legs dark brown with white annulations on tibia and tarsal segments, hind-legs pale brown. Forewing length

3.9–5.2 mm (mean 4.6 mm; n = 3); ground color variable: grey entirely or grey in basal half and pale brown in apical half, wing markings variable, reddish brown to dark brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; median fascia dark brown to black in costal half, mottled brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum, dorsal half outlined in pale brown scales; postmedian fascia divided into two sections, an irregular oval patch at costa and a triangular, dark brown pretornal patch; postmedian band a large semioval patch extending to termen, usually with deep notch originating near M_3; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing mostly white, with variably brown scaling at apex; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus moderately bilobed, with patches of setae from either side of apex, extending ventrally, as long as uncus; socius absent; gnathos a weakly sclerotized band, fused with membranous subscaphium, strongly microtrichiate medially; cucullus narrow, parallel sided, costal margin concave, apex narrowly rounded, ventral margin concave, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate emargination, lobe extending ventrally 0.2-0.5 times its length past the ventral margin of the cucullus; Spc_2 0.6 times the length of Spc_1; Spc_3 from base, spines on Spc_3 very long and feathery, reaching, sometimes extending past apex of cucullus. Phallus tapering distally, curved, length ca. 0.5 times that of the cucullus, with 1-5 nearly indiscernable teeth along dorsal curvature. **Female**. *Head:* As in male. *Thorax*: As in

male, except forewing length 3.9–5.5 mm (mean 4.6; n = 5) and hindwing variably brown. *Abdomen*: Dark brown. Genitalia with apophyses anteriores ca. 0.9 times as long as apophyses posteriores; sterigma conical, with rounded base, spinulate around anterior 0.3; ostium oriented posteriorly; ductus bursae ca. 1.2 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with paired linear, shallow signum consisting of thickened cells, and two accessory sacs from anterior end..

Holotype. ♂, "3257, Jan.29.84; Type No. 8152 U.S.N.M.; ♂ genitalia on slide, CH 18 May 1922" (USNM)

Paratypes. **USA**. Ohio, Wooster, 28 December 1898 (1 ♀, CUIC); 8 January 1899 (1 ♀, slide HRR 454, AMNH); 9 January 1899 (1 ♂, CUIC); 6 March 1899 (1 ?, slide 1004, AMNH); No locality data: 29 January 1884 (1 ♂, slide HRR 280, USNM); 12 January 1884, in seeds of *Rhus* (1 ♀, slide HRR 281, USNM); 16 May 1893 (1 ♀, slide HRR 296, USNM).

Additional specimens examined. **CANADA**. Ontario, Beamsville, W. L. Putnam, 27 June 1937 (1 ♂, CNCLEP00099663, slide TOR 5062, CNC); **USA**. Alabama, Lawrence Co., Joe Wheeler State Park, R. L. Brown, 27 May 2004 (1 ♂, 31100, slide HRR 597, MEM); Connecticut, East River, from *Cornus*, Chas R. Ely, 4 August 1909 (1 ♂, slide 71767; 1 ♀, slide 71764, USNM)(1 ♂, slide HRR 451; 1 ♀, slide HRR 453, AMNH); Florida, Alachua Co., San Felasco Hammock Preserve State Park, H. D. Baggett, 25 March 1988 (1 ♂, 77875, slide HRR 463, MEM); Illinois, Putnam Co., M. O. Glenn, 11 August 1940, on *Rhus glabra* (1 ♂, slide 97879, USNM); 26 July 1949, on *Sambucus canadensis* (1 ♀, slide HRR 350, INHS); 27 July 1949, on sumac seed

heads (1 ♂, slide HRR 495; 2 ♀, slides HRR 496, HRR 216, INHS); 28 May 1950, on *Prenanthes* (1 ♂, slide 145820, USNM); 14 June 1950, on *Prenanthes* (1 ♀, USNM); Kentucky, Laurel Co., For. Serv. Rd. 615a, D. J. Wright, 30 April 1993 (3 ♂, CNCLEP00157878, slide HRR 249; CNCLEP00157870, slide TOR 5160; CNCLEP00157874, CNC); 4 May 1996 (2 ♂, CNCLEP00157880, slide TOR 5162; CNCLEP00157882; 1 ♀, CNCLEP00157879, slide TOR 5161, CNC); For Serv. Rd 131, 2mi. From Rd 3497; 19 April 1992 (1 ♀, CNCLEP00157884, slide TOR 5163, CNC); Maryland, Beltsville, on *Rhodora nudiflorum*, 1 July 1950 (2 ♂, slides 72223, HRR 019; 3 ♀, slide HRR 018, USNM); Mississippi, Forest Co., Brooklyn, R. Kergosien, 16 February - 15 March 1997 (1 ♀, 77993, slide HRR 606, MEM); George Co., 3 miles North of Lucedale, R. Kergosien, 19–31 March 1996 (1 ♂, 77961, slide HRR 679, MEM); Oktibbeha Co., Dorman Lake, Pat Porter, 15 April 1990 (1 m, 77933, slide HRR 467, MEM); Osborn, R. L. Brown & L. Koehn, 30 August 1997 (1 ♀, 77983, slide HRR 327, MEM); Tishomingo Co., J.P. Coleman State Park, R. Kergosien, 3–23 September 1995 (1 ♀, 77891, slide HRR 673, MEM); Wilkinson Co., Centreville, G. Strickland, 12 March 1972 (1 ♂, 77897, slide HRR 677, MEM); Missouri, on *Eryngium yuccifolium* seed heads, Boone Co., Rock Bridge State Park, Paul McKenzie, 30 July 2017 (1 ♀, slide HRR 471, Koenig); 1 August 2017 (1 ♂, slide HRR 473; 1 ♀, slide HRR 472, Koenig); 6 August 2017 (2 ♂, slides HRR 474, HRR 475, Koenig); 9 August 2017 (1 ♂; 1 ♀, slide HRR 476, Koenig); 11 August 2017 (2 ♀, slides HRR 477, HRR 478, Koenig); 13 August 2017 (1 ♀, Koenig); 15 August 2017 (1 ♂, Koenig); 17 August 2017 (1 ♀, Koenig); 26 August 2017 (1 ♀, Koenig); Lincoln Co., Cuivre River State Park, Sherwood Prairie, Bruce Schuette, 20 July – 18 August (1 ♂, slide 5116; 2 ♀, slide 5151, Koenig);

East Unit, Blazing Star Trail 2 August 2017 (1 ♂, Koenig); 5 August 2017 (1 ♂, Koenig); 8 August 2017 (1 ♂, Koenig); 9 August 2017 (1 ♂, Koenig); New Jersey, Caldwell, W. D. Kearfott, 17 May 1903 (1 ♂, slide 804, AMNH); New York, Orient, Long island, Roy Latham, 9 September 1953 (1 ♀, USNM); Ohio, Scioto, Shawnee State Forest Picnic Point, D. J. Wright, 30 April 1990 (2 ♂, CNCLEP00157868, slide TOR 5158; CNCLEP00157869, slide TOR 5159, CNC); Cincinnati, Annette F. Braun, 8 August 1909 (1 ♂, slide HRR 090); Oklahoma, Bartlesville, Mark Dreiling, 8 August 2009 (1 ♂, CNCLEP 00099697, slide TOR 5073, CNC); 8 September 2009 (1 ♀, CNCLEP 00099696, slide TOR 5079, CNC); Pennsylvania, Hazleton, on *Kalmia angustifolia*, 7 April 1905 (1 ♀, slide 71768, USNM); 15 April 1905 (1 ♀, slide HRR 452, AMNH); New Brighton, 16 May 1907 (1 ♂, USNM); Rhode Island, on *Rhus* (1 ♀, USNM); Tennessee, Chester Co., near Henderson, K. Childs, 8–12 April 2015 (1 ♂, slide HRR 230, CUIC); Virginia, Falls Church, on *Rhus*, C. Heinrich, 14 May 1915 (1 ♀, slide 71769, USNM) (1 ♀, CNCLEP00099631, slide HRR 297, CNC); West Virginia, Morgan Co., Sleepy Creek Forest, J. Glaser, 2 May 2010 (1 ♂, slide HRR 123, USNM).

Distribution and biology. The range for *P*. *rhoifructana* is throughout the eastern half of the U.S. and portions of southeastern Canada, from New Brunswick, south along the coastal states to Florida and Mississippi, and westward to Oklahoma. Easily the most polyphagous species in *Paralobesia*, this species has been reared from a variety of hosts in several families:

- *Rhus* sp. L. (Anacardiaceae)
- *Eryngium yuccifolium* Michx. (Apiaceae) seed heads
- *Eupatorium purpureum* (L.) E. E. Lamont (Asteraceae)

- *Prenanthes* sp. L. (Asteraceae)
- *Sambucus nigra* L. ssp. *canadensis* (L.) R. Bolli (Caprifoliaceae)
- *Cornus* L. (Cornaceae)
- *Kalmia angustifolia* L. (Ericaceae)
- *Rhodora nudiflorum* (*Rhododendron periclymenoides*) (Michx.) Shinners (Ericaceae)

Discussion. One of the paratypes listed by Kearfott (1907) was assigned a date of 28, January. As we could only locate a specimen with the correct locality and type number but with a labelled collection date of 8 January 1899, we are assuming the text was in error and that this specimen is part of the type series. Another specimen has the same label data as the type series, but the date of 24 February 1899 is not listed in his type series. One specimen, with a given date of 6 March, was not located.

DNA sequence data. Our phylogenetic analysis of *Paralobesia* using COI results in a group containing both *P*. *rhoifructana* and *P*. *cypripediana*, requiring genitalic dissection for final identification (Fig. 25).

Paralobesia pallicirculus **Royals and Gilligan, sp.n.**

Figs. 100–103, 173, 206

Diagnosis. *Paralobesia pallicirculus* is a unique species in both wing pattern and male and female genitalia. On the forewing, the interfascial area between the subbasal and median fascia is constricted at the cubitus, creating a semioval in the dorsal half

that is outline in silvery white scales. This, combined with the bright discal spot, makes this specimen unmistakable. Male genitalia are similar to those of *P*. *wontonana*, but can be distinguished by the uncus setae patches that are shorter than the uncus, and the large tooth at the apex of the phallus that is directed apically rather than basally as in *P*. *wontonana*. Female genitalia are similar to those of *P*. *slingerlandana* but can be differentiated by the dorsal margin of the sterigma that extends anteriorly well past the ventral margin. In *P*. *slingerlandana* the dorsal margins are about even.

Description. Male. *Head:* Vertex rough scaled, brown; labial palpus light brown, ca. 2 times diameter of compound eye; segment II rough scaled with spot of black scales laterally; segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with dark brown and tan scales; posterior crest mottled with dark brown scales; fore- and mid-legs dark brown with tan annulations on tibia and tarsal segments, hind legs mostly pale with white annulations on tarsal segments; forewing length 4.8–6.0 mm (mean 5.5 mm; n = 28); ground color mottled tan and silver; wing markings mottled brown and dark brown, outlined in pale scales; costal strigulae pairs 2–9 expressed as pale dashes along costa; subbasal fascia a narrow band narrowing from costa to radius, widening from radius to cubitus, and narrowing from cubitus to dorsum; median fascia mottled with dark brown in the costal half and brown in the dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot present, pale; postmedian fascia divided into two sections, an elongate patch at the costa extending towards distal point of median fascia and a triangular pretornal patch; postmedian band a large redbrown semioval patch extending to termen and down towards tornus, usually with notch originating from

termen near M_3; preterminal fascia a small circular patch near the apex, center dark; fringe scales darkly mottled; hind wing uniformly dark brown; cubital pecten brown. *Abdomen:* Coloration a mottled dark brown with pale scaling at terminus; genitalia with uncus reduced curved posteriorly, with two patches of setae extending ventrally from apex, shorter than uncus; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with the membranous subscaphium; cucullus strongly clavate, widest at apex, stout, costal margin concave, apex squarely rounded, ventral margin convex with constriction medially, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate emargination, extending ventrally beyond cucullus 0.25-0.5 times its length, Spc_1 and Spc_2 separated by deep U-shaped emargination, Spc_2 0.5 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by shallow emargination, 0.3 the depth of previous; Spc_3 on a raised lobe, spines on Spc3 stout and spikelike, extending posteriolaterally baerly past Spc_2; caulis ca. 3/4 length of phallus; phallus tapering distally, curved, length ca. 1/2 that of the cucullus, sclerotized along ventral curvature, with large elongate tooth near and extending towards apex, rarely serrate. **Female.** *Head:* As in male, except vertex scales pale. *Thorax:* As in male, except forewing length 5.5–6.4 mm (mean 6.0 mm; n = 5). *Abdomen:* Coloration variably brown with dark scaling at posterior. Genitalia with apophyses anteriores ca. 1.5 times as long as apophyses posteriores; sterigma cylindrical in shape, moderately microtrichiate, anterodorsal margin slightly concave, extending anteriorly 2.0 times as far as posteroventral margin, posteroventral margin serrate; ostium oriented posteriorly; ductus bursae ca. 2 times as long as corpus bursae, posterior 0.25 strongly sclerotized;

ductus seminalis arising in posterior 0.25 of ductus bursae, anterior of sclerotization; corpus bursae with paired long, shallow signum of thickened cells, 0.3 times the length of corpus bursae, lacking acessory sacs.

Holotype. ♂, “OH(io): Wyandot Co., Killdeer Plains, June 14, 1991, leg. D. J. Wright; specimen ID CNCLEP00157905; ♂ genitalia on slide HRR 413” (CNC).

Paratypes. USA: Iowa, Howard County, Hayden Prairie, D.J. Wright, 28 June 1995 (1 ♂, CNCLEP00155978, slide HRR 251, CNC), (1 ♂, CNCLEP00155977, slide TOR 5180, CNC); Pocahontas County, Kalsow Prairie, 2 July 1993 (1 ♂, CNCLEP00155980, slide HRR 307, CNC), (1 ♂, CNCLEP00155981, slide TOR 5181, CNC), (1 ♂, CNCLEP00155979, CNC); 19 July 1998, (1 ♀, CNCLEP00142040, slide TOR 5183, CNC), (1 ♀, CNCLEP00157914, slide TOR 5171, CNC), (1 ♀, CNCLEP00157915, slide HRR 253, CNC); 22 Jun 2000, (1 ♀, CNCLEP00142039, slide TOR 5182, CNC); 18 July 2003, (1 ♂, CNCLEP00155983, slide HRR 252), (10 ♂, CNCLEP00155982, CNCLEP00155984, CNCLEP00155985, CNCLEP00157907, CNCLEP00157908, CNCLEP00157909, CNCLEP00157910, CNCLEP00157911, CNCLEP00157912, CNCLEP00157913, CNC); Ohio: Wyandot County, Killdeer Plains, 14 Jun 1991, (4 ♂, CNCLEP00156162, CNCLEP00156163, CNCLEP00156164, CNCLEP157906, CNC); Erie County, Resthaven Wildlife Area, 13 July 1991 (1 ♂, CNCLEP00157900, CNC); 20 July 1990 (2 ♂, CNCLEP00157902, CNCLEP00157901, 1 ♀, CNCLEP00157904, CNC), (1 ♂, CNCLEP00157898, slide TOR 5169, CNC), (1 ♂, CNCLEP00157903, slide HRR 461, CNC), (1 ♂, CNCLEP00157899, slide TOR 5170, CNC); Kansas: Nemaha County, Nemaha Co. St. Lake, J. B. Heppner, 28 June 1976 (1 ♀, slide HRR 524, FSCA).

Distribution and biology. *Paralobesia pallicirculus* has been collected in northern central parts of the United States. Collection records indicate a flight period from mid-June to late July. No host data has been recorded for this species.

Etymology: The name for this species was chosen to describe the distinguishing forewing marking of a semicircle outlined in pale scales along the dorsal edge. It is a combination of the Latin *pallidus* for pale and *circulus* for circle.

DNA sequence data. *Paralobesia pallicirculus* is well represented clade (68% BS) sister to *P*. *marilynae* (Fig. 25).

Paralobesia marilynae **Royals and Gilligan**

Figs. 104–106, 174

Diagnosis. *Paralobesia marilynae* is similar to both *P*. *monotropana* and *P*. *cypripediana*. All three species can be separated by the arrangement of the spine clusters, the teeth on the phallus, and the setae on the uncus in the males; these differences are discussed in detail under the *P*. *monotropana* description. Most other species of *Paralobesia* that resemble *P*. *marilynae* have long (extending past Spc_1) setae at Spc_3, versus the relatively short (not extending past Spc_1) in *P*. *marilynae*, and a different configuration of teeth on the phallus, if present. Females are unknown.

Description. **Male**. *Head*: Vertex rough scaled, pale brown; labial palpus pale brown, ca.1.75 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with reddish-orange and tan scales; posterior crest mottled with dark brown and orange scales; fore- and mid-

legs dark brown with tan annulations on tibia and tarsal segments, hind-legs mostly pale brown with white annulations on tarsal segments. Forewing length 5.2–5.7 mm (n = 3); ground color blue grey, wing markings dark reddish brown and bright orange; costal strigulae pairs 2–9 expressed as pale brown dashes along costa; subbasal fascia a narrow band narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum; median fascia dark brown, broad from costa to cubitus, distal margin extending towards termen along cubitus, and angling back to dorsum; postmedian fascia divided into two sections, an oval patch at the costa and a triangular pretornal patch, both mottled with bright orange scales; postmedian band a large semioval patch, scaled dark brown, extending to termen, usually with notch originating from termen near M_3; preterminal fascia a small irregular patch near apex; fringe scales darkly mottled. Hindwing a uniform dark brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Coloration pale to dark brown. Genitalia with uncus reduced, weakly bilobed, curved posteriorly, without patch of setae from apex; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus clavate, costal margin concave, with slight angle medially, apex broadly rounded, ventral margin convex, ventral half covered in stout spine-like setae, apex and dorsal half covered in fine setae; Spc_1 separated from cucullus by moderate narrow emargination, extending ventrally beyond cucullus ca. 0.50–0.75 times as its length, Spc_1 and Spc_2 separated by deep U-shaped emargination, Spc_2 0.75 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and peglike, Spc_2 and Spc_3 separated by shallow emargination, Spc_3 on a raised lobe, spines on Spc_3 stout and spikelike, extending past edge of Spc_2. Caulis large, ca. same

length as phallus. Phallus tapering distally, curved, ca. same length as cucullus, with a single tooth near apex. **Female**. Unknown.

Holotype. ♂, “Canada, QC, Gatineau Park, Folly Bog [fen], 45.456084°N 75.782735°W; Marilyn H.S. Light, 3.VII.2014; Larvae ex *Cypripedium reginae* stem+fruit; Adult emerged 30.IV.2015; CNCLEP00132704; Barcode of Life Project, Leg(s) removed, DNA extracted; ♂ genitalia on slide, HRR 242” (CNC).

Paratypes. **CANADA**: same location, collector, and host as holotype; near Hickory Trail, 45.45°75.7667°W, 138 m, egg laid 24 Jun 2013, hatched 28 Jun 2013, holed fruit & pupal shelter 8 Sep 2013, overwintered 17 Oct 2013, taken out 26 Mar 2014, emerged 2 May 2014 (1 ♂, slide TOR 5114, CNCLEP00112595, CNC); larva bagged on plant# FB131109C on 3 Jul 2014, emerged 28 Mar 2015 (1 ♂, CNCLEP00132703, CNC); larva collected on 5 Aug 2015, adult emerged 30 Apr 2016 (1 ♂, slide HRR 241, CNCLEP00141502, CNC); larva collected on 7 Aug 2015, pupated 12 Aug 2015, emerged 28 Mar 2016 (1 ♂, CNCLEP00141501, CNC).

Etymology. This species is named in honor of Marilyn H.S. Light, who has contributed greatly to our knowledge of *Paralobesia* biology by monitoring *C. reginae* populations in Gatineau Park for many years.

Distribution and biology. Of the 25 sequenced specimens verified as *P*. *marilynae*, 20 were collected from a population of *C*. *reginae* plants in Gatineau Park in southwestern Québec, while the remaining five were collected from *C*. *reginae* plants located in Lanark in eastern Ontario. The full range of this species is unknown. Eggs of *P*. *marilynae* are laid prior to seed development over a period of one to two weeks. Eggs are laid on the underside of the floral bracts and hatch within 36 hours. Upon

hatching, larvae enter a developing ovary and feed on ovary tissue. If a capsule is not available, larvae will enter the stem of the plant. There is little evidence that they will feed on developing seeds. Larvae will leave the seed capsule to pupate when desiccation of the capsule occurs, or when the food source is depleted. Rarely will they leave to feed on foliage. Larvae *in situ* likely drop or crawl to the ground and create a fold in deciduous litter in which to pupate.

Discussion. The five specimens listed above are the only specimens reared to adulthood. An additional 20 specimens (14 larvae and six eggs) were determined to be *P*. *marilynae* using DNA barcoding, but these are not included in the type series.

DNA sequence data. This species is a well-supported clade (93% BS) (Fig. 26).

Paralobesia landryi **Royals and Gilligan, sp.n.**

Figs. 175, 207

Diagnosis. *Paralobesia landryi* wing pattern is unknown. Male genitalia may be confused with that of *P*. *rhoifructana* but may be distinguished by a few subtle features. In males of *P*. *landryi*, the uncus comes to a round tapered point, and Spc_1 extends about halfway its length past the ventral margin of the cucullus. In *P*. *rhoifructana*, the uncus is moderately bilobed, and Spc_1 only slightly extends past the ventral margin of the cucullus. Female genitalia of *P*. *landryi* may be confused with a number of other *Paralobesia* sp. that possess a conical sterigma (e.g., *P*. *rhoifructana*, *P*. *yaracana*, *P*. *spiraeifoliana*) but can be separated from these by the slightly bulging center, and paired triangular depressions in the dorsal surface along the anterodorsal margin.

Description. **Male**. *Abdomen:* Genitalia with uncus roundly tapered, curved posteriorly, setae from apex as long as uncus; socius absent; gnathos microtrichiate medially, fused with membranous subscaphium; cucullus weakly clavate, narrowest near the base, dorsal margin weakly concave, apex narrowly rounded, ventral margin convex, nearly straight, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, extending 0.5 times its length past ventral margin of cucullus; Spc_2 ca. 0.75 times length of Spc_1; Spc_3 at base, spines on Spc_3 long and feathery, extending to apex of cucullus. Phallus thin, tapering distally, nearly straight, length ca. 0.5 times that of the cucullus, with one side sclerotized and a serrated sclerotized flap curving over dorsal curvature. **Female**. *Abdomen*: Genitalia with apophyses anteriores ca. 1.2 times as long as apophyses posteriores; ductus bursae ca. 1.0 times as long as corpus bursae; colliculum weakly sclerotized; sterigma bell-like in shape with center slightly widened, moderately sclerotized and weakly microtrichiate; ostium oriented posteriorly; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with paired, linear signum of thickened cells, and two accessory sacs at anterior end.

Holotype. ♂, Canada, Ontario, Owen Sound, Bayview Escarpment Provincial Park, CBG Collections Staff, 10 July 2014, BIOUG34158-D01, ♂ genitalia on slide HRR 575 (CBG)

Paratypes. **CANADA**. Same collection data as holotype (1 ♂, BIOUG34158-C12, slide HRR 574; 2 ♀, BIOUG34158-B05, slide HRR 573; BIOUG34158-G06, slide HRR 576, CBG); Saskatchewan, Grasslands National Park, East Block, M. Otway, 23 July 2014 (1 ♀, BIOUG21139-A03, slide HRR 572, CBG).

Distribution and biology. Limited collection data for *P. landryi* shows localities in southern Ontario and along the southern border of Saskatchewan.

Discussion. The five specimens that compose this type series are stored in alcohol at the Centre for Biodiversity Genomics (CBG). Specimen quality was poor and none of the above specimens were suitable for preparation of a wing mount. The wing pattern is unknown.

Etymology. The specific epithet *landryi* is in reference to J.-F. Landry who reared a specimen and suggested its inclusion in *Paralobesia*.

DNA sequence data. This species was detected as a distinct group (85% BS) in our phylogenetic analysis (Fig. 26).

Paralobesia wontonana **Royals and Gilligan, sp.n.**

Figs. 107–108, 176, 208

Diagnosis. *Paralobesia wontonana* may be confused with *P*. *blandula* in female genitalia, and are similar in male genitalia to *P. pallicirculus*, but may be distinguished based on male gentialia and some characteristics of the female sterigma. In *P*. *wontonana*, male genitalia have setae extending ventrally from each side of the uncus that are longer that the uncus. Spc_1 is concentrated at the distal end of the lobed projection and is extended almost entirely past the ventral margin of the cucullus. In *P*. *blandula*, there are no setae coming from the apex of the uncus, and the large Spc_1, occupying most of the lobed projection, extends about 0.5 times its length past the ventral margin of the cucullus. In females of *P*. *wontonana*, the posterior edge of the

sterigma has the appearance of gathered folds and is not entirely serrate. In *P. blandula*, the sterigma has a posterior border that is finely serrate around entire edge, and has lateral shoulders. The male genitalia of *P. pallicirculus* can be disinguished by the uncus setae patches that are shorter than the uncus, and the large tooth at the apex of the phallus that is directed apically rather than basally as in *P. wontonana.*

Description. **Male**. *Thorax:* Forewing ground color leaden grey and pale brown, wing markings mostly dark brown and brown; costal strigulae pairs 3–9 expressed as pale brown and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing slightly from cubitus to dorsum; dark streak of scales in interfascial area between costal stigulae 7 and 8; median fascia dark brown in costal half, mottled brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot present as patch of pale scales; dark streak of scales in interfacial area between median fascia and postmedian fascia, broken in center; postmedian fascia divided into two sections, an irregular oval patch at costa and a triangular pretornal patch, both dark brown; postmedian band a large, long semioval patch extending to termen, with deep notch originating from termen near CuA_1; preterminal fascia a small dark patch near apex; fringe scales dark. Hindwing brown; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Genitalia with uncus, slightly bilobed and curved posteriorly, setae from apex of uncus long, reaching tegumen; socius absent; gnathos a thin, weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus weakly clavate, dorsal margin weakly concave, apex narrowly rounded, ventral margin convex, ventral half covered in

spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, concentrated at distal end of lobe, extending ventrally beyond cucullus so all spines are nearly past ventral margin of cucullus; Spc_2 about same size as Spc_1; Spc_3 at base, spines on Spc_3 short and spine-like, extending past edge of Spc_2, not reaching Spc_1, with small barb near end. Phallus tapering distally, nearly straight, length ca. 0.75 that of the cucullus, with a stongly sclerotized sawlike took near apex. **Female**. *Thorax*: As in male. *Abdomen*: Genitalia apophyses anteriores ca. 1.2 times as long as apophyses posteriores; ductus bursae ca. 1.5 times as long as corpus bursae; colliculum weakly sclerotized; sterigma rounded at base, with posterior end looking pinched or folds gathered together, moderately sclerotized and weakly microtrichiate; ostium oriented posteroventralyl; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with paired, narrow, long signum of thickened cells 0.25 times the length of corpus bursae and two accessory sacs, ca. 0.3 times the length of corpus bursae.

Holotype. ♀ “Putnam Co[unty]. Ill[inois]., 29 June 1968, M. O. Glenn; ♀ genitalia on slide HRR 140)” (USNM).

Paratypes. **CANADA**: Ontario, Port Franks, K. H. Stead, 8 July 2014 (2 ♀, BIOUG21120-A11, slide HRR 568; BIOUG21329-B09, slide HRR 569; CBG); Rouge National Urban Park, North of Twyn Rivers Drive, 43.811, -79.162, BIObus 2013, 9 June 2013 (1 ♂, BIOUG19920-A07, slide HRR 571, wing mount on slide HRR 682, CBG); Saskatchewan, Grasslands National Park, East Block, M. Otway, 8 July 2014 (1 ♀, BIOUG21120-C02, slide HRR 567, CBG); Québec, Gatineau Park, near Hickory

Trail, Folly Bog fen, Marilyn H. S. Light, 9 June 2013 (1 ♀, BIOUG19920-A02, slide HRR 570, wing slide HRR 681, CBG).

Distribution and biology. Limited collection data for *P*. *wontonana* indicates a range along southern Canada from Saskatchewan east to southeastern Ontario. These specimens were collected in malaise traps from early June to early July.

Discussion. The five specimens that compose the type series are stored in alcohol at the Centre for Biodiversity Genomics (CBG). Specimen quality was poor and only one was suitable for mounting wings for examination

Etymology. The specific epithet *wontonana* comes from the female sterigma appearing like a wonton dumpling, rounded with gathered folds at one end.

DNA sequence data. These sequenced specimens, using COI, grouped in a phylogenetic analysis with a boostrap support value of 87% (Fig. 26).

***Paralobesia vernoniana* (Kearfott, 1907)**

Figs. 109–112, 177, 209

Polychrosis vernoniana Kearfott 1907:7; Barnes and McDunnough 1917:167; Heinrich 1926:94; McDunnough 1939:40; Brower 1983:24; Brown 2005:472.

Paralobesia vernoniana; Obraztsov 1953:94.

Endopiza vernoniana; Powell 1984:31; Godfrey et al. 1987:32.

Polychrosis ambrosiana Kearfott 1907:8; Barnes and McDunnough 1917:167; Forbes 1923:472; Heinrich 1926:94 (as synonym); Brown 2005:472. (as synonym)

Paralobesia ambrosiana; Obraztsov 1953:94. (as synonym)

Diagnosis. *Paralobesia vernoniana* has a rather variable wing pattern and is nearly identical to *P*. *sambuci*. Female genitalia of these two species are impossible to differentiate, necessitating the need for association with, and dissection of male genitalia for accurate identification. This species is superficially similar to both *P*. *aemulana* and *P*. *spiraeifoliana*, but can be separated by male genitalia. In *P*. *vernoniana*, Spc_1 does not extend past the ventral margin of the cucullus. In *P*. *aemulana* Spc_1 is about flush or extending just past the ventral margin of the cucullus, and in *P*. *spiraeifoliana* it extends well past the cucullus margin. Male genitalia of *P*. *vernoniana* are most easily confused with those of *P*. *rhoifructana*. In *P*. *vernoniana*, the Spc_1 is slightly smaller than Spc_2 and often shorter than the ventral margin of the cucullus, and the phallus has a single tooth located in the ventral curvature or side near the center. In *P*. *rhoifructana*, the male genitalia have Spc_1 of similar or larger size than Spc_2, generally flush with or extending just past the ventral margin of the cucucullus, and a phallus with a series of 2-5 teeth, sometimes difficult to observe, in the center of the dorsal curvature. In *P*. *sambuci*, Spc_3 is very short, extending past Spc_2 but not reaching Spc_3.

Redescription. **Male**. *Head*: Vertex mottled brown; labial palpus pale brown, all segments combined ca.1.8 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna brown. *Thorax:* Dorsum with dark transverse band across mesonotum; posterior crest dark brown; Fore- and mid-legs dark brown with white annulations on tibia and tarsal segments, hind-legs pale brown. Forewing length 4.1–4.7 mm (mean 4.4 mm; n = 5); ground color variably light to bluish grey; wing markings reddish brown with mottled dark brown or black; costal strigulae pairs 3–9

expressed as pale brown dashes along costa; Basal fascia a thin band of dark brown scales, widening from costa to cubitus, merging with patch of elongate dark scales at dorsum; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, brown to dark brown; median fascia dark brown to black in costal half, mottled brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum, outlined of pale brown scales in dorsal half present or absent; postmedian fascia divided into two sections, a variably sized, irregular oval patch at costa and a triangular, dark brown pretornal patch; postmedian band a variably shaped, large semioval patch extending to termen, usually with deep notch originating near M_3, generally dark brown in costal half and reddish brown in dorsal half; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing variably brown to dark brown; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus weakly bilobed, with patches of setae from either side of apex, extending ventrally, as long as uncus; socius absent; gnathos a weakly sclerotized band, fused with membranous subscaphium, weakly microtrichiate medially; cucullus narrow, tapering to apex, costal margin concave, apex narrowly rounded, ventral margin concave, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate emargination, lobe not reaching, or flush with the ventral margin of the cucullus; Spc_2 0.1-0.5 times the length of Spc_1; Spc_2 separated from Spc_3 by deep emargination, 0.5 times the depth of emargination between Spc_1 and Spc_2; Spc_3 from narrowly rounded protruding lobe at base, spines on Spc_3 very long and feathery, reaching, sometimes

extending past apex of cucullus. Phallus tapering distally, curved, length ca. 0.5 times that of the cucullus, with 1-2 strongly sclerotized teeth along dorsal or lateral curvature. **Female**. *Head:* As in male. *Thorax*: As in male. *Abdomen*: Dark brown. Genitalia with apophyses anteriores ca.1.0 times as long as apophyses posteriores; sterigma conical, with rounded base, spinulate around anterior 0.3, with longitudinal wrinkles; ostium oriented posteriorly; ductus bursae ca. 1.5 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with paired, linear shallow signum consisting of thickened cells, and two accessory sacs at anterior end.

Lectotypes. ♂, "Caldwell, N.J.; Ironweed, iss[ued] VIII.7; Barnes Collection; ♂ genitalia on slide HRR 587" (USNM); ♂ Cincinnati, O., L.VIII.10, iss[ued]VIII.20; reared from *Ambrosia trifidii* flowers; TYPE collection of W.D. Kearfott; Kearfott Col. Acc. 4667; ♂ genitalia on slide HRR 448" (AMNH).

Paralectotypes. **USA**. D.C. Bennings, 7 August (1 ♀, slide HRR 589, AMNH); on *Ironweed*, 28 July 1905 (4 ♀, slides HRR 370, HRR 450, #2, AMNH); New Jersey, Caldwell, 4 August (2 ♂, slide HRR 447; 2 ♀, AMNH); 7 August (2 ♂, slides HRR 444; 1 ♀, HRR 44, AMNH)(1 ♂, slide 71777, USNM); 10 August (1 ♀, slide HRR 445, AMNH); Missouri, Kirkwood, Murfeldt (1 ♀, AMNH); Ohio, Cininnati, Annette F. Braun, on *Ambrosia trifida*, 22 August (1 ♂, AMNH), 23 August (1 ♂, slide 71776, USNM); 24 August (1 ♀, slide #1, AMNH); 28 August (2 ♂, slides HRR 456, 71772; 1 ♀, slide 97883, USNM)(2 ♂, slide HRR 590, AMNH); 5 September (1 ♂, slide HRR 449, AMNH); 10 September (1 ♂, slide 71775, USNM).

Additional specimens examined. **USA**. Arkansas, Arkansas Co., 2 mi SE of Ethel, R. L. Brown, 9 August 1971(1 ♀, 77877, slide HRR 595, MEM); 20 August 1971

(1 ♂, slide HRR 378, USNM); Florida, Lake Placid, Archbold Bio. Sta., R. W. Hodges, 1–8 June 1964 (1 ♀, slide HRR 125, USNM); Illinois, Putnam Co. m. O. Glenn, 8 August 1974 (1 ♀, slide HRR 213, INHS); Oconee, on Ironweed, 8 July 1915 (1 ♂, slide HRR 582; 1 ♀, slide HRR 580, USNM); 16 July 1923 (1 ♀, slide HRR 445, USNM); Iowa, Pocahontas Co., Kalsow Prairie, D. J. Wright, 19 July 1998 (1 ♀, CNCLEP00157916, slide TOR 5172, CNC); Kansas, Onaga (1 ♂, AMNH); Crevcoeur, 29 July 1922 (1 ♂, slide 145821, USNM); Louisiana, Baton Rouge EBR Parish, G. Strickland, 19 March 1970 (1 ♂, slide HRR 656, FSCA); 24 March 1970 *1 ♂, slide HRR 539, FSCA); 2 July 1970 (1 ♀, slide HRR 519, FSCA); 19 February 1971 (1 ♂, slide HRR 520, FSCA); Iberia Park, Avery Island, R. L. Brown & R. M. Clary, 7 June 2000 (1 ♂, 37775, slide HRR 290, MEM); Maryland, Washington Co., Hancock, J G.asser, 16 August 2012 (1 ♀, slide HRR 040, USNM); Mississippi, Claiborne Co., 5.6mi West of Port Gibson. T12N, R2E, Sec 31m D. Hildebrandt, 28 August 1933 (1 ♂, 77868, slide HRR 462, MEM); Forest Co., Brooklyn, R. Kergosien, 1–6 July 1996 (2 ♀, 77992, slide HRR 600; 77948, HRR 632, MEM); Hancock Co., R. Kergosie, 7 July 1992 (1 ♀, 77870, slide HRR 611, MEM); Harrison Co., Long Beach, R. Kergosien, 28 May 1991 (1 ♀, 97980, slide HRR 437, MEM);14 October 1994 (1 ♂, 77965, slide HRR 628, MEM); 15 June 1996 (1 ♀, 77966, silde HRR 629, MEM); 1 September 1996 (1 ♂,77863, slide HRR 613, MEM); 3 July 1997 (1 ♂, 77973, slide HRR 272, MEM); 12 September 1997 (1 ♂, 77900, slide HRR 338, MEM); Issaquena Co., 2mi East of Tallula, R. Kergosien, 20–31 May 1996 (1 ♂, 77932, slide HRR 336, MEM); Jackson Co., O.C.R.L. Ocean Sp., R Kergosien, 17 June 1992 (1 ♂, 77988, slide HRR 330; 1 ♀, 77987, slide HRR 329, MEM); Shepard state park, R. Kergosien, 15–22 August 1995 (1 ♂, 77869, slide HRR 612, MEM);

Tishomingo Co., J.P. Coleman State Park, R. Kergosien, 14 August – 2 September 1995 (1 ♀, 77901, slide HRR 678, MEM); New Jersey, Caldwell, on *Vernonia noveboracensis*, W. D. Kearfott, 9 August 1902 (1 ♀, AMNH); New York, Tappan, 23 July 1991 (2 ♂, slides HRR 270, HRR 420; 1 ♀, slide HRR 269, AMNH); Ohio, Cininnati, Annette F. Braun, 20 May 1906 (1 ♂, slide HRR 585; 1 ♀, slide HRR 458, USNM) (1 ♀, CNCLEP00105442, slide TOR 1370, CNC); Oklahoma, Bartlesville, Mark Dreiling, 1301 Cherokee Hills Drive, 1 September 2008 (1 ♂, slide HRR 260; 1 ♀, slide HRR 259, CNC); 9 June 2009 (1 ♀, slide HRR 345, CNC); 17 June 2009 (1 ♀, slide HRR 349, CNC); 1680 Cherokee Hills Drive, 22 March 2009 (1 ♂, slide TOR 5069, CNC); 1768 Cherokee Hills Drive, 25 April 2009 (1 ♀, slide HRR 344, CNC); Tennessee, Chester Co., near Henderson, K. Childs, 26 March – 9 April 2014 (1 ♂, slide HRR 118, CUIC); 8–12 April 2015 (1 ♀, slide HRR 119, CUIC);

Distribution and biology. The range for *P*. *vernoniana* is throughout the Midwest, from Iowa, south to Kansas and Oklahoma to Louisiana, northeast to New Jersey. Host plants include primarily those in the Asteraceae, with a single specimen reared from Amaranthaceae:

- *Amaranthus* L. (Amaranthaceae)
- *Ambrosia trifida* L. (Asteraceae)
- *Aster* L. (Asteraceae)
- *Vernonia* sp. Schreb (Asteraceae)
- *Vernonia noveboracensis* (L.) Michx. (Asteraceae)

Discussion. Only 13 of the listed 21 specimens in the type series of *P*. *vernoniana*, and 12 of the 15 for *P*. *ambrosiana* were located. Klots' attribution of the *P*.

vernoniana and *P*. *ambrosiana* lectotype designations to Heinrich (1926) was invalid, as multiple male specimens from the listed locality are present in the AMNH, so we designate here a lectotype for each. One paralectotype for *P*. *ambrosiana* (♂ USNM slide 71774) is in fact *P*. *sambuci*.

DNA sequence data. In the phylogenetic analysis using COI, *P. vernoniana* forms a group with, and is indistinguishable from *P*. *sambuci*, and *P*. *wontonana*, making dissection of male genitalia necessary for identification (Fig. 26).

Paralobesia sambuci **(Clarke, 1953)**

Figs. 113–116, 178, 210

Polychrosis sambuci Clarke 1953:228.

Paralobesia sambuci; Brown 2005:472; Gilligan et al. 2008:48.

Endopiza sambuci; Powell 1984:31; Godfrey et al. 1987:32.

Diagnosis. *Paralobesia sambuci* has a rather variable wing pattern and is nearly inseparable from *P*. *vernoniana*. Female genitalia of these two species are impossible to differentiate, necessitating the need for association with, and dissection of male genitalia for accurate identification. Male genitalia are most easily confused with those of *P*. *cypripediana* and *P*. *monotropana*. In *P*. *sambuci*, Spc_3 is very short, extending past Spc_2 but not reaching Spc_1, Spc_1 does not extend past the ventral margin of the cucullus, and in the central ventral curvature of the phallus is a single well scleroized tooth. In *P*. *vernoniana*, Spc_3 is long and feathery, extening to the apex of the cucullus.

In both *P*. *monotropana* and *P*. *cypripediana*, Spc_1 extends to some degree past the ventral margin of the cucullus and both have more than a single tooth on the convex curvature of the phallus.

Redescription. **Male**. *Head*: Vertex mottled brown; frons scaling uniformly white; labial palpus pale brown, all segments combined ca.1.8 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna brown. *Thorax:* Dorsum mottled brown with dark transverse band across mesonotum; posterior crest dark brown; fore- and mid-legs dark brown with white annulations on tibial and tarsal segments, hind-legs pale brown. Forewing length 4.0–5.0 mm (mean 4.5 mm; n = 20); ground color variably light to bluish grey; wing markings reddish brown with mottled dark brown or black; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; basal fascia a thin band of dark brown scales, widening from costa to cubitus, merging with patch of elongate dark scales at dorsum; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, brown to dark brown; median fascia dark brown to black in costal half, mottled brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum, outlined of pale brown scales in dorsal half present or absent; apical spot usually present as patch of pale scales; postmedian fascia divided into two sections, a variably sized, irregular oval patch at costa and a triangular, dark brown pretornal patch; postmedian band a variably shaped, large semioval patch extending to termen, usually with deep notch originating near M_3, generally dark brown in costal half and reddish brown in dorsal half; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing variably brown to

dark brown; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus rounded, curved posteriorly, with patches of setae as long as uncus extending ventrally from either side of apex; socius absent; gnathos a weakly sclerotized band, fused with membranous subscaphium, moderately microtrichiate medially; cucullus narrow, tapering to apex, costal margin concave, apex narrowly rounded, ventral margin concave, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate emargination, lobe not reaching, or flush with the ventral margin of the cucullus; Spc_2 0.5–1.0 times the length of Spc_1; Spc_2 separated from Spc_3 by deep emargination, 0.5 times the depth of emargination between Spc_1 and Spc_2; Spc_3 from narrowly rounded protruding lobe at base, spines on Spc_3 very short, reaching Spc_2 but not Spc_1. Phallus tapering distally, curved, length ca. 0.5 times that of the cucullus, with a strongly sclerotized teeth along dorsal or lateral curvature. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.6–5.2 mm (mean 4.9; n = 3). *Abdomen*: Dark brown. Genitalia apophyses anteriores ca.1.0 times as long as apophyses posteriores; sterigma conical, with rounded base, spinulate around anterior third, with longitudinal wrinkles; ostium oriented posteriorly; ductus bursae ca. 1.5 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with paired, linear shallow signum consisting of thickened cells, and two accessory sacs at anterior end.

Holotype. ♂, “Putnam Co., Ill. 3 July 1943, M. O. Glenn; Reared ex-larva on *Sambucus canadensis*; TYPE no. 61486 *Polychrosis sambuci* Clarke; ♂ genitalia on

slide, 22.X.1946, J.F.G.C. 4198; ♂ genitalia on slide by Clarke, USNM 145816" (USNM).

Paratypes. **USA**. Illinois, Putnam Co., M. O. Glenn, 4 September 1939 (1 ♂, slide 71766, USNM); 4 July 1941, on Elderberry (1 ♀, slide DJW 1880, INHS); 15 July 1941, on Elderberry (1 ♀, slide HRR 351, INHS); 8 July 1942, reared from larvae on *Sambucus canadensis* (1 ♂, slide 71758, USNM); 31 August 1946 (1 ♂, slide HRR 353, INHS); reared from larvae on *Sambucus canadensis*, 30 July 1947, (1 ♀, slide 71759, USNM); 31 July 1947 (1 ♂, slide 71757, USNM); 21 July 1948 (1 ♂, slide DJW 1879, INHS); 24 July 1949 (1 ♀, slide HRR 352, INHS).

Additional specimens examined. **USA**. Florida, Alachua Co., Gainesville, D.F. Habeck, 8 April 1967, on *Sambucus* (1 ♀, slide HRR 523, FSCA); Maron Co., Boardman, P.J. Perum and K. Regan, 6 May 1976, on *Sambucus simpsonii* (1 ♀, slide HRR 518, FSCA); Illinois, Putnam Co., M. O. Glenn, 30 August 1949 (1 ♀, slide HRR 490, INHS); 12 July 1955 (1 ♂, slide HRR 491, INHS); 29 July 1967 (1 ♀, slide HRR 218, INHS); 17 August 1969 (1 ♂, slide HRR 209, INHS); 3 September 1969 (1 ♂, slide HRR 208, INHS); 2 July 1974 (1 ♀, slide HRR 224, INHS); 11 August 1974 (2 ♀, slides HRR 137, HRR 220, INHS); 18 August 1974 (3 ♂, slides HRR 206, HRR 214, HRR 219, INHS); 20 August 1974 (1 ♀, slide HRR 210, INHS); 10 August 1975 (1 ♀, slide HRR 529, INHS); 28 July 2975 (1 ♀, slide HRR 665, INHS); 14 September 1976 (1 ♀, slide HRR 141, INHS); Kinderhook, Lewis C. Hackk, 18 April 1932 (1 ♂, slide HRR 586 (USNM); Oconee, on Ironweed, 8 July 1915 (1 ♂, slide HRR 581, USNM); Kansas, Onaga (1 ♂, AMNH); Mississippi, Forest Co., Brooklyn, R. Kergosien, 1-6 July 1996 (2 ♀, 77991, slide HRR 438; 98039, slide HRR 321, MEM); Harrison, Long Beach, R.

Kergosien, 24 May 1995 (1 ♂, 77960, slide HRR 680, MEM); Warren Co., Vicksburg, Ricky Patterson, 29 July 1999 (1 ♀, 77977, slide HRR 276, MEM); Missouri, Crawford Co., Onondaga Cave S[tate] P[ark], J. J. Dombroksie, 15 April 2016 (1 ♂, JD22917, slide HRR 237, CUIC); Ohio, Cincinnati, Annette F. Braun, 20 May 1906 (1 ♂, CNCLEP00105441, slide TOR 5064, CNC); 28 August, on *Ambrosia trifida* (1 ♂, slide 71774, USNM) [previously in *P*. *ambrosiana* type series]; Oklahoma, Mark Dreiling, Bartlesville, 1301 Cherokee Hills Drive, 8 September 2008 (1 ♂, MDOK-0800, slide HRR 348, CNC); 11 September 2009 (1 ♂, MDOK-3397, slide HRR 347, CNC); 1302 Cherokee Hills Drive, 27 September 2008 (1 ♀, MDOK-1534, slide HRR, CNC); 1683 Cherokee Hills Drive, 22 March 2009 (1 ♀, MDOK-1931, TOR 5075, CNC); 1700 Cherokee Hills Drive, 4 April 2009 (1 ♂, MDOK-1949, slide HRR 346, CNC); 1758 Cherokee Hills Drive, 16 April 2009 (1 ♂, MDOK-2091, slide HRR 258, CNC); 1764 Cherokee Hills Drive, 18 April 2009 (1 ♂, MDOK-2097, slide TOR 5070, CNC); 9 May 2009 (1 ♀, MDOK-2253, slide TOR 5076, CNC); Pennsylvania, Allegheny Co., Oak Station, Fred Marloff, 12 September 1987 (1 ♂, slide HRR 122, USNM); Tennessee, Chester Co., near Henderson, K. Childs, 19–22 April 2014 (1 ♂, JD22005, slide HRR 231, CUIC); 7 April 2015 (1 ♂, JD21379, slide HRR 229, CUIC); Texas, Liberty, Bottimer Exp[edition], on leaves of *Amaranthus spinosus*, 4 July 1923 (1 ♀, slide HRR 129, USNM); No locality information: 15 June 1880 (2 ♀, slides HRR 267, HRR 583, AMNH); 2 April 1898 (1 ♂, slide HRR 584, AMNH).

Distribution and biology. The range for *P*. *sambuci* includes the southern Midwest and the southern U.S., from Pennsylvania south to Florida, west to southern

Texas, and north to Kansas and Illinois. This species feeds primarily on American black elderberry, but has records from three families of host plants:

- Leaves of *Amaranthus spinosus* L. (Amaranthaceae)
- *Ambrosia trifida* L. (Asteraceae)
- *Sambucus* L. sp. (Caprifoliaceae)
- *Sambucus nigra* L. ssp. *canadensis* (L.) R. Bolli (Caprifoliaceae)
- *Sambucus simpsonii* Rehder ex Sarg. (Caprifoliaceae) [synonym of *Sambucus nigra* L. ssp. *canadensis*]
- *Vernonia* sp. Schreb (Asteraceae)

Discussion. We were unable to locate three of the female paratypes listed by Clarke (1952). One of the examined specimens (♂, USNM slide 71774) was originally part of the type series for *P*. *ambrosiana*, but was verified to be *P*. *sambuci*.

DNA sequence data. *Paralobesia sambuci* forms a group with and is indistinguishable (using COI) from *P*. *vernoniana* and *P*. *wontonana*, requiring dissection of male genitalia to confidently identify these species (Fig. 26).

Paralobesia crispans **Royals and Gilligan, sp.n.**

Figs. 117–120, 179, 211

Diagnosis. *Paralobesia crispans* is superficially similar to *P*. *rhoifructana* but can at once be separated by both male and female genitalia. In *P*. *crispans* males, the apical uncus setae are shorter than the uncus, Spc_2 is separated from Spc_3 by a deep

emargination, 0.5 times the depth of the emargination between Spc_1 and Spc_2, and Spc_3 spines arching dorsally near the base, giving them a loose curled look. In *P*. *rhoifructana* males, the apical uncus setae are as long as the uncus, the emargination between Spc_2 and Spc_3 is shallow, and Spc_3 spines extend ventrally and laterally with no arch. Females of *P*. *crispans* have a cylindrical sterigma that is broader than it is tall, and those of *P*. *rhoifructana* have a conical sterigma, rounded at the base and tapering to ostium.

Description. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca. 1.8 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum tan scaled; posterior crest dark brown; legs mostly pale brown on femora, dark brown with white annulations on tibial and tarsal segments. Forewing length 4.3–6.6 mm (mean 5.8 mm; n = 37); ground color grey in basal third, mottled grey and light brown in apical two thirds, wing markings a mottled reddish brown and dark brown; costal strigulae pairs 3–9 expressed as white and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown, distal edge lined with light brown scales; median fascia dark brown in costal half with a mix of brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, meeting postmedian fascia and angling back to the dorsum; postmedian fascia divided into two sections, an irregular triangular patch at costa, dark to light brown, and a triangular dark brown pretornal patch; postmedian band a large semioval patch extending to termen and nearly to costa, with deep notch originating from termen near M_3, red-brown with dark brown scaling in center;

preterminal fascia a small circular patch near apex, red-brown with dark brown center; fringe scales darkly mottled. Hindwing brown in apical half, light brown to white at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Greyish brown, pale elongate scales from terminal segment. Genitalia with uncus reduced, rounded, curved posteriorly, with two patches of setae shorter than uncus extending ventrally from each side of apex; socius absent; gnathos, weakly microtrichiate medially, fused with membranous subscaphium; cucullus clavate, stout, costal margin broadly concave, apex widely rounded, ventral margin convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; sacculus with three distinct clusters of spine-like setae, two on padlike lobes proximal to the cucullus and a third on a raised projection from anterior surface; Spc_1 separated from cucullus by narrow emargination, flush with or extending ventrally slightly beyond cucullus, Spc_1 and Spc_2 separated by deep, narrow U-shaped emargination, Spc_2 ca. same size as Spc_1, spines on both Spc_1 and Spc_2 spine-like, Spc_2 and Spc_3 separated by shallow emargination ca. 0.5 times as deep as emargination between Spc_1 and Spc_2, Spc_3 on a raised lobe, spines on Spc_3 elongate, wispy, reaching apex of cucullus, with short barb near apices. Phallus tapering distally, curved, sclerotized along ventral curvature, length ca. 0.64 that of the cucullus, with 0–5 short projections along apical 0.3 of dorsal curvature, often hard to observe. Vinculum 4.0 times as thick as tegumen. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 5.1–6.8 mm (mean 6.1; n = 25). *Abdomen*: Brown dorsally, pale brown ventrally, with darker scaling on posterior segments. Genitalia with apophyses anteriores ca. 0.8 times as long as apophyses posteriores; sterigma cylindrical, boarder than high, constricted around

center, anterodorsal margin with indentation present or absent; ostium oriented posteriorly; ductus bursae ca. 1.2 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with paired linear, shallow, signum consisting of thickened cells and two accessory sacs from anterior end.

Holotype. ♂, “Highlands, 3865’, Macon Co[unty]. No[rth]. Car[olina]. 1 July 1958 R. W. Hodges; ♂ genitalia on slide HRR 105” (USNM).

Paratypes. **USA**. Kentucky, Laurel Co., Forest Service Rd. 615e, D. J. Wright, 4 May 1996 (1 ♀, CNCLEP00155975, slide TOR 5178, CNC); North Carolina, Ashe Co., Mt. Jefferson State Park Summit, J. Bolling Sullivan, 1 June 2000 (6 ♂, slides HRR 482, HRR 190, HRR 191, HRR 187, HRR 201, HRR 186, HRR 189, USNM); Avery Co., Moore Mountain, J. Bolling Sullivan, 25–27 June 2000 (1 ♂, slide HRR 485; 9 ♀, slides HRR 111, HRR 165, HRR 166, HRR 167, HRR 168, HRR 169, HRR 172, HRR 173, HRR 175, USNM); 22–23 June 2001 (5 ♂, HRR 194, HRR 193, HRR 198, HRR 195, HRR 197; 6 ♀, slides HRR 153, HRR 199, HRR 200, HRR 151, HRR 152, HRR 192, USNM); Avery Co., Grandfather Mt., Cliffside Overlook, J. Bolling Sullivan, 25–27 June 2000 (1 ♂, slide HRR 485, USNM); Avery Co., Grandfather Mt. Visitor Ctr., J. Bolling Sullivan, 25–27 June 2000 (1 ♂, slide HRR 196, USNM); Haywood Co., Black Balsam Mt., Pisgah National Forest, J. Bolling Sullivan, 26–27 June 2001, (1 ♂, slide HRR 202, USNM); Macon Co., Highlands, J. G. Franclemont, 25 June 1958 (5 ♂, slide HRR 511; 5 ♀, USNM); 29 June 1958 (1 ♂, USNM); 2 July 1958 (1 ♀, USNM); 4 July 1958 (4 ♀, slides HRR 508, HRR 510, USNM); Macon Co., Highlands, R.W. Hodges, 23 June 1958 (1 ♀, USNM); 24 June 1958 (5 ♂, slides HRR 101, HRR 513, USNM); 26 June 1958 (1 ♂, slide HRR 104, USNM); 29 June 1958 (1 ♂, slide HRR 670, USNM); 30 June 1958

(1 ♀, USNM); 1 July 1958 (1 ♂; 2 ♀, slide HRR 107, USNM); 2 July 1958 (3 ♂; 1 ♀, USNM); 3 July 1958 (2 ♀, slide HRR 106, USNM); 4 July 1958 (4 ♀, slide HRR 671, USNM); 6 July 1958 (2 ♀, slide HRR 669, USNM); 7 July 1958 (4 ♀, USNM); 8 July 1958 (1 ♀, USNM); 9 July 1958 (1 ♀, USNM); 14 July 1958 (1 ♀, slide HRR 108, USNM); 24 July 1958 (1 ♀, slide HRR 507, USNM); Stokes Co., Hanging Rock State Park, J. Bolling Sullivan 8–9 July 1997 (1 ♂, slide HRR 484, USNM); Tennessee, Cocke. Co., Great Smoky Mountain National Park, R. L. Brown & S. M. Lee, 9 June 2002 (1 ♀, slide HRR 625, USNM).

Distribution and biology. The range for *P*. *crispans* is primarily the central eastern states of the U.S., with the majority of specimens from western North Carolina and neighboring states.

Etymology. The name of this species '*crispans'* was chosen to describe the long feathery spines of Spc_3 that are dorsally curved at the base, giving them consistently curled appearance when slide mounted.

DNA sequence data. We were not able to obtain many sequences for this species for out analysis. The group is not very well-supported with a bootstrap support value of 68% (Fig. 26).

Discussion.One specimen (♂, MEM 97,883, slide HRR 596) has genitalia identical to that of *P*. *crispans* but has a much darker, greyer overall wing pattern. Two more specimens, both male (CNC, CNCLEP00099642 and USNM, slide HRR 372) are similar in genitalia, but smaller than, and with Spc_3 one half the length of those of *P*. *crispans*, and are from Maine. It is likely that these two latter specimens represent a new species but we do not have enough material to confidently describe them as such.

***Paralobesia worthi* Royals and Gilligan, sp.n.**

Figs. 121–124, 180, 212

Diagnosis. *Paralobesia worthi* is superficially similar to *P*. *andereggiana*, but can be distinguished by its much darker wing markings and unmistakable male and female genitalia. Male genitalia have a very large, strongly curved phallus, almost twice the length of the cucullus, with numerous short cornuti. Female genitalia are characterized by their unique sterigma – a wide U shape, strongly microtrichiate, with the ostium taking up most of the ventral surface, and a strongly sclerotized and spiraled colliculum, extending nearly one half of the ductus bursae.

Description. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.4 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum red brown with dark transverse line; posterior crest mottled red and white; fore- and mid-legs mostly pale brown on femora, dark brown with white annulations on tibia and tarsal segments, hind legs pale. Forewing length 5.3–6.8 mm (mean = 6.1; n = 4); ground color mostly grey, wing markings dark brown to black; costal strigulae pairs 3–9 expressed as white and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; median fascia dark brown to black, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum, widening at dorsum; postmedian fascia divided into two sections, an irregular patch at costa and a triangular pretornal patch, both dark brown; postmedian band a large semioval patch extending to termen, with deep notch originating from termen near M_3,

dark brown; preterminal fascia a small irregular patch near apex, red-brown with dark brown center; fringe scales darkly mottled. Hindwing brown to dark brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten pale brown. *Abdomen:* Greyish brown. Genitalia with uncus highly reduced, lacking setae from apex; socius absent; gnathos a weakly sclerotized band, weakly microtrichiate medially, fused with membranous subscaphium; cucullus weakly clavate, short, less than half the length of entire valve, costal margin broadly concave, apex rounded, ventral margin weakly convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate emargination, extending 0.5 times its length beyond ventral cucullus margin, Spc_2 ca.0.5 times as long as Spc_1, spines on both Spc_1 and Spc_2 bluntly spine-like, emargination between Spc_2 and Spc_3 absent, spines on Spc_3 thin, wispy, reaching just to Spc_1. Phallus strongly curved, sclerotized along dorsal curvature and one side, length ca. 1.8 times that of the cucullus, with sclerotized tooth at center of ventral curvature, vesica with numerous short cornuti, shorter than width of phallus. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 5.8–6.8 mm (n = 2). *Abdomen*: Brown. Genitalia with apophyses anteriores ca. same length as apophyses posteriores; sterigma a wide U, strongly sclerotized and microtrichiate; ostium oriented posteriorly; ductus bursae ca. 1.5 times the length of corpus bursae, with strongly sclerotized spiraled colliculum along posterior half; ductus seminalis arising in anterior 0.5 of ductus bursae anterior to colliculum; corpus bursae with paired linear, shallow, signum of thickened cells and two accessory sacs at anterior end.

Holotype. ♂, “Oregon: Lane Co., Eugene, Coastal Farm & Ranch. Hwy 00: LBAM lure; #39-3178, 6.viii.2009, M. T. Savelich; Diss. 11-25-09 Genitalia prep by: ODA, RAW #73; ♂ genitalia on slide HRR 424” (USNM)

Paratypes. **USA**: California, Riverside Co., Pine Cove (1 ♂, slide 145837, USNM); San Jacinto Mountains, J. & P. Brown, 1 July 2017 (1 ♀, slide HRR 264, USNM); 6 July 2017 (1 ♂, slide HRR 266, USNM); 7 July 2017 (1 ♀, slide HRR 265, USNM); Shasta Co., Hat Creek, H. Ruckes Jr., from *Libocedrus decurrens* cones, 6 September 1956 (1 ♀, 312374, EMEC); Tuolumne Co., Dodge Ridge, H. Ruckes Jr., from *Libocedrus decurrens* cones, 13 September 1956 (1 ♂, 312372, slide 103; 1 ♀, 312373, EMEC); Oregon, Lane Co., Eugene, 4 mi WSW of Coburg, M. T. Savelich, 19–27 June 2017 (1 ♂, ODAC).

Distribution and biology. Limited collection data indicates that this species is one of the only *Paralobesia* on the West Coast, with records from Oregon and northern and central California. Specimens from California were reared from *Calocedrus* (*Libocedrus*) *decurrens* (Torr.) Florin (Cupressaceae), the only record of this family as a host for a *Paralobesia* species. This cedar is native to Oregon, California and Nevada (USDA-NRCS, 2018)

Etymology. This species is named in honor of Richard A. Worth from the Oregon Department of Agriculture who brought to our attention the existence of this new species nearly 10 years ago.

DNA sequence data. This species is well-supported on our tree, sister to *P. palliolana* (Fig. 26), another species of *Paralobesia* that has been recorded from the West.

Paralobesia palliolana (McDunnough, 1938)

Figs**.** 125–129, 181, 213

Polychrosis palliolana McDunnough 1938:91; McDunnough 1939:40.

Paralobesia palliolana; Obraztsov 1953:93; Brown 2005:472.

Endopiza palliolana; Powell 1983:31.

Polychrosis piceana Freeman 1941: 124; new synonomy.

Paralobesia piceana; Obraztsov 1953:93; Brown 2005:472.

Endopiza piceana; Powell 1983:31.

Diagnosis. This species is easily separated from others of *Paralobesia* by both wing pattern and male and female genitalia. The wings possess a metallic leaden grey ground color, which contrasts sharply with the dark brown and orange scaled wing markings. In the male genitalia, $Spc_{1\text{-}2}$ are large and jawlike, with spines on Spc_2 being longer than those on Spc_1. Female genitalia of *P*. *palliolana* may be confused with *P*. *ridingsi* but can be differentiated by the sterigma. In females of *P*. *palliolana*, the sterigma is moderately conical with a tapered posterior end, and the ventral and dorsal anterior margins are even in length. In *P*. *ridingsi* the sterigma is sub-rectangular and the posterior margin is evenly rounded, and the anterodorsal margin is longer than the anteroventral margin.

Redescription. **Male**. *Head*: Vertex pale brown; labial palpus pale brown, all segments combined ca. 1.8 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled brown with transverse band of dark brown scales; posterior crest mottled dark brown; legs brown

with white annulations on tibia and tarsal segments. Forewing length 3.7–5.8 mm (mean 4.7 mm; n = 38); ground color metallic grey, wing markings orange brown to dark brown and black; costal strigulae pairs 3–9 expressed as silver white dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing slightly from cubitus to dorsum, wider at dorsum; median fascia mostly dark brown lightly mottled with orange scales, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot sometimes present as faint patch of white scales; postmedian fascia divided into two sections, an irregular triangle at costa and an irregular pretornal patch, merged at costal end with postmedian band; postmedian band a thin, long semioval patch, not touching termen except for a few streaks, creating a series of silver and dark brown dashed along costa, merged with tornal patch at dorsal edge; preterminal fascia a small indistinct streak near apex; fringe scales mottled brown. Hindwing uniform brown; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Dark brown. Genitalia with uncus weakly bilobed, without patch of setae from apex; socius absent; gnathos a weakly sclerotized band, strongly microtrichiate medially, fused with membranous subscaphium; cucullus slightly clavate, costal margin broadly concave, apex rounded, ventral margin convex, ventral half covered in long, thick, blunt peglike setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by wide emargination, extending ventrally beyond cucullus ca. 0.1–0.3 times its length; spines thick, shorter than Spc_2; Spc_2 with long spines, separated from Spc_3 by very shallow emargination; Spc_3 at base, spines on Spc_3 long and feathery, length variable, extending past Spc_1, sometimes reaching apex of cucullus. Phallus tapering distally,

curved, ca. 0.75 times the length of the cucullus, teeth variable, with single tooth at apex of phallus and/or on dorsal curvature. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.1–5.6 mm (mean 4.8; n = 22). *Abdomen*: Dark brown. Genitalia apophyses anteriores ca. 1.0 times as long as apophyses posteriores; sterigma sub-rectangular, but with posterior corners tapering inward, strongly sclerotized and strongly microtrichiate; ostium oriented posteriorly; ductus bursae ca. 1.0 times as long as corpus bursae; colliculum weakly sclerotized; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with paired long, shallow, signum of thickened cells 0.3 times the length of corpus bursae and two accessory sacs.

Holotype. ♀, "S[outh]. Milford, N[ova].S[cotia]., 25-VI-1934, J. McDunnough; ♀ Holotype, *Polychrosis palliolana*, No. 4319; Database # CNCLEP00019792; ♀ genitalia on slide TOR 4070" (CNC).

Paratypes. **CANADA**: Nova Scotia, South Milford, J. McDunnough, 22 June 1934 (1 ♀, CNCLEP00105125, slide TOR 2340, CNC); 29 June 1934 (1 ♂, CNCLEP00103660, slide TOR 5056, CNC); 7 July 1934 (1 ♀, CNCLEP00105126, slide TOR 1362, CNC); Queens, White Point Beach, J. McDunnough, 16 July 1934 (1 ♀, CNCLEP00105127, slide TOR 1363, CNC); 17 July 1934 (1 ♀, CNCLEP00103661, CNC); Ontario, Ottawa, Mer Bleue, W. J. Brown, 7 May 1928 (1 ♀, CNCLEP00103662, slide TOR 1364, CNC); Québec, Kazabazua, F. P. Ide, 10 June 1927 (1 ♀, CNCLEP00103663, slide TOR 1361, CNC).

Additional specimens examined. **CANADA**: Alberta, Canmore on *Picea glauca*, 17 February 1958 (1 ♂, CNCLEP00099629, slide HRR 365, CNC); Jasper

National Park, Highway 16, Athabasca River, BioBus2012, 14 June 2012 (1 ♂, BIOUG04561-F03, slide HRR 360; 2 ♀, BIOUG04561-F04; BIOUG04663-C04, slide HRR 359, CNC); The Pallisades, B. C. Schmidt & G. A. Anweiler, 27 June 2016 (1 ♀, TOR-DNA-1033, slide HRR 343, CUIC); British Colombia, China Creek, on Douglas Fir, 23 May 1953 (1 ♂, CNCLEP00099614, CNC); John Dean Park, on Douglas Fir, 23 June 1954 (1 ♂, CNCLEP00099613, CNC); Lac La Hache, in *Pinus engelmanni* cones, 10 February 1953 (1 ♂, CNCLEP00099612, CNC); Mud Creek, in *Larix occidentalis* cones, 26 February 1954 (1 ♂, CNCLEP00099611, CNC); Manitoba, Riding Mtn. Park, J. McDunnough, 12 June 1938 (1 ♂, CNCLEP00099627, slide HRR 363; 1 ♀, CNCLEP00099626, CNC); New Brunswick, Restigouche, Red Brook, on *Picea glauca*, 26 February 1969 (1 ♂, CNCLEP00099618, slide TOR 444, CNC); North Tetagouche, on *Picea glauca*, 26 February 1969 (1 ♂, CNCLEP00099621, CNC); Nova Scotia, Colchester, near Kemptown, on *Picea glauca*, 26 February 1969 (1 ♀, CNCLEP00099619, CNC); near Otter Brook, on *Picea rubens*, 26 February 1969 (1 ♀, CNCLEP00099620, CNC); Halifax, Bog E. of Big Indian Lake, Halifax Watershed, Douglas C. Ferguson, 26 June 1968 (1 ♂, slide HRR 400, USNM); Pictou, Broadway, 17 February 1969 (1 ♀, CNCLEP00099617, slide TOR 445, CNC); Baddeck, J. McDunnough, 20 June 1936 (1 ♂, CNCLEP00103636, slide HRR 256, CNC); T. N. Freeman, 2 July 1936 (1 ♂, CNCLEP00099653, slide HRR 255, CNC); Cape Breton National Park, P. T. Dang, 27 July 1983 (1 ♀, CNCLEP00099622, CNC); Parrsboro, Ottawa House, J. McDunnough, 3 July 1944 (1 ♀, CNCLEP00103665, slide TOR 5066, CNC); Ontario, Lambton, Port Franks, K. H. Stead, 27 July 2014 (1 ♂, TOR-DNA-1042, slide HRR 095, CUIC); 29 July 2014 (1 ♂, slide HRR 042, CUIC); 1 August 2015 (1 ♂,

BIOUG25029-D07, slide 312, CUIC); 26 May 2016 (1 ♂, slide HRR 434, CUIC); Ganaraska, Tamarack, 7 February 1944 (1 ♂, CNCLEP00099625, slide TOR 442, CNC); Sault Ste. Marie, on Larch, 6 February 1944 (1 ♀, CNCLEP00099624, slide HRR 362, CNC); Prince Edward Island, Brackley Beach Can. Nat. Park, J. McDunnough, 5 July 1940 (1 ♂, CNCLEP00103664, slide TOR 5065, CNC); Kings Co., Hermanville, 27 February 1969 (1 ♀, CNCLEP00099607, slide HRR 361, CNC); Québec: Chelsea, 24 May 1931 (1 ♂, slide 71778, USNM); Dépôt-Pensive, on Black Spruce, 12 March 1940 (1 ♂, slide TOR 443, CNC); Terrebonne, Ste-Agathe, lac Brûlé, J.-F. Landry, 13 July 2000 (1 ♀, CNCLEP00003022, slide HRR 358, CNC); at *Aruncus dioicus*, 4 July 2014 (1 ♂, CNCLEP00006649, slide TOR 1475, CNC); Saskatchewan, Indian Head, 16 February 1953: on *Picea pungens* (1 ♂, CNCLEP00099616, slide HRR 364, CNC); on *Picea glauca*.(1 ♀, CNCLEP00099615, CNC); on *Picea abies* (1 ♀, CNCLEP00099630, CNC); **USA**: Kentucky, Powell Co., Tunnel Ridge Rd., D. J. Wright, 8 July 1989 (1 ♀, CNCLEP00157917, slide TOR 5173, CNC); Michigan, Rose Lake, D. Mosler: 8 June 1972 (2 ♂, slide 16158, USNM); 6 August 1972 (1 ♂, slide HRR 401, USNM); Minnesota, Duluth: (1 ♂, HRR 217, INHS); D. Hagler (1 ♀, slide 625806, INHS); New York, Syracuse, A. H. MacAndrews, 9 May 1930 (1 ♂, slide 71781, USNM); North Carolina, Macon Co., Highlands: J. G. Franclemont, 1 July 1958 (1 ♀, slide HRR 102, USNM); 4 August 1958 (1 ♂, slide HRR 368, USNM); 8 August 1958 (2 ♂, slides HRR 366, HRR 367, USNM); 13 August 1958 (2 ♂, slide HRR 287; 2 ♀, slides HRR 288, HRR 289, USNM); R. W. Hodges, 20 July 1958 (1 ♀, slide HRR 233, USNM); 22 July 1958 (1 ♀, slide HRR 100, USNM); Watauga, Zionville, M. Lynch: 26 July 2014 (1 ♂, slide HRR 096, CUIC); 1 August 2014 (1 ♂, slide HRR 117, CUIC); Oregon, 32 NE of

Prineville, J. K. McPike, 17 May – 3 July 1984 (1 ♂, slide HRR 397, USNM); Tennessee, Blount Co., Bote Mountain Trail, Segebarth Family, 19 May 2005 (1 ♂, DNA-ATBI-2176; 1 ♀, DNA-ATBI-2175, slide HRR 357, CNC); Sevier Co., Great Smoky Mountain National Park, Chimneys, R. L. Brown, 30 August 1986 (1 ♂, 77888, slide 1529, MEM); Vermont, South Hero West Shore Barnesbay, J. D. Hedbor, 22 July 2006 (1 ♂, slide HRR 114, FSCA); Virginia, Fairfax Co., 1km East of Fairfax, J. Brown: 3 September 2005 (1 ♂, slide 118557, USNM); 17 June 2012 (1 ♂, slide HRR 369, USNM); Fenwick, on *Pinus resinosa*, 7 July 1950 (1 ♂, slide 71779, USNM); Washington, Seattle, Spruce Cones, 19 May 1944 (1 ♂, slide 71782, USNM).

Distribution and biology. Collection data for *P. palliolana* suggest a wide range, from northwestern U.S. and southwestern Canada, west to Prince Edward Island in eastern Canada, and ranging south to Tennessee. The suggested flight period is mid-March through mid-August. A number of different hosts for this species have been recorded, primarily in the Pinaceae, with a single recorded host in the Rosaceae:

- *Aruncus dioicus* (Walter) Fernald (Rosaceae)
- Black Spruce (*Picea mariana* Mill.) (Pinaceae)
- Larch (*Larix* sp.) (Pinaceae)
- *Larix occidentalis* Nutt. (Pinaceae) – in cones
- *Picea abies* (L.) Karst. (Pinaceae) – in cones
- *Picea glauca* (Moench) Voss (Pinaceae) – in cones
- *Picea pungens* Engelm. (Pinaceae) – in cones
- *Picea rubens* Sarg. (Pinaceae)
- *Pinus engelmannii* Carrière (Pinaceae) – in cones

- *Pinus resinosa* Aiton (Pinaceae)
- *Pseudotsuga menziesii* (Mirb.) Franco (Pinaceae)

Discussion. No differences were found between *P*. *palliolana* and *P*. *piceana* in wing pattern nor genitalia. However, the variety of hosts and wide range of habitats suggest a cryptic species in this group. No other species in *Paralobesia* is known to feed on so many host plants.

DNA sequence data. This *P. palliolana* complex is well represented in our phylogenetic tree (79% BS), and is sister to *P*. *worthi* (Fig. 26)

***Paralobesia exasperana* (McDunnough, 1938)**

Figs. 130–133, 182, 214

Polychrosis exasperana McDunnough 1938:91; McDunnough 1939:40;
Paralobesia exasperana; Obraztsov 1953:93; Brown 2005:472.
Endopiza exasperana; Powell 1983:31.

Diagnosis. *Paralobesia exasperana* is nearly indistinguishable from *P*. *spiraeifoliana* in wing pattern and male genitalia. Female genitalia are identical to those of *P. crispans*, therefore association between, and dissection of both male and female genitalia are required for positive identification. Female genitalia of *P*. *exasperana* have a cylindrical sterigma, more broad than high, while that of *P*. *spiraeifoliana* is conical, tapering towards the posterior end.

Redescription. **Male**. *Head*: Vertex pale reddish brown; frons scaling uniformly white; labial palpus pale brown, all segments combined ca. 2.0 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum tan scaled; posterior crest dark brown; legs mostly pale brown on femora, dark brown with white annulations on tibial and tarsal segments. Forewing length 4.2–5.1 mm (mean 4.7 mm; n = 4); ground color pale brown to light grey, wing markings reddish brown and dark brown; costal strigulae pairs 3–9 expressed as white and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; median fascia mostly uniform brown or dark brown, with paler scaler against costal edge, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, meeting postmedian fascia and angling back to the dorsum; postmedian fascia divided into two sections, an irregular triangular patch at costa, dark to light brown, and a triangular dark brown pretornal patch, sometimes meeting via thin line of dark scales; postmedian band a large semioval patch extending to termen and often meeting costa with a thin band of scales, with deep notch originating from termen near M_3, red-brown with dark brown scaling; preterminal fascia a small circular patch near apex, red-brown with dark brown center; fringe scales darkly mottled. Hindwing tawny brown, paler at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Genitalia with uncus weakly bilobed curved posteriorly, with two patches of setae shorter than uncus extending ventrally from each side at apex; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus narrow, tapering slightly to apex, costal margin broadly concave, apex narrowly

rounded, ventral margin convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, extending ventrally 0.5 times its length beyond cucullus, Spc_2 ca.0.6 times the size of Spc_1, Spc_2 and Spc_3 separated by moderate emargination ca.0.3 times the depth of emargination between Spc_1 and Spc_2, Spc_3 on flattened lobe at base, spines on Spc_3 elongate, nearly reaching apex of cucullus, with short barb near apices. Phallus tapering distally, curved, sclerotized along ventral curvature, length ca. 0.5times that of the cucullus, fully sclerotized along one side, with a serrate, sclerotized flap wrapping to other from center and apex. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.6–5.0 mm (mean 4.8; n = 4). *Abdomen*: Genitalia with apophyses anteriores ca. 0.8 times as long as apophyses posteriores; sterigma cylindrical, boarder than high, constricted in center, anterodorsal margin with indentation present or absent; ostium oriented posteriorly; ductus bursae ca. 1.2 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with paired linear, shallow, signum consisting of thickened cells and two accessory sacs from anterior end.

Holotype. ♀, “S. Milford, N.S., 25-VI-1934 J. McDunnough; HOLOTYPE, *Polychrosis exasperana* No.4320, McD.; Database # CNCLEP00019794; CNC genitalia slide TOR 4050; Slide Pol. ♀, No. 10a” (CNC).

Paratypes. **CANADA**: Nova Scotia, Petite Riviere, J. McDunnough, 16 July 1935 (1 ♂, CNCLEP00105438, slide TOR 1378, CNC); S. Milford, J. McDunnough, 23 July 1934 (1 ♀, CNCLEP00103649, slide TOR 1373, CNC); 30 July 1934 (1 ♀, CNCLEP00103648, slide TOR 2338, CNC).

Additional specimens examined. **CANADA**: Petite Riviere, J. McDunnough, 16 July 1935 (2 ♀, CNCLEP00103650, slide TOR 1372; CNCLEP00105436, slide TOR 1375, CNC).

Distribution and biology. The locality information is limited to Petite Riviere and S. Milford in Nova Scotia. No host information is known.

Discussion. In Clarke's description of *P*. *exasperana* (1953), he notes that these specimens are nearly identical in wing pattern to *P*. *spiraeifoliana*, and that the specimens from the original type locality, in particular the males, were too worn to confidently be assigned the name of *P*. *exasperana*, and were ommited from the type series. The genitalia of these males are also nearly identical to *P*. *spiraeifoliana*, but since we have no evidence that these above specimens are *not P*. *exasperana*, we are leaving them named as such until additional males and females can be collected and sequenced.

Paralobesia piperana **Royals and Gilligan, sp.n.**

Figs. 134–137, 183, 215

Diagnosis. *Paralobesia piperana* is unlikely to be confused with any other *Paralobesia* species. On forewings of *P*. *piperana*, the wing markings constrast sharply with the ground color and the postmedian band has a very distinct border and is almost diamond in shape. Male genitalia of *P*. *piperana* have small lobed soccii that are nearly bare, a large rounded Spc_2 with splayed spines, and long setae on Spc_3. No other species in *Paralobesia* has this combination of characters. Females of *P*. *piperana* have

a narrow conical sterigma, tapering evenly, with nearly straight sides, to a very narrow ostium, with an antrum that is evenly narrowed. While some other females in *Paralobesia* have a conical sterigma (e.g. *P*. *yaracana*, *P*. *rhoifructana* and, *P*. *sambuci*), these are generally rounded around the base and do not have such a narrow ostium, with the antrum widening to ostium.

Description. **Male**. *Head*: Vertex brown to dark brown; labial palpus pale brown, all segments combined ca. 1.7 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna brown. *Thorax:* Dorsum brown with transverse band of brown scales across mesonotum; posterior crest dark brown; legs dark brown with white annulations on tibia and tarsal segments. Forewing length 5.2–6.3 mm (mean 5.8 mm; n = 12); ground color grey, wing markings reddish and dark brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; dorsal half of interfascial area between subbasal fascia and median fascia pale yellowish brown; median fascia dark brown to black in costal half, brown to pale brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, an irregular oval patch at costa and a triangular, dark brown pretornal patch; postmedian band a large semioval patch extending to termen, usually with notch originating near tornus and reaching center of wing; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing brown; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus reduced, without patches of setae from either

side of apex; socius paired lobes, lacking setae; gnathos a weakly sclerotized band, fused with membranous subscaphium, microtrichiate medially; cucullus elongate and narrow, costal margin concave, apex rounded, ventral margin concave, nearly straight, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by moderate emargination, lobe extending so one third of spine cluster extends past the ventral margin of the cucullus; Spc_2 on a very widely rounded lobe, spines splayed; Spc_3 from backside of base, spines on Spc_3 thin and elongate, extending past Spc_1 but not past apex of cucullus. Phallus tapering distally, nearly straight, length ca. 0.8 times that of the cucullus, lacking teeth.

Female. *Head:* As in male. *Thorax*: As in male, except forewing length 5.2–5.9 mm (mean = 5.6; n = 3). *Abdomen*: Dark brown. Genitalia with apophyses anteriores ca. 1.2 times as long as apophyses posteriores; Sterigma conical, tapering to a narrow point; ostium oriented posteriorly; ductus bursae ca. 1.0 times as long as corpus bursae; ductus seminalis arising in posterior 0.25 of ductus bursae; corpus bursae with paired long, shallow signum consisting of thickened cells, and two accessory sacs at anterior end.

Holotype. ♂ "TN: Cocke Co., Great Smoky Mt. N[ational]. P[ark]. Foothills Pkw – 140, 35º50'12"N 80º11'10"W, 9 June 2002, R. L. Brown & S. M. Lee; MEM 20,191; ♂ genitalia on slide HRR 624" (MEM).

Paratypes. **USA**. Massachusetts, Marthas Vineyard, F. M. Jones, 4 May 1948 (1 ♀, slide HRR 588, AMNH); North Carolina, Avery Co., Moore Mountain, J. Bolling Sullivan, 25-27 June 2000 (1 ♀, slide HRR 171, USNM); Grandfather Mt. Cliffside Overlook, J. Bolling Sullivan, 25-27 June 2000 (1 ♂, slide HRR 480, USNM); Carteret

Co., Ft. Macon State Park, J. Bolling Sullivan, 16 July 1996 (1 ♂, slide HRR 483, USNM); Tennessee, Cocke Co., Foothills Pkwy & I-40, R. L. Brown, 9 June 2002 (1 ♂, CNCLEP00157886; CNCLEP00157887, slide TOR 5164, CNC); Great Smoky Mountain National Park, Foothills pky – 140, R. L. Brown & S. M. Lee, 9 June 2002 (2 ♀, 20190, slide HRR 623; 20195, slide HRR 641, MEM; 10 ♂, 20198; 20188, slide HRR 621; 20290; 20194; 20276, slide HRR 639; 20189; 20196; 20279, slide HRR 640; 20193, slide HRR 642; 20187, slide HRR 435).

Distribution and biology. Collection data is limited for *P*. *piperana* but the distribution ranges from Massachusetts, south to South Carolina, and west to Tennessee. Only one host record was recorded for this moth as 'Maritime shrub.'

DNA sequence data. This species is not represented in our phylogenetic tree.

***Paralobesia slingerlandana* (Kearfott, 1904)**

Figs. 138–141, 184, 216

Polychrosis slingerlandana Kearfott 1904:295; Barnes and McDunnough 1917:167; Heinrich 1926:95; McDunnough 1939:40.

Paralobesia slingerlandana; Obraztsov 1953:94; Brown 2005:472.

Endopiza slingerlandana; Powell 1983:31; Godfrey et al. 1987:32.

Diagnosis. *Paralobesia slingerlandana* is difficult to distinguish from many other species in this group due to its non-distinct wing patten and variable coloration and is particularly similar to *P*. *rhoifructana*. However, both male and female genitalia have

distinctive characters to separate them. In male genitalia, Spc_1 is anteriorly-posteriorly flattened flattened and extends halfway past the ventral margin of the cucullus. In other males of *Paralobesia* this lobe either does not extend past the cucullus margin, or is rounded or bulbous. Also present in males of *P*. *slingerlandana* is a distinct, sclerotized, serrated flap extending from the dorsal curvature of the phallus near the apex and folding over the dorsal side. No such feature is present in other males of this group. In females of *P*. *slingerlandana*, the sterigma may be confused with *P*. *pallicirculus*. However, the anterodorsal margin of the latter extends far beyond the ventral margin, while these dorsal margins in *P*. *slingerlandana* are almost equal.

Description. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca. 2.1 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled with brown and tan scales with a transverse band of dark brown scales; posterior crest mottled with dark brown scales; Fore- and mid-legs dark brown with white annulations on tibia and tarsal segments, hind-legs pale brown. Forewing length 4.3–4.6 (mean 4.6 mm; n = 2); ground color blue grey, wing markings a mix of red-brown and dark brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, mottled dark brown; median fascia mostly dark brown with mottled brown scaling, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, an irregular patch at costa and a triangular pretornal patch with dark center; postmedian band a large semioval patch extending to termen, meeting costa and

tornus, usually with notch originating from termen near M_3; preterminal fascia a small indistinct patch near apex; fringe scales darkly mottled. Hindwing uniform dark brown throughout; fringe scales long, dark brown; cubital pecten brown *Abdomen:* Dark brown. Genitalia with uncus weakly bilobed and curved posteriorly, with patch of setae as long as uncus extending ventrally from sides; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus weakly clavate, costal margin broadly concave, apex widely rounded, ventral margin nearly straight, ventral half covered in spine-like setae, apex and dorsal edge covered in finer setae; Spc_1 flattened, almost parallel sided, separated from cucullus by narrow emargination; extending ventrally beyond cucullus ca. 0.5 times its length, Spc_2 1.0 times as large as Spc_1, spines on both Spc_1 and Spc_2 blunt and spine-like, Spc_2 and Spc_3 separated by shallow emargination, 0.1 times the depth of that between Spc_1 and Spc_2; Spc_3 on a raised lobe, spines on Spc_3 thick and short, extending anterolaterally just past Spc_2, not reaching Spc_1. Phallus tapering distally, curved, length ca. 0.5 that of the cucullus, with a sclerotized serrated flap extending from the dorsal curvature of the phallus near the apex and folding over the unsclerotized dorsal edge. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.6–5.3 mm (mean = 4.9; n = 5). *Abdomen*: Coloration brown. Genitalia with papillae anales narrow; apophyses anteriores ca. 1.0 times as long as apophyses posteriores; sterigma cylindrical, moderately spiculed, with notch in anterodorsal margin; ostium oriented posteriorly; ductus bursae ca. 1.5 times as long as corpus bursae, with lateral sclerotized plates within sterigma, wide at ostium; ductus seminalis arising in posterior 0.3 of ductus

bursae; corpus bursae with paired long, shallow, linear signum of thickened cells, 0.25 times the length of corpus bursae, lacking paired accessory sacs.

Holotype. ♀, "K-257, E[merged] VIII.9.; Type no. 8151 U.S.N.M.; *Polychrosis slingerlandana* Co-type, Kearfott; ♀ genitalia on slide, 10 Feb. 1923 N. P. #26; USNM 97882" (USNM).

Additional specimens examined. **CANADA**: Ontario: St. Davids, W. L. Putman, on *Eupatorium perfoliatum*, 2 June 1934 (1 ♀, CNCLEP00105440, slide TOR 1382, CNC); **USA**: Illinois: Putnam Co. M. O. Glenn, from *Eupatorium perfoliatum*, 29 June 1938 (1 ♂, INHS); 1 July 1938 (1 ♂, slide HRR 425, INHS), (1 ♀, slide HRR 135, USNM); Louisiana: Bossier Parish, Bodcau W. M. M., R. L. Brown, 20 May 1996 (1 ♀, 98116, slide HRR 594, MEM); E. B. R. Parish, Baton Rouge, G. Strickland, 30 June 1970 (1 ♀, slide HRR 654, FSCA); New Jersey: Caldwell, on *Eupatorium perfoliatum*, W. D. Kearfott, emerged 7 August (1 ♀, slide HRR 423, AMNH); Essex Co., from *Eupatorium*, W. D. Kearfott, emerged 7 August 1902 (1 ♀, slide HRR 268, AMNH); New York: Orient, Long Island, from Joe Pye weed, Roy Latham, 3 August 1954 (1 ♂, slide HRR 093, CUIC); Pennsylvania: Philadelphia, 2 August (1 ♂, slide HRR 421, AMNH).

Distribution and biology. The limited collection data for *P. slingerlandana* indicates a broad range through the eastern U.S. from coastal New York and southern Ontario southwest to Louisiana. Collection dates suggest a flight period from early late May to early August.

Discussion. While we assume there were multiple specimens in the type series, in his original description (1907) Kearfott did not give a specific number nor sex, but listed U. S. Nat. Mus. as the depository for the type. As we can only locate a single

female from USNM with a type label, we are labeling this the lectotype. Another specimen from AMNH has a *P*. *slingerlandana* type label and was assumed by Heinrich (1926) to be the holotype. As Kearfott made no mention of the AMNH in the original description, this designation is invalid.

DNA sequence data. No sequence data has been collected for this species.

***Paralobesia yaracana* (Kearfott, 1907)**

Figs. 142–145, 185, 217

Polychrosis yaracana Kearfott 1907:5; Barnes and McDunnough 1917:167; Heinrich 1926:93; McDunnough 1939:40.

Paralobesia yaracana; Obraztsov 1953:93; Brown 2005:472; Gilligan et al. 2008:48.

Endopiza yaracana; Powell 1983:31; Godfrey et al. 1987:32.

Diagnosis. *Paralobesia yaracana* is similar in appearance to *P*. *blandula*. In *P*. *yaracana*, the forewings have a pale brown ground color, wing markings outlined in bright white scales, and a very dark costal half of the median fascia, appearing as a dark spot along midline of costa to the naked eye. *Paralobesia blandula* has forewings with orange-brown markings and a conspicuous creamy pale scaling in the dorsal half of the interfascial area between the subbasal fascia and median fascia, creating a pale circular spot.

Redescription. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca. 1.6 times diameter of compound eye, segment II

rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum red brown with dark transverse line; posterior crest mottled red and white; fore- and mid-legs mostly pale brown on femora, dark brown with white annulations on tibia and tarsal segments, hind legs pale. Forewing length 4.3–5.2 mm (mean = 4.8 mm; n = 11); ground color grey, wing markings a mottled reddish brown and dark brown, outlined in white; costal strigulae pairs 2–9 expressed as white and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown, distal edge lined with white scales; median fascia dark brown to black in costal half, appearing to the naked eye as an obvious spot along costa with a mix of brown in dorsal half, broad from costa to cubitus, distal margin extending towards the termen along the cubitus and surrounded by white scaling, meeting postmedian fascia and angling back to the dorsum; postmedian fascia divided into two sections, an irregular triangular patch at costa and a triangular pretornal patch, both dark brown; postmedian band a large semioval patch extending to termen and nearly to costa, with deep notch originating from termen near M_3, brown with dark brown scaling in center; preterminal fascia a small irregular patch near apex, red-brown with dark brown center; fringe scales darkly mottled. Hindwing brown at apex, white at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten pale brown. *Abdomen:* Greyish brown, pale elongate scales from terminal segment. Genitalia with uncus rounded, curved posteriorly, with two patches of setae shorter than uncus extending ventrally from each side of apex; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus weakly clavate, elongate, costal margin broadly concave, apex rounded, ventral margin weakly

convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; sacculus with three distinct clusters of spine-like setae, two on padlike lobes proximal to the cucullus and a third on a raised projection from anterior surface at base; Spc_1 separated from cucullus by narrow emargination, flush with or extending ventrally slightly beyond cucullus margin, Spc_1 and Spc_2 separated by deep, narrow U-shaped emargination, Spc_2 ca. 0.5 times as big as Spc_1, spines on both Spc_1 and Spc_2 bluntly spine-like, Spc_2 and Spc_3 separated by shallow emargination ca. 0.3 times as deep as emargination between Spc_1 and Spc_2; spines on Spc_3 elongate, wispy, reaching apex of cucullus. Phallus tapering distally, curved, sclerotized along ventral curvature and one side, length ca. 0.7 times that of the cucullus, with 2–3 short projections along center of dorsal curvature, often hard to observe. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length 4.2–5.2 mm (mean = 4.8; n = 7). *Abdomen*: Brown. Genitalia with apophyses anteriores ca. same length as apophyses posteriores; sterigma bell-like, moderately sclerotized and spiculated around anterior 0.3, with a slight indentation along the dorsal anterior margin, posterior margin serrate; ostium oriented posteriorly; ductus bursae ca. same length as corpus bursae, colliculum weakly sclerotized; ductus seminalis arising in posterior 0.5 of ductus bursae; corpus bursae with paired long, shallow, signum of thickened cells and two accessory sacs at anterior end.

Lectotype. ♂, “Cin(cinnati)., O[hio]., 4-29’03; Collected by Annette F. Braun; TYPE Collection of W.D. Kearfott; *Polychrosis yaracana* cotype Kearf.; Kearfott Col. Ac. 4667; ♂ genitalia on slide, HRR 431” (AMNH).

Paralectotypes. **USA**: Ohio, Cincinnati, Annette F. Braun, 5 May 1904 (1 ♂, slide HRR 302, AMNH); 14 May 1904 (1 ♂, AMNH).

Additional specimens examined. **CANADA:** Ontario: Ottawa, C. H. Young, 16 June 1905 (1 ♂, CNCLEP00099699, slide TOR1384); 27 June 1906 (1 ♀, CNCLEP00099700, slide TOR 1385); J. McDunnough, Bobcaygeon, 6 June 1932 (1 ♀, CNCLEP00099609, slide TOR 2233, CNC); Orillia, 10 June 1925 (1 ♀, CNCLEP00099698, slide TOR 1383, CNC); Québec: Rougemont Montagne, D. Handfield, 13 June 2008 (1 ♂, MDH005951, slide HRR 469, MDH); **USA:** Illinois: Putnam County, M. O. Glenn, 26 May 1967 (1 ♂, slide HRR 222, INHS); 20 May 1976 (1 ♂, slide 23367, USNM); Kentucky: Powell County, Tunnel Ridge Rd. D. J. Wright (1 ♀, CNCLEP00157918, slide TOR 5174, CNC); Maine: Bar Harbor, A. E. Brower, 20 June 1951 (1 ♂, slide HRR 432, USNM); Mississippi: Tishomingo County, Tishomingo St. Pk., J. R. MacDonald, 11-12 April 1986 (1 ♂, 77935, slide HRR 644, MEM); New York: Gowanda, W. Wild, 8 June 1913 (1 ♂, CUIC; 1 ♀, slide 71763, USNM); Tompkins County: McLean, 27 May 1931 (1 ♂, slide HRR 277, AMNH); 22 May 1932 (1 ♀, slide HRR 278, AMNH); Ohio: Cincinnati, Annette F. Braun, 5 May 1909 (1 ♀, slide HRR 303, USNM); Pennsylvania: Allegheny County, Oak Station, Fred Marloff, 3 June 1906 (1 ♂, USNM); 2 June 1912 (1 ♂, slide 71762, USNM).

Distribution and biology. Collection data marks the range for *P*. *yaracana* as far north as Maine and parts of southern Canada south through Mississippi. Collection records indicate a flight period from late April to mid-June. No host data has been recorded for *P*. *yaracana*.

Discussion. Kearfott (1907) listed five paratypes with the same locality and collector information, collected between 29 April and 14 May. We were only able to locate three of these specimens in AMNH. Klots' (1942) designation of a lectotype by

Heinrich (1926) is invalid as there are multiple male specimens fitting the description by Kearfott in AMNH. Therefore one of the three located syntypes is designated here as the lectotype.

Two specimens with the same collection data may belong in this group. However, the female has darker hindwings, and the male genitalia, while matching in wing pattern, has a Spc_3 shorter than other specimens. These may together be a new species, however one other valid *P*. *yaracana* specimen has the same collection data. These two odd specimens are located in the MEM (77,936 and 77,938).

DNA sequence data. This species is not represented in our phylogenetic analysis.

Paralobesia kearfotti **Royals and Gilligan, sp.n.**

Figs. 146–149, 185

Diagnosis. *Paralobesia kearfotti* is superficially similar to *P*. *yaracana*, with mostly white hind wings, and identical in male genialia to *P*. *hodgesi*, but may be distinguished from both based on forewing coloration. In *P*. *kearfotti*, the forewing markings are a uniform brown against a paler brown ground color, with a thin postmedian band nearly reaching tornus, and the hindwings are mostly white with apexes brown. In *P*. *yaracana*, the wing markings are of a similar shade of brown to the ground color, except for the costal half of the median fascia, which is dark brown to black, appearing as an obvious dark spot along costa. In *P*. *hodgesi*, the hindwings are browner than white, and the basal half of the forewing has a dark grey ground color.

Description. **Male**. *Head*: Vertex reddish brown; labial palpus pale brown, all segments combined ca. 1.6 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled brown with transverse band of dark scales across mesonotum; posterior crest dark brown; legs brown with white annulations on tibia and tarsal segments. Forewing length 4.7–5.9 mm (mean = 5.3 mm; n = 4); ground color brownish grey in the basal half, pale brown in the apical half, split diagonally from midway along dorsum to costal strigulae 7, wing markings dark brown and brown; costal strigulae pairs 5–9 expressed as pale brown and grey dashes along costa; subbasal fascia a narrow band of dark scales; median fascia mottled dark brown and brown, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; discal spot present as patch of pale scales; postmedian fascia divided into two sections, a small dark patch at costa and a triangular pretornal patch; postmedian band a large, long semioval patch extending to termen by a narrow dash of scales, usually with notch originating from termen near M_3, dorsal margin tapering, nearly reaching tornus; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing white, brown in apical 0.25; fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus curved posteriorly, with setae patches from either side extending ventrally, as long as uncus; socius absent; gnathos a thin, weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus wide, costal margin weakly concave, apex widely rounded, nearly flat, ventral margin sweakly convex, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow

emargination, extending ventrally 0.25-0.3 times its length past the ventral margin of the cucullus; Spc_2 ca. 0.6 times as large as Spc_1; emargination between Spc_2 and Spc_3 moderate, 0.5 times that of emargination between Spc_1 and Spc_2; Spc_3 from low projection at base, spines on Spc_3 long and feathery, extending past Spc_1 to midway along cucullus. Phallus tapering distally, curved, length ca. 0.6 times that of the cucullus, single lateral sclerotized tooth present, often difficult to see. **Female**. Unknown

Holotype. ♂, "Putnam Co., Ill., 25 May 1967, M. O. Glenn; ♂ genitalia on slide HRR 215" (INHS).

Paratypes. Same locality and collector as holotype, 1 June 1963 (1 ♂, slide HRR 505, INHS); 25 May 1964 (1 ♂, slide HRR 221, INHS); 4 June 1966 (1 ♂, slide HRR 225, INHS).

Distribution and biology. The only known specimens of this species were collected in Putnam Co., Illinois in late May and early June. No host data has been recorded.

DNA sequence data. This species is not represented in our phylogenetic analysis.

Etymology. The specific epithet *kearfotti* is to honor William D. Kearfott who completed most of the early work in *Paralobesia* (as *Polychrosis*).

Paralobesia hodgesi **Royals and Gilligan, sp.n.**

Figs. 150, 187

Diagnosis. *Paralobesia hodgesi* is superficially very similar to *P*. *rhoifructana* but may be identified by male genitalia. In *P*. *hodgesi* males, Spc_3 is about half as long as

Spc_3 in *P*. *rhoifructana*, reaching just past Spc_1. Male genitalia are very similar to those of *P*. *kearfotii*, but these two species may be differentiated by wing pattern. *Paralobesia hodgesi* has a dark grey ground color and hind wings that are dusted well with brown. The forewings of *P*. *kearfotti* have a lighter grey-brown ground color and nearly white hindwings, with brown only at the apex. Female genitalia are unknown.

Description. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca.1.5 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled brown with transverse band of dark scales across mesonotum; posterior crest dark brown; legs brown with white annulations on tibia and tarsal segments. Forewing length 4.7 mm (n = 1); ground color dark grey in the basal half, light grey in the apical half, wing markings dark brown and brown; costal strigulae pairs 3–9 expressed as pale brown and grey dashes along costa; subbasal fascia a narrow band of dark scales; median fascia mottled dark brown and brown, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, a small patch at costa and a triangular pretornal patch, both reddish brown with dark brown center; postmedian band a large, long semioval patch extending to termen by a wide dash of scales, usually with notch originating from termen near M_3, dorsal margin tapering, nearly reaching tornus, fading to brown scales; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing brown, paler scaled nearer base, fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus rounded, curved posteriorly, with setae patches from either side extending ventrally, as long as uncus; socius absent;

gnathos microtrichiate medially, fused with membranous subscaphium; cucullus wide, costal margin weakly concave, apex widely rounded, nearly flat, ventral margin sweakly convex, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, extending ventrally 0.2-0.5 times its length past the ventral margin of the cucullus; Spc_2 ca. 0.6 times as large as Spc_1; emargination between Spc_2 and Spc_3 moderate, 0.25 times that of emargination between Spc_1 and Spc_2; Spc_3 from low projection at base, spines on Spc_3 of medium length, extending just past Spc_1. Phallus tapering distally, curved, length ca. 0.6 times that of the cucullus, no armature present. **Female**. Unknown

Holotype. ♂, “R. W. Hodges, Devil’s Den St. Pk., Wash[ington]. Co. Ark[ansas]. 29-VI-1966; ♂ genitalia on slide HRR 013” (USNM).

Paratypes. None – known only from type.

Distribution and biology. This specimen was collected in northwest Arkansas, and no host information was recorded.

DNA sequence data. This species is not represented in our phylogenetic analysis.

Etymology. The specific epithet *hodgesi* is to honor Ronald W. Hodges who collected this specimen and passed away in 2017.

Paralobesia glenni **Royals and Gilligan, sp.n.**

Figs. 151–153, 188

Diagnosis. *Paralobesia glenni* is superficially very similar to *P*. *spiraeifoliana* but may be separated by male genitalia. In *P*. *glenni*, the lobe with Spc_1 is rounded and extends nearly entirely past the ventral margin of the cucullus, and the phallus has a single sclerotized tooth from the ventral curvature near the apex. *Paralobesia spiraeifoliana* males possess a phallus with no such tooth, and Spc_1 extends about halfway its length past the ventral margin of the cucullus. Female genitalia are unknown.

Description. **Male**. *Head*: Vertex reddish brown; labial palpus pale brown, all segments combined ca.1.3 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum mottled brown with transverse band of dark scales across mesonotum; posterior crest dark brown; legs brown with white annulations on tibia and tarsal segments. Forewing length 4.6–4.9 mm (mean 4.7 mm; n = 3); ground color borwn to pale brown, wing markings dark brown; costal strigulae pairs 3–9 expressed as pale brown dashes along costa; subbasal fascia a narrow band of dark scales; median fascia mottled dark brown and brown, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, and angling back to the dorsum; postmedian fascia divided into two sections, a small patch at costa and a triangular pretornal patch, dark brown; postmedian band a large, long semioval patch extending to termen; usually with deep notch originating from termen near M_3, dorsal margin tapering, nearly reaching tornus, fading to brown scales; preterminal fascia a small dark patch near apex; fringe scales darkly mottled. Hindwing uniform brown, fringe scales long, brown basally, pale apically; cubital pecten brown. *Abdomen:* Brown. Genitalia with uncus rounded, curved posteriorly, with setae patches from either side extending ventrally, as long as uncus;

socius absent; gnathos microtrichiate medially, fused with membranous subscaphium; cucullus narrow, costal margin weakly concave, apex narrowly rounded, ventral margin weakly convex, ventral half covered in spine-like setae, apex and dorsal half covered in finer setae; Spc_1 on distally enlarged lobe, separated from cucullus by narrow emargination, extending almost its entire length past the ventral margin of the cucullus; Spc_2 ca. 0.6 times as large as Spc_1; emargination between Spc_2 and Spc_3 moderate, 0.25 times that of emargination between Spc_1 and Spc_2; Spc_3 from low projection at base, spines on Spc_3 of medium length, extending past Spc_1 to center of cucullus. Phallus tapering distally, curved, length ca. 0.7 times that of the cucullus, with a sclerotized tooth in apical third of ventral curvature. **Female**. Unknown

Holotype. ♂, “Putnam Co., Ill. 31 July 1972, M. O. Glenn; ♂ genitalia on slide HRR 212” (INHS).

Paratypes. **USA**. Illinois, Putnam Co., M. O. Glenn, 6 August 1965 (1 ♂, slide HRR 207, INHS); M. O. Glenn, 30 July 1976 (1 ♂, slide HRR 205, INHS).

Distribution and biology. Only three specimens of *P*. *glenni* are known, two from Putnam County, Illinois, and another without locality information.

DNA sequence data. This species is not represented in our phylogenetic analysis.

Etymology. The specific epithet *glenni* is to honor Murray O. Glenn who collected this specimen.

Paralobesia aruncana (Kearfott, 1907)

Figs. 154–157, 189, 218

Polychrosis aruncana Kearfott 1907:5; Barnes and McDunnough 1917:167; Heinrich 1926:95; McDunnough 1939:40.

Paralobesia aruncana; Obraztsov 1953:93; Brown 2005:472.

Endopiza aruncana; Powell 1983:31.

Diagnosis. *Paralobesia aruncana* is easily distinguishable from other species in this group by the coloration of the forewing. The costal half of the median band is a bright yellow orange, without a well-defined border, blending into ground color. The postmedian fascia has a dark rounded costal portion, reaching the termen with a thin curved band of scales, and a red-brown tapering dorsal half, making the postmedian fascia appear as a sideways comma. This combination of coloration is not found in any other *Paralobesia* species.

Redescription. **Male**. *Head*: Vertex pale reddish brown; labial palpus pale brown, all segments combined ca. 1.7 times diameter of compound eye, segment II rough scaled, segment III smooth scaled; antenna dark brown. *Thorax:* Dorsum tan scaled; posterior crest dark brown; legs mostly pale brown on femora, dark brown with white annulations on tibial and tarsal segments. Forewing length 4.1 mm (n = 1); ground color pale brown to light grey, wing markings reddish brown and dark brown; costal strigulae pairs 3–9 expressed as white and grey dashes along costa; subbasal fascia narrowing from costa to radius, widening from radius to cubitus, narrowing from cubitus to dorsum, dark brown; median fascia mostly uniform brown or dark brown, with paler

scales against costal edge, broad from costa to cubitus, distal margin extending towards the termen along the cubitus, meeting postmedian fascia and angling back to the dorsum; postmedian fascia divided into two sections, an irregular triangular patch at costa, dark to light brown, and a triangular dark brown pretornal patch, sometimes meeting via thin line of dark scales; postmedian band a large semioval patch extending to termen and often meeting costa with a thin band of scales, with deep notch originating from termen near M_3, red-brown with dark brown scaling; preterminal fascia a small circular patch near apex, red-brown with dark brown center; fringe scales darkly mottled. Hindwing tawny brown, paler at base; fringe scales long, dark brown basally, pale brown apically; cubital pecten brown. *Abdomen:* Genitalia with uncus weakly bilobed, curved posteriorly, with two patches of setae shorter than uncus extending ventrally from each side of apex; socius absent; gnathos a weakly sclerotized band, microtrichiate medially, fused with membranous subscaphium; cucullus narrow, tapering slightly to apex, costal margin broadly concave, apex narrowly rounded, ventral margin convex, ventral half covered in long spine-like setae, apex and dorsal half covered in finer setae; Spc_1 separated from cucullus by narrow emargination, extending ventrally 0.5 times its length beyond cucullus, Spc_2 ca. 0.6 times the size of Spc_1, Spc_2 and Spc_3 separated by moderate emargination ca. 0.3 times the depth of emargination between Spc_1 and Spc_2, Spc_3 on flattened lobe at base, spines on Spc_3 elongate, nearly reaching apex of cucullus, with short barb near apices. Phallus tapering distally, curved, sclerotized along ventral curvature, length ca. 0.5 times that of the cucullus, fully sclerotized along one side, with a serrate, sclerotized flap wrapping to other side from center and apex. **Female**. *Head:* As in male. *Thorax*: As in male, except forewing length

4.4–4.8 mm (mean = 4.6; n = 2). *Abdomen*: Genitalia with apophyses anteriores ca. 1.0 times as long as apophyses posteriores; sterigma conical, rounded out at base; ostium encompassing entirety of posterior surface, oriented posteriorly; ductus bursae ca. 1.6 times as long as corpus bursae; ductus seminalis arising in posterior 0.3 of ductus bursae; corpus bursae with paired linear, shallow, signum consisting of thickened cells, lacking two accessory sacs from anterior end.

Lectotype. ♂ "9215, on *Aruncus aruncus*; C[abin].J[ohn].Bridge Md. iss[ued] May 16-1900; TYPE collection of W.D. Kearfott; *Polychrosis aruncana* TYPE, Kearf.; Kearfott Col. Ac. 4667; LECTOTYPE; ♂ genitalia on slide TMG 727" (AMNH)

Paratypes. **USA**. Maryland, Cabin John Bridge, from *Aruncus aruncus*, 10 May 1900 (1 ♀, slide HRR 112, USNM); 11 May 1900 (1 ♀, slide HRR 092, USNM); 16 May 1900 (1 ♂, USNMENT01048972, slide 71780, USNM); 21 May 1900 (1 ♂, USNMENT01048973, slide HRR 506, USNM).

Distribution and biology. The only records of *P*. *aruncana* that were located and examined for this revision were four paralectotypes and the lectotype, all from Cabin John Bridge, Maryland. All were reared from *Aruncus aruncus* – synonym of *Aruncus dioicus* (Walter) Fernald var. *vulgaris* (Maxim.) H. Hara (Rosaceae)

Discussion. We were able to locate five of the eight listed specimens in the type series (Kearfott 1907), including the lectotype.

DNA sequence data. This species is not represented in our phylogenetic tree.

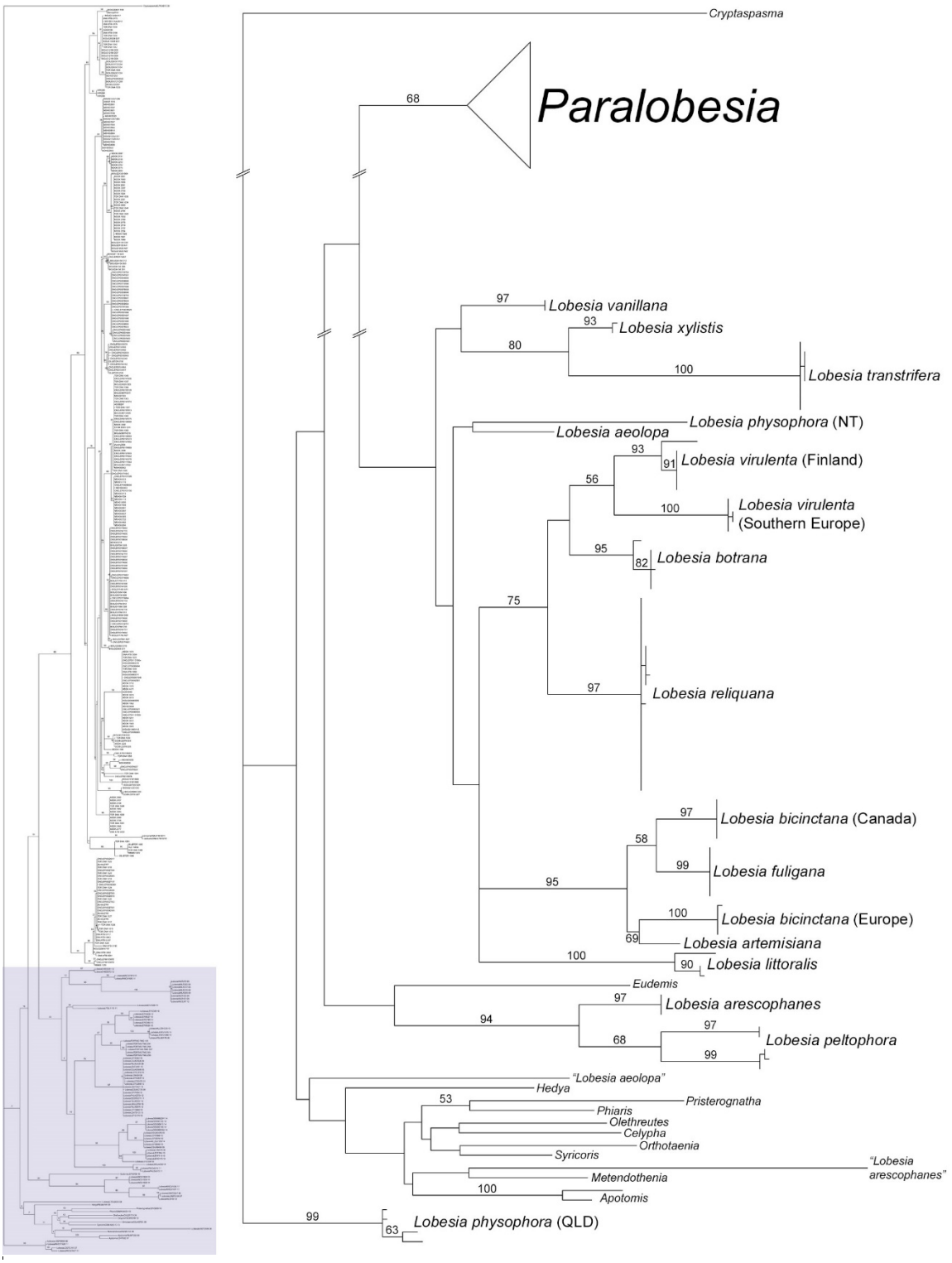


Fig. 23: The results of our maximum likelihood phylogenetic analysis using CO1 sequence data; the tree is expanded to show the relationships between *Paralobesia* and the various outgroups. Section 1 of 4.

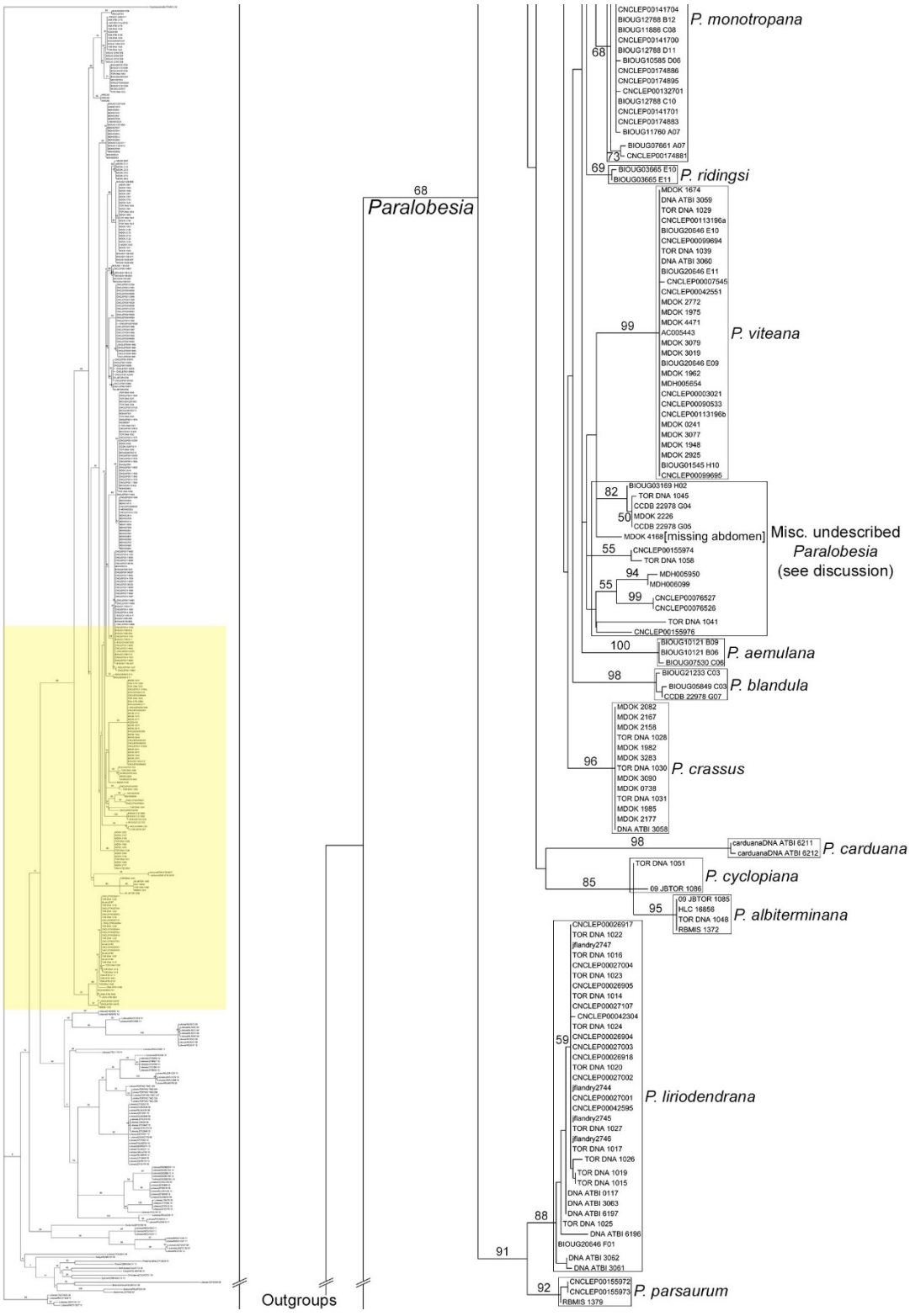


Fig. 24: The results of our maximum likelihood phylogenetic analysis using CO1 sequence data, section 2 of 4.

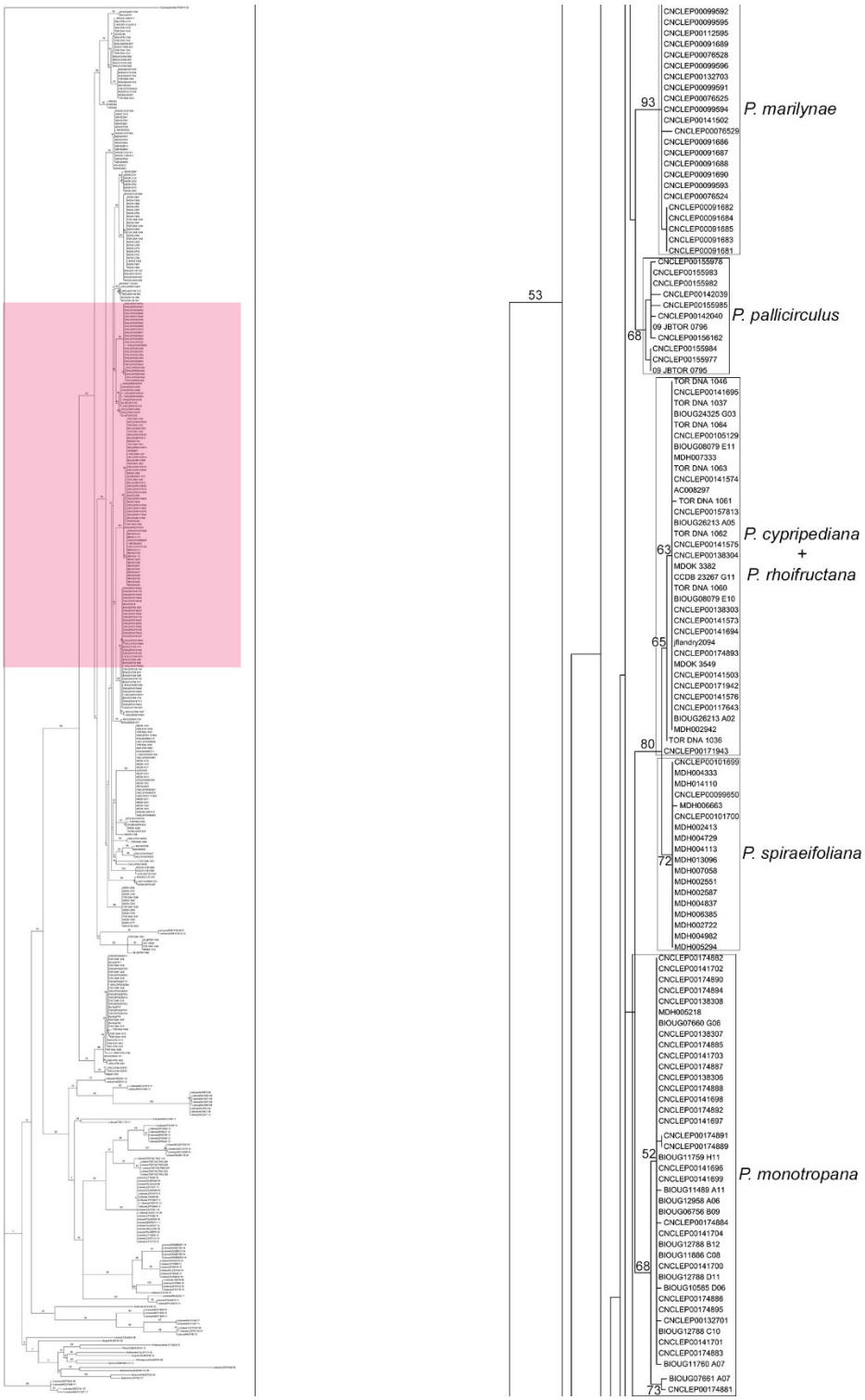


Fig. 25: The results of our maximum likelihood phylogenetic analysis using CO1 sequence data, section 3 of 4.

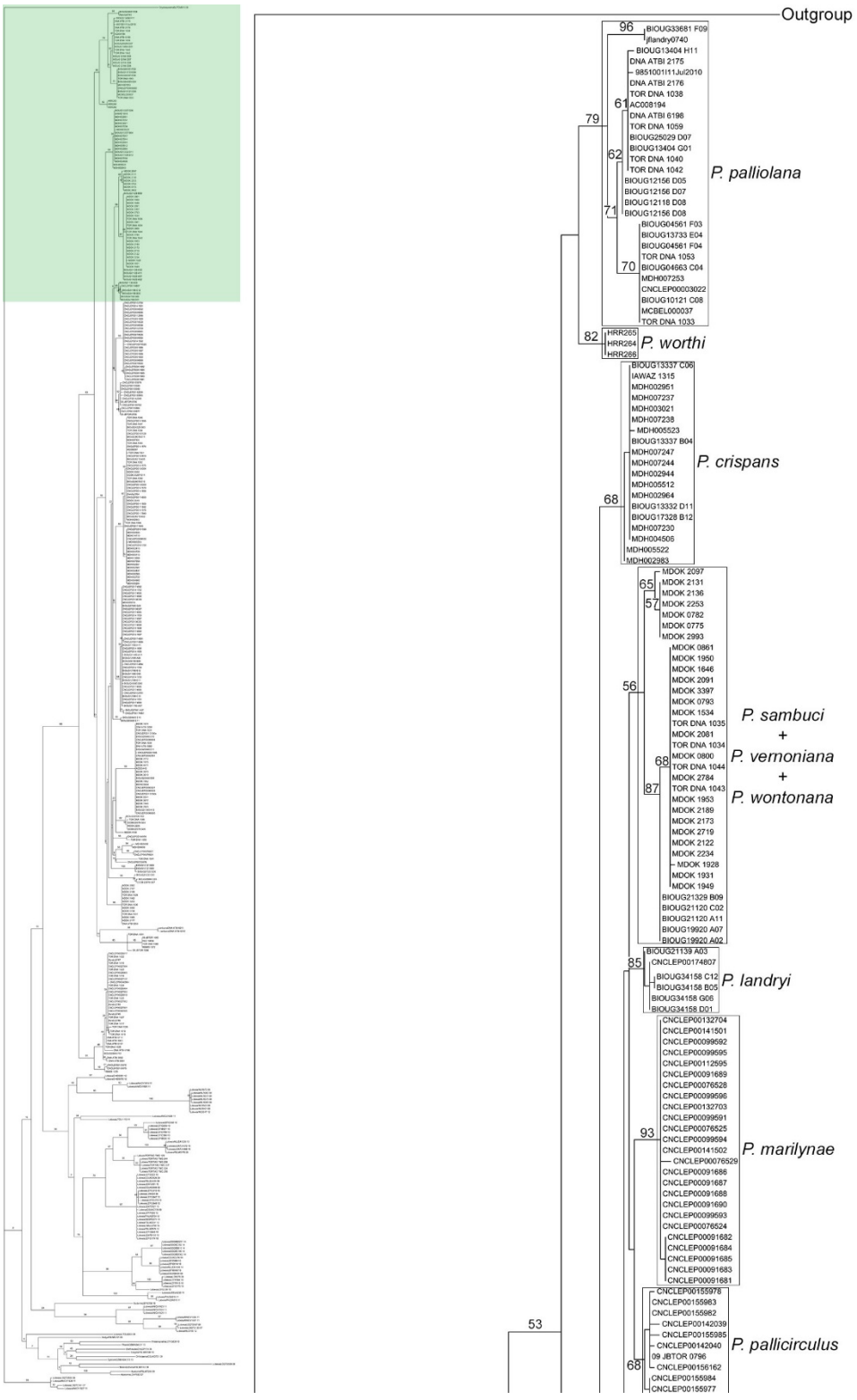
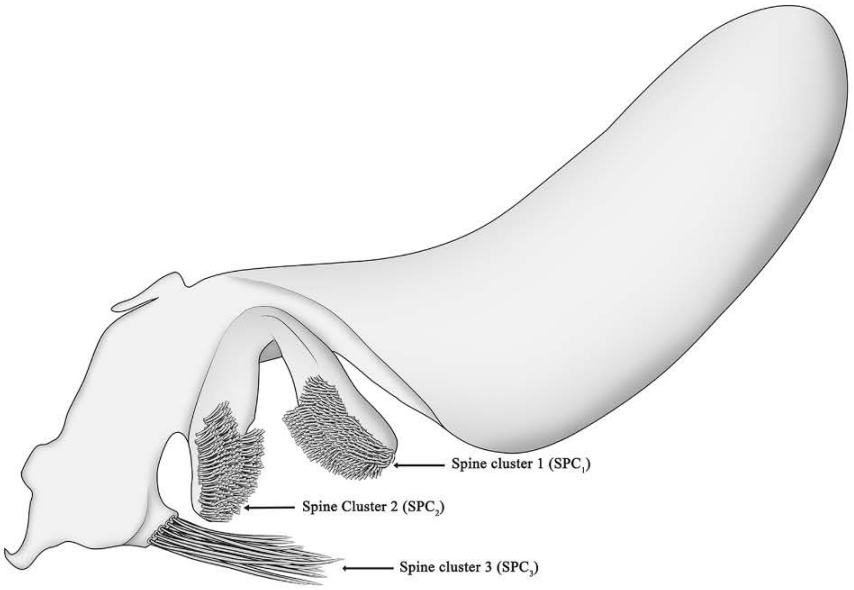


Fig. 26: The results of our maximum likelihood phylogenetic analysis using CO1 sequence data, section 4 of 4.



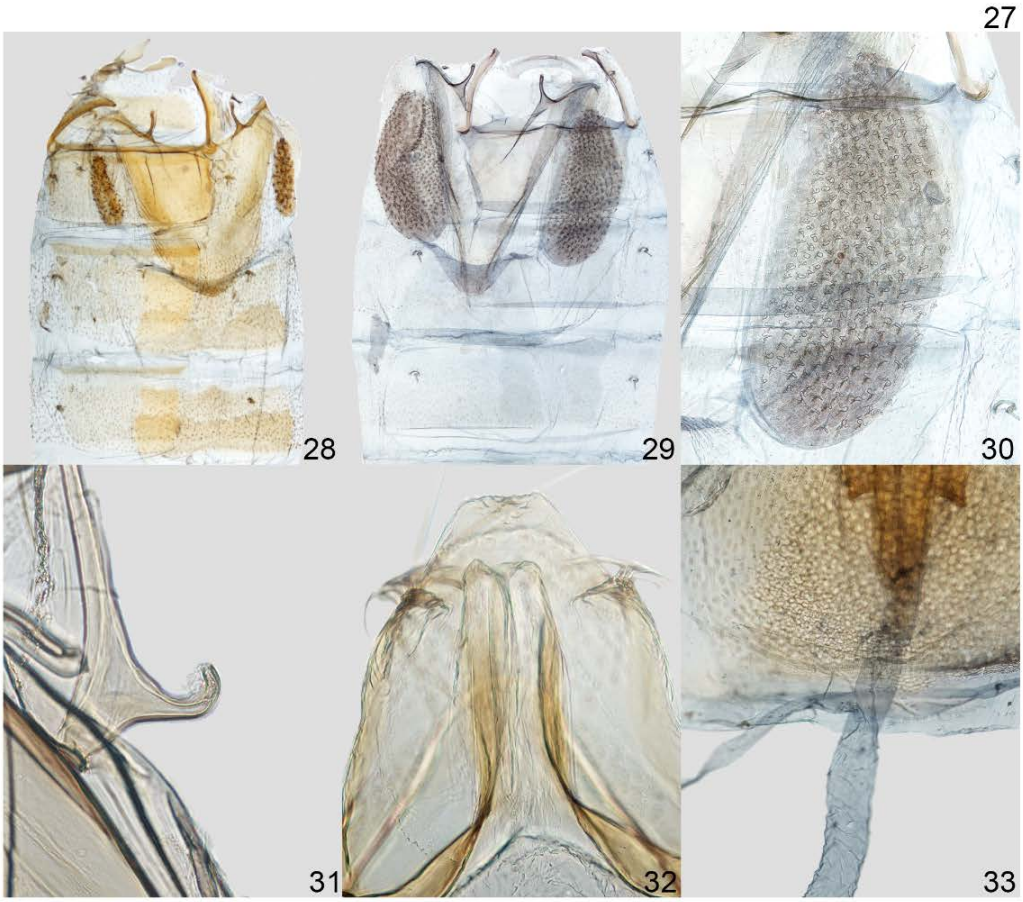


Fig. 27: Valve structure of *Paralobesia* males, showing the three spine clusters on sacculus. Figs. 28-30: Abdominal pockets with modified scales laterally on S2 in the male. Fig. 31: Hooked peduncili for muscle attachment from male tegumen. Fig. 32: Flaplike socii continuous with the teguminal apex. Fig. 33: Inception of the ductus seminalis close to the “neck” of the corpus bursae.

Fig. 34: Flagellomere with single row of scales (*P. viteana*). Fig. 35: Forewing with dark patch of scales at base of dorsum of *P. crassus*. Fig. 36: Weak pterostigma along costal edge of male forewing of *P. liriodendrana*. Fig. 37: Ventral emargination separating cucullus from sacculus. Fig. 38: Sterigma of *P. andereggiana* female seated in membranous pouch behind sternite. Fig. 39: Paired accessory sacs at the anterior end of the corpus bursae of *P. viteana*. Fig. 40: Male hair pencils on hind tibiae *P. parsaurum*.

Fig. 41: *Paralobesia andereggiana* male; Fig. 42: *P. andereggiana* male; Figs. 43–44: *P. andereggiana* females; Fig. 45: *P. parsaurum* male Holotype; Figs. 46–47: *P. parsaurum* males; Fig. 48: *P. parsaurum* female; Fig. 49: *P. magnoliana* male Holotype; Figs. 50–51: *P. magnoliana* males; Fig. 52: *P. magnoliana* female; Fig. 53: *P. liriodendrana* male lectotype; Figs. 54–55: *P. liriodendrana* males.

Fig. 56: *Paralobesia liriodendrana* female; Fig. 57: *P. albiterminana* male holotype; Fig. 58: *P. albiterminana* female; Figs. 59–60: *P. albiterminana* females; Fig. 61: *P. cyclopiana* female holotype; Figs. 62–63: *P. cyclopiana* males; Fig. 64: *P. cyclopiana* female; Fig. 65: *P. carduana* female holotype; Figs. 66–67: *P. carduana* males; Fig. 68: *P. carduana* female; Fig. 69: *P. crassus* male holotype; Fig. 70: *P. crassus* male.

Fig. 71: *Paralobesia crassus* female; Fig. 72: *P. crassus* female; Fig. 73: *P. blandula* male holotype; Figs. 74–75: *P. blandula* males; Fig. 76: *P. blandula* female; Fig. 77: *P. aemulana* male holotype; Figs. 78–80: *P. aemulana* females; Fig. 81: *P. viteana* female; Fig. 82: *P. viteana* male; Fig. 83: *P. viteana* female; Fig. 84: *P. monotropana* male holotype; Fig. 85: *P. monotropana* male.

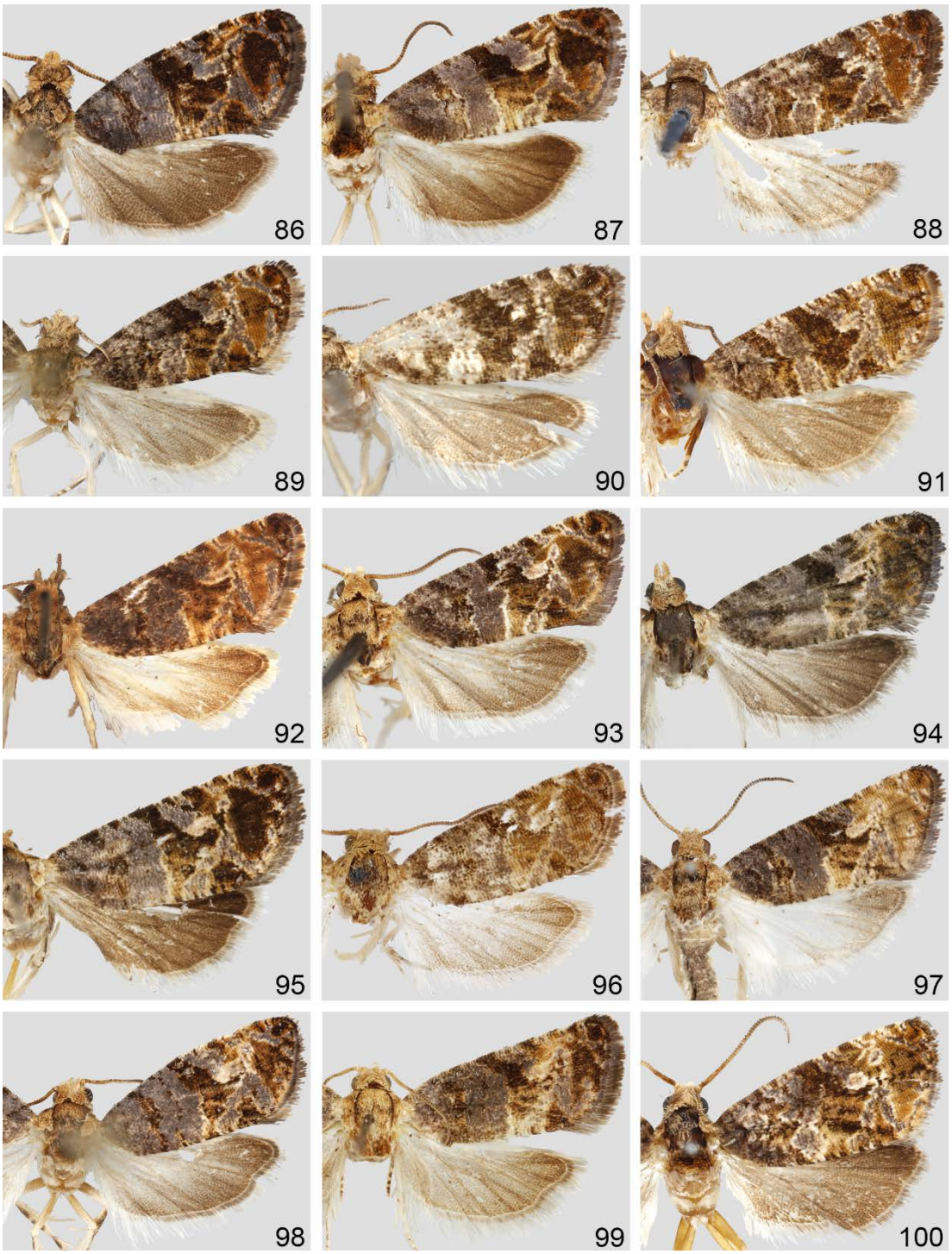


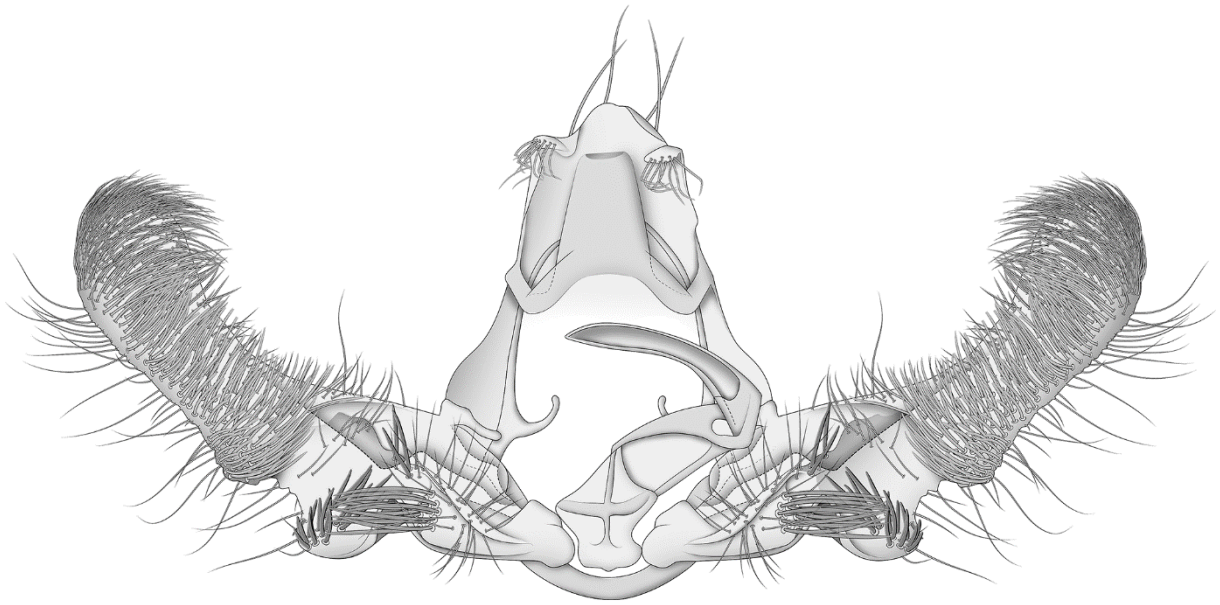
Fig. 86: *Paralobesia monotropana* male; Fig. 87: *P. monotropana* female; Fig. 88: *P. spiraeifoliana* male holotype; Figs. 89–90: *P. spiraeifoliana* males; Fig. 91: *P. spiraeifoliana* female; Fig. 92: *P. cypripediana* male holotype; Fig. 93: *P. cypripediana* male; Figs. 94–95: *P. cypripediana* females; Fig. 96: *P. rhoifructana* male holotype; Fig. 97: *P. rhoifructana* male; Figs. 98–99: *P. rhoifructana* females; Fig. 100: *P. pallicirculus* male holotype.

Fig. 101: *Paralobesia pallicirculus* male; Figs. 102–103: *P. pallicirculus* females; Fig. 104: *P. marilynae* male holotype; Figs. 105–106: *P. marilynae* males; Fig. 107: *P. wontonana* female holotype; Fig. 108: *P. wontonana* male (wing mount); Fig. 109: *P. venoniana* male lectotype; Fig.110: *P. ambrosiana* male lectotype; Figs. 111–112: *P. vernoniana* males; Fig. 113: *P. sambuci* male holotype; Figs. 114–115: *P. sambuci* males.

Fig. 116: *Paralobesia sambuci* female; Fig. 117: *P. crispans* male holotype; Fig. 118: *P. crispans* male; Figs 119–120: *P. crispans* females; Fig. 121: *P. worthi* male holotype; Fig. 122: *P. worthi* male; Figs. 123–124: *P. worthi* females; Fig. 125: *P. palliolana* female holotype; Figs. 126–127: *P. palliolana* males; Figs. 128–129: *P. palliolana* female; Fig.130: *P. exasperana* female holotype.

Fig. 131: *Paralobesia* exasperana male; Fig. 132: *P. exasperana* male; Fig. 133: *P. exasperana* female; Fig. 134: *P.* piperana male holotype; Figs. 135–137: *P. piperana* males; Fig. 138: *P. slingerlandana* female holotype; Figs. 139–141: *P. slingerlandana* females; Fig. 142: *P. yaracana* male holotype; Figs. 143–144: *P. yaracana males*; Fig. 145: *P. yaracana* female.

Fig. 146: *Paralobesia kearfotti* male holotype; Figs. 147–149: *P. kearfotti* males; Fig. 150: *P. hodgesi* male holotype; Fig. 151: *P.* glenni male holotype; Figs. 152–153: *P. glenni* males; Fig. 154: *P. aruncana* male holotype; Fig. 155: *P. aruncana* male; Figs. 156–157: *P. aruncana females.*



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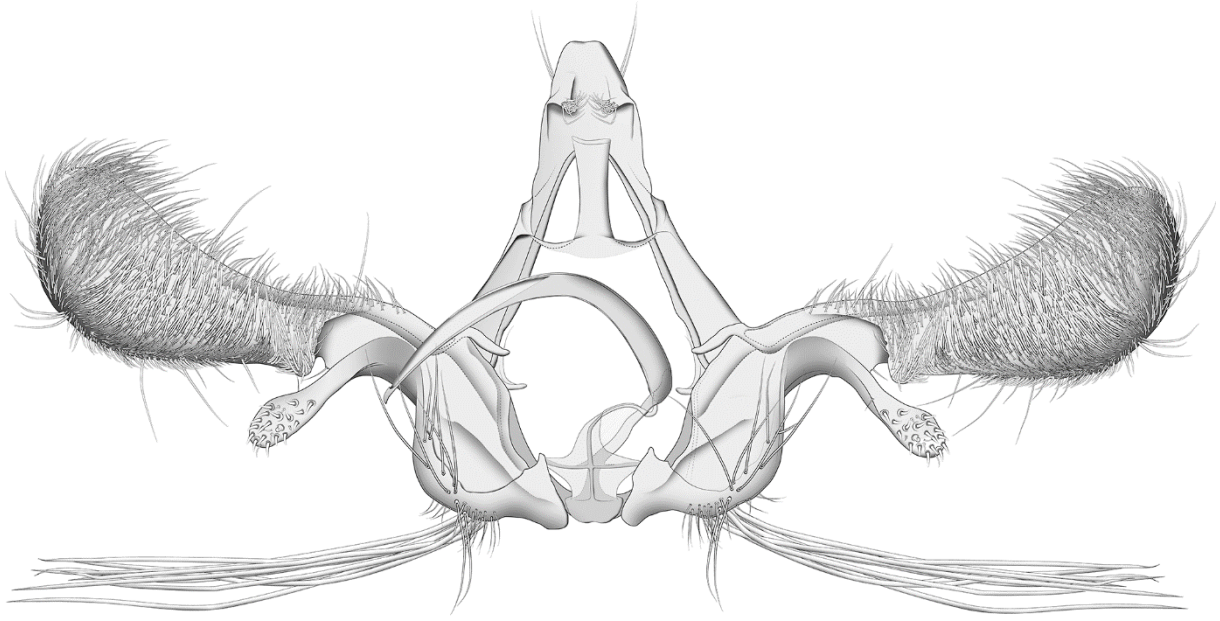

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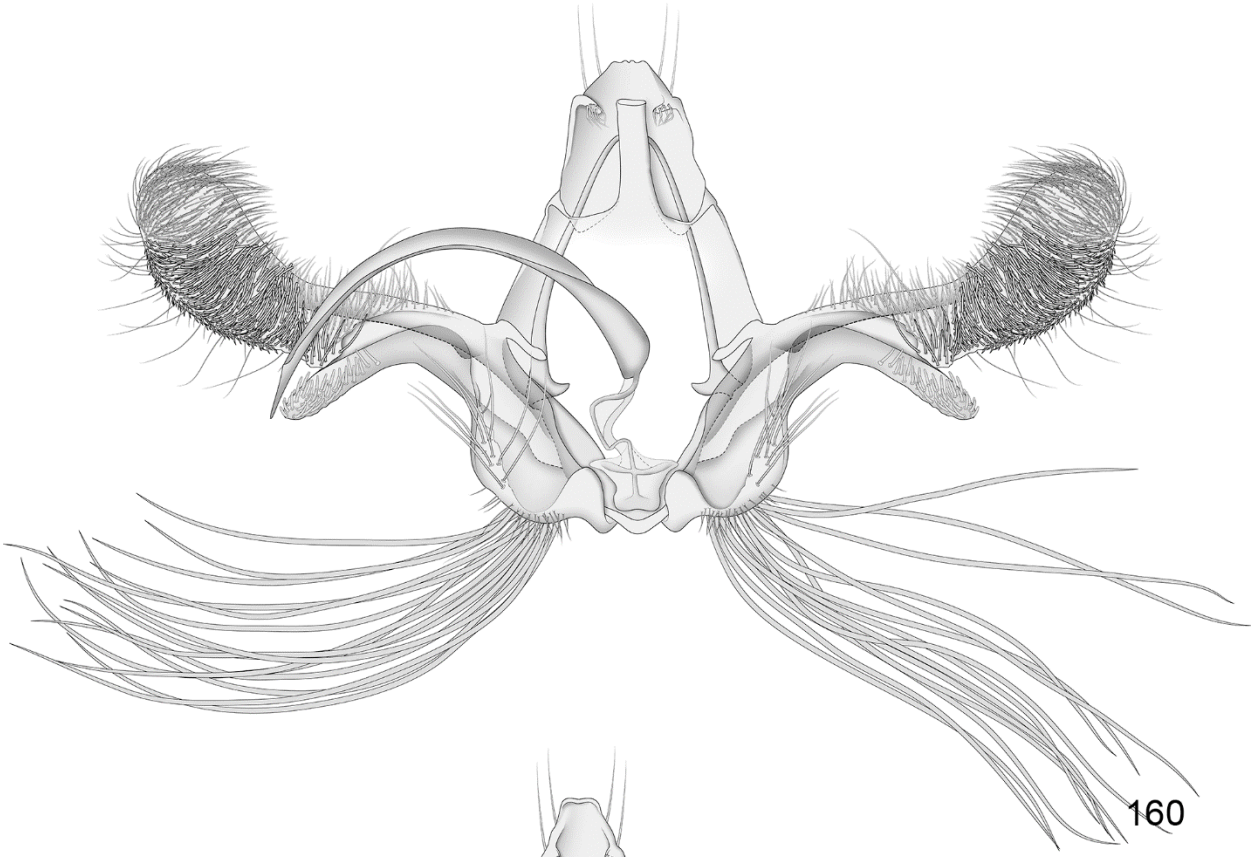
Fig. 158: male genitalia of *Paralobesia andereggiana*; Fig. 159: male genitalia of *P. parsaurum.*



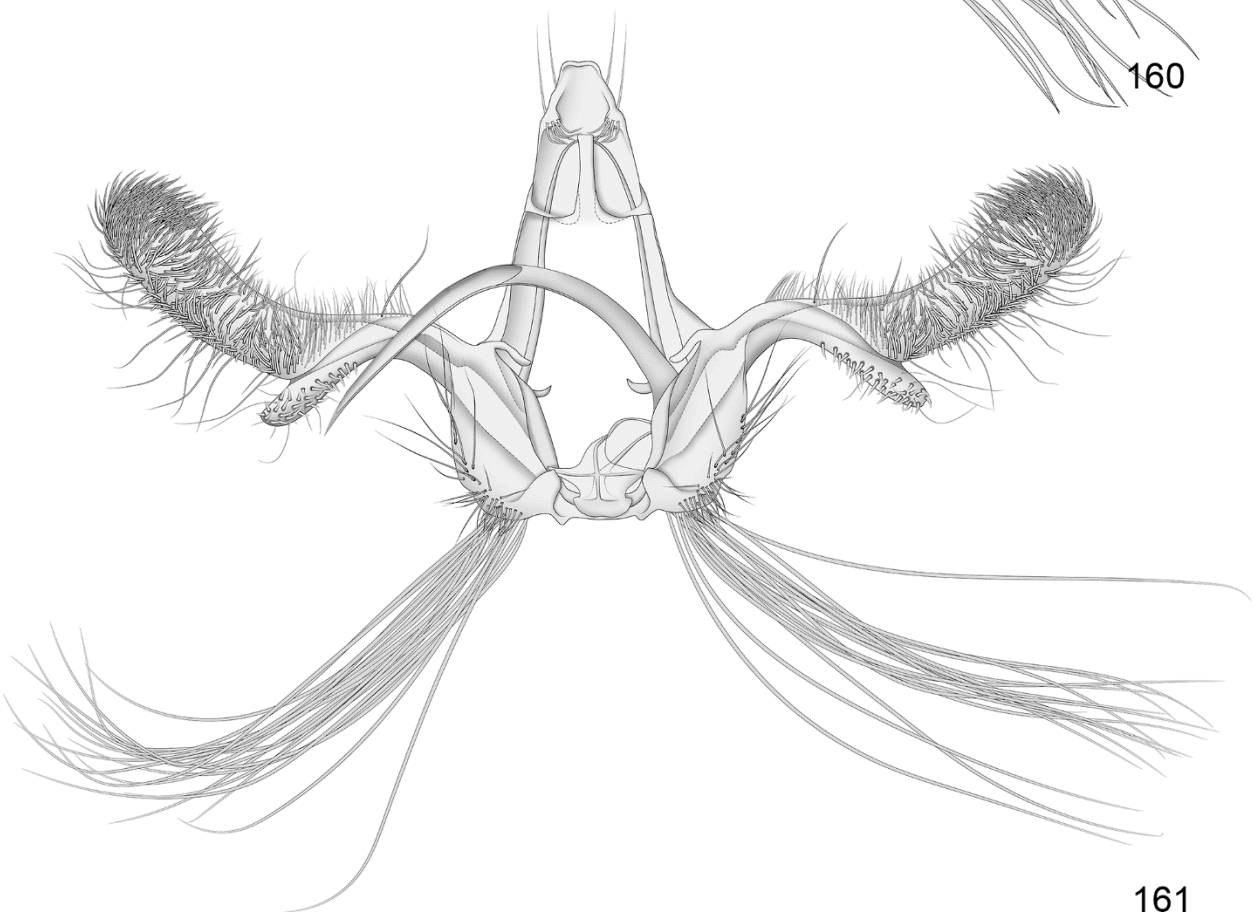
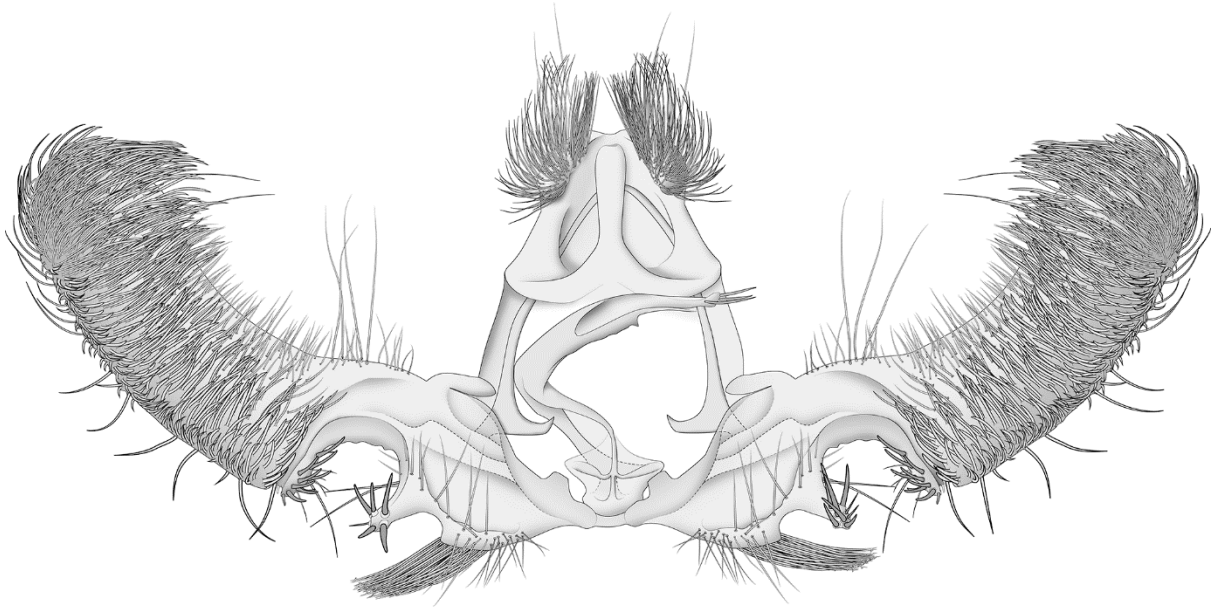


Fig. 160: male genitalia of *Paralobesia magnoliana*; Fig. 161: male genitalia of *P. liriodendrana.*



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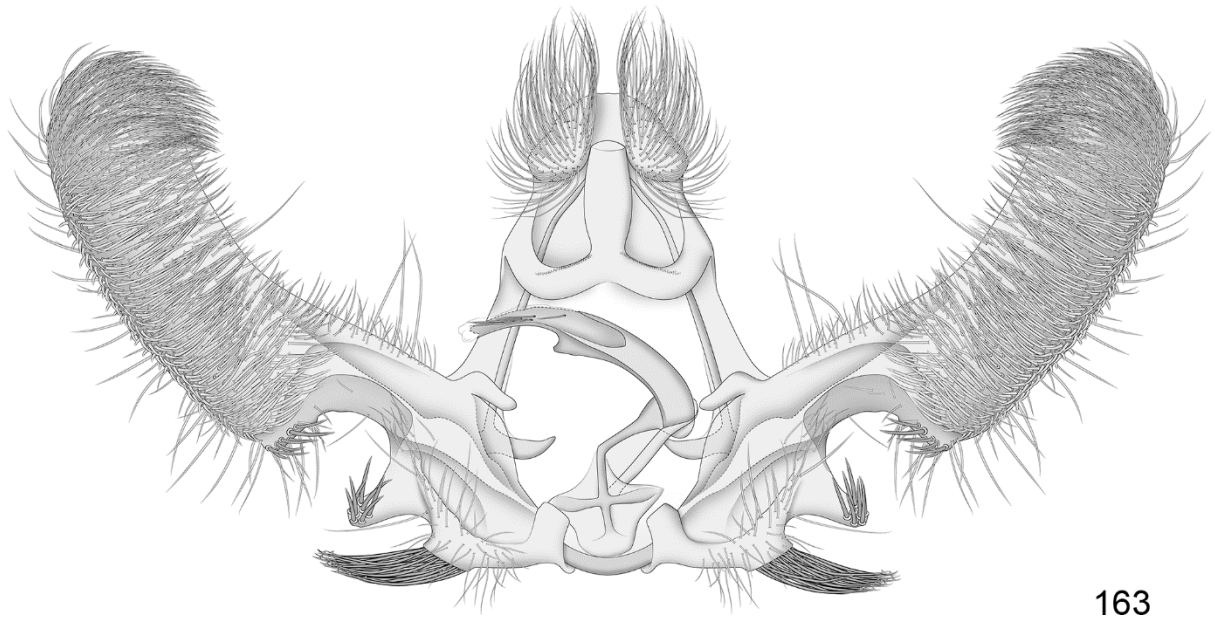

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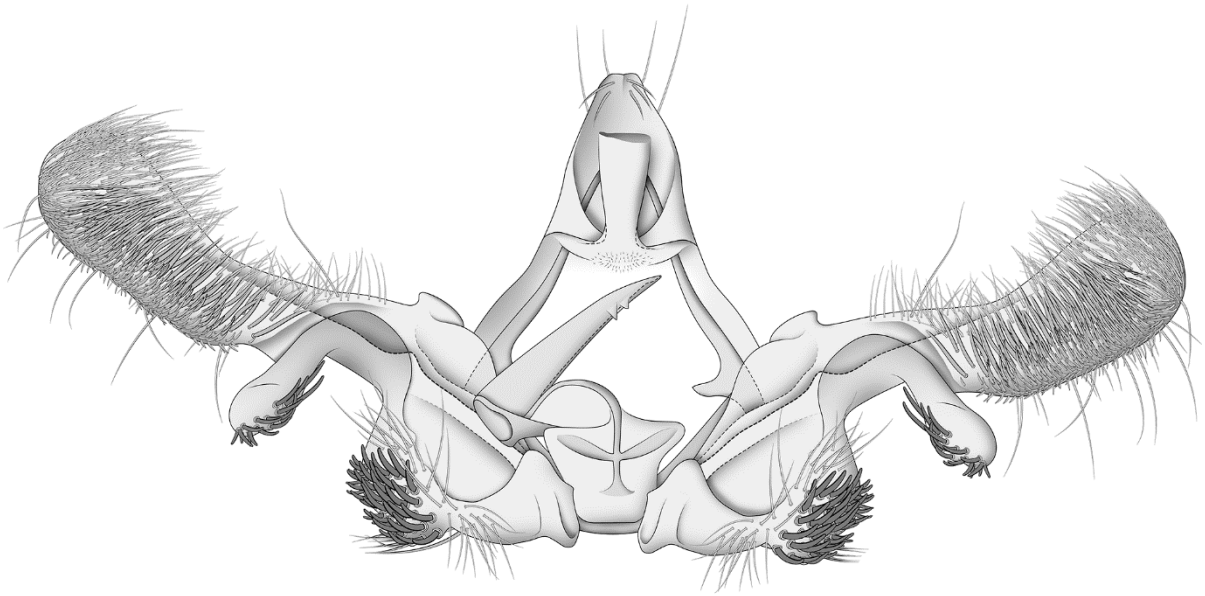
Fig. 162: male genitalia of *Paralobesia albiterminana*; Fig. 163: male genitalia of *P. cyclopiana.*



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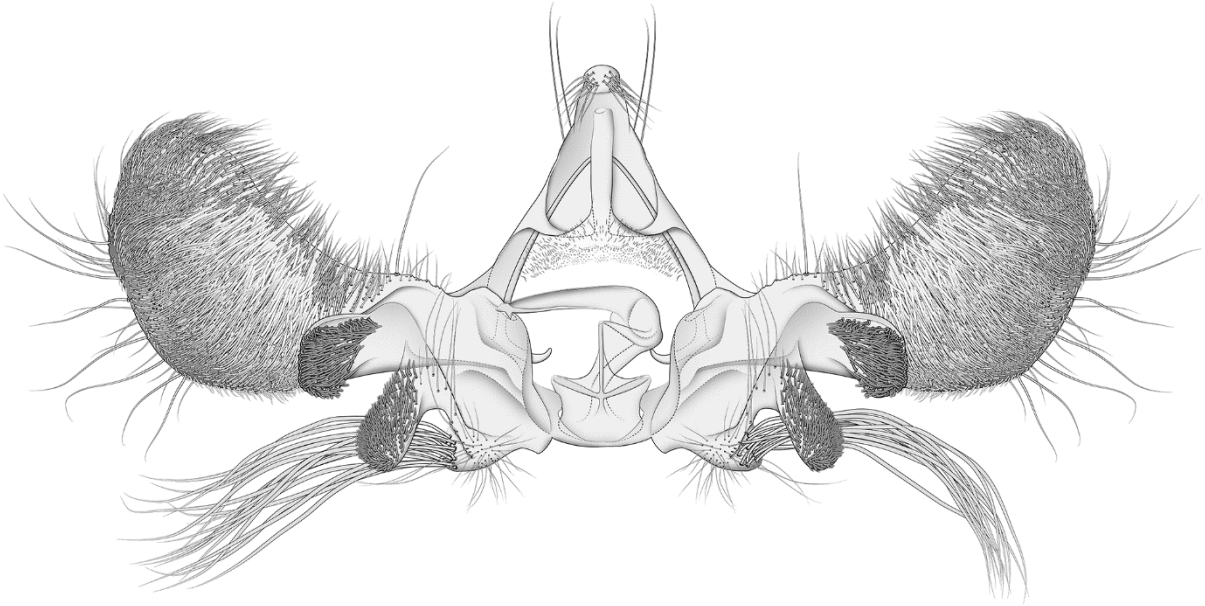

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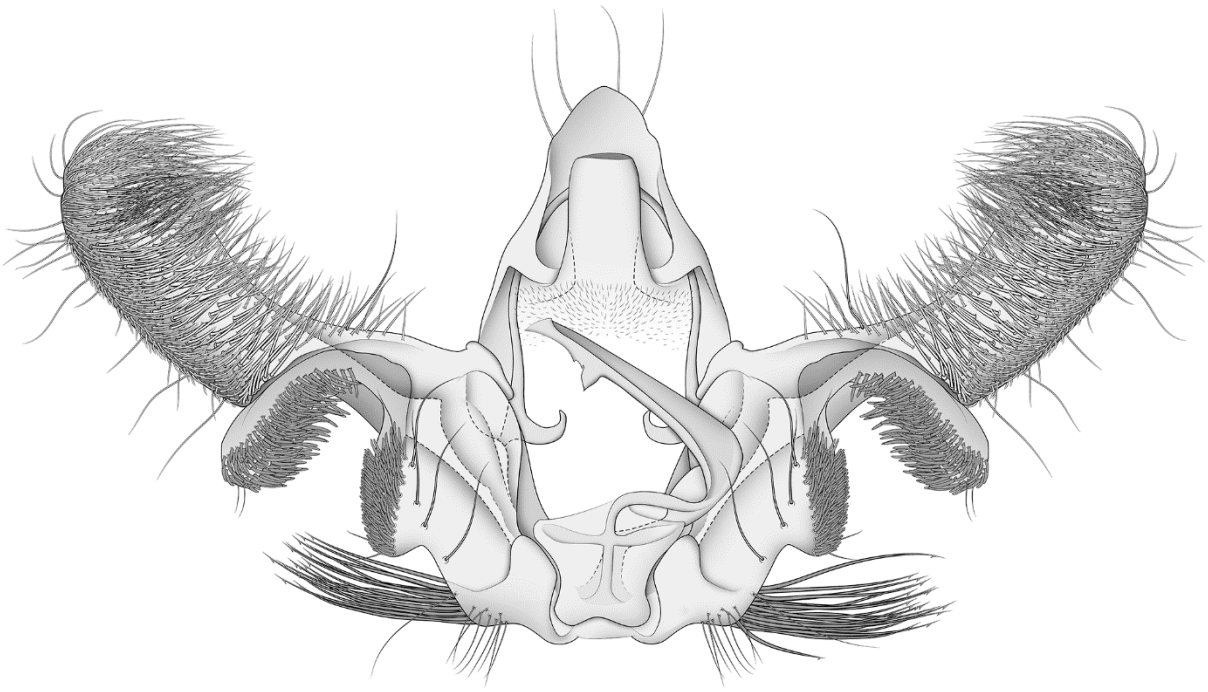
Fig. 164: male genitalia of *Paralobesia carduana*; Fig. 165: male genitalia of *P. crassus.*



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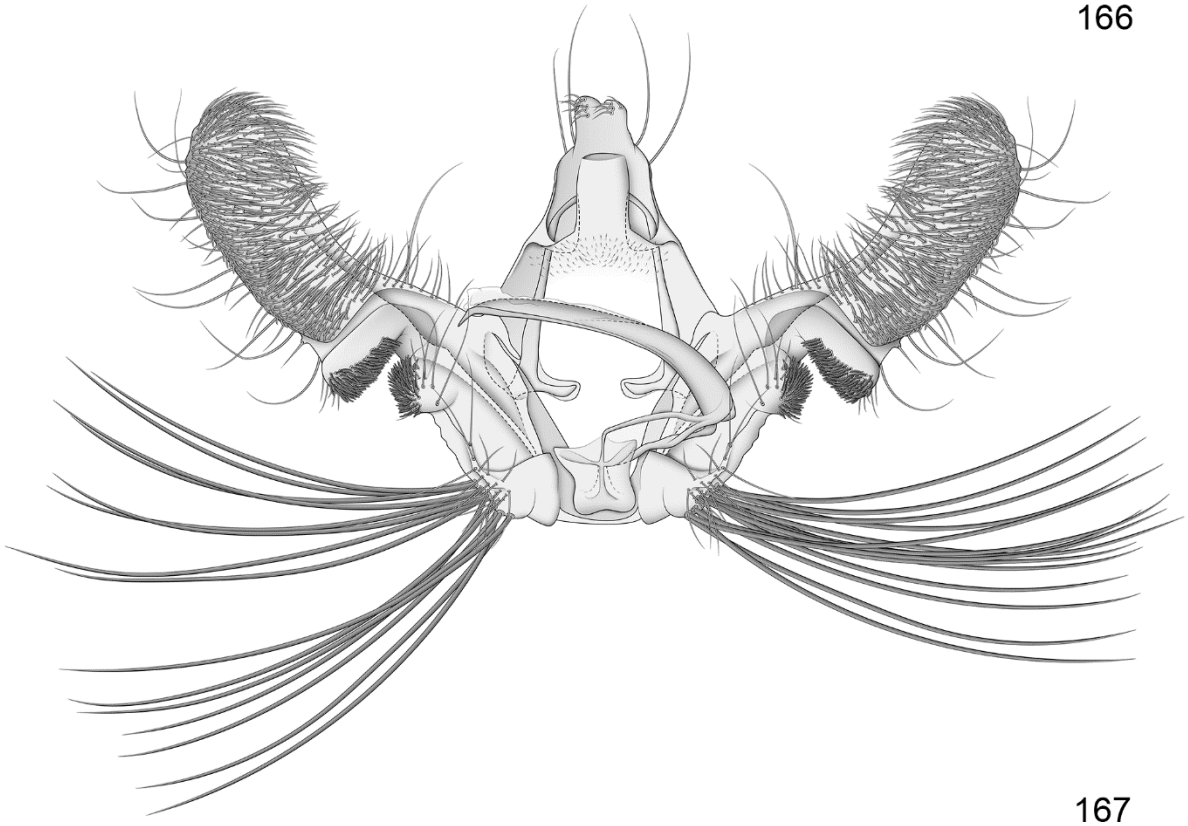

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Fig. 166: male genitalia of *Paralobesia blandula*; Fig. 167: male genitalia of *P. aemulana.*

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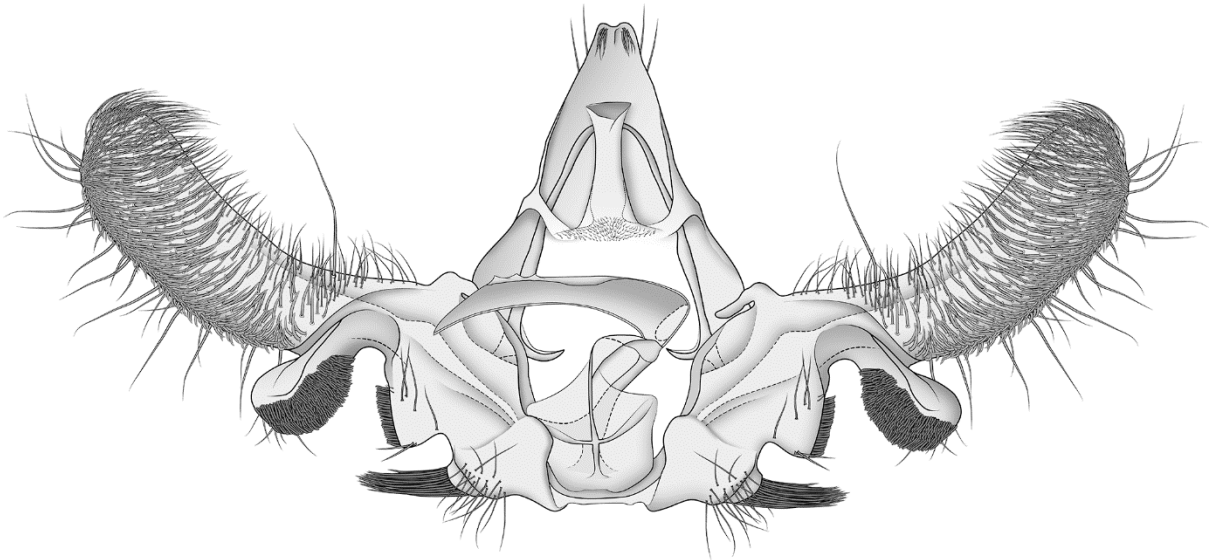

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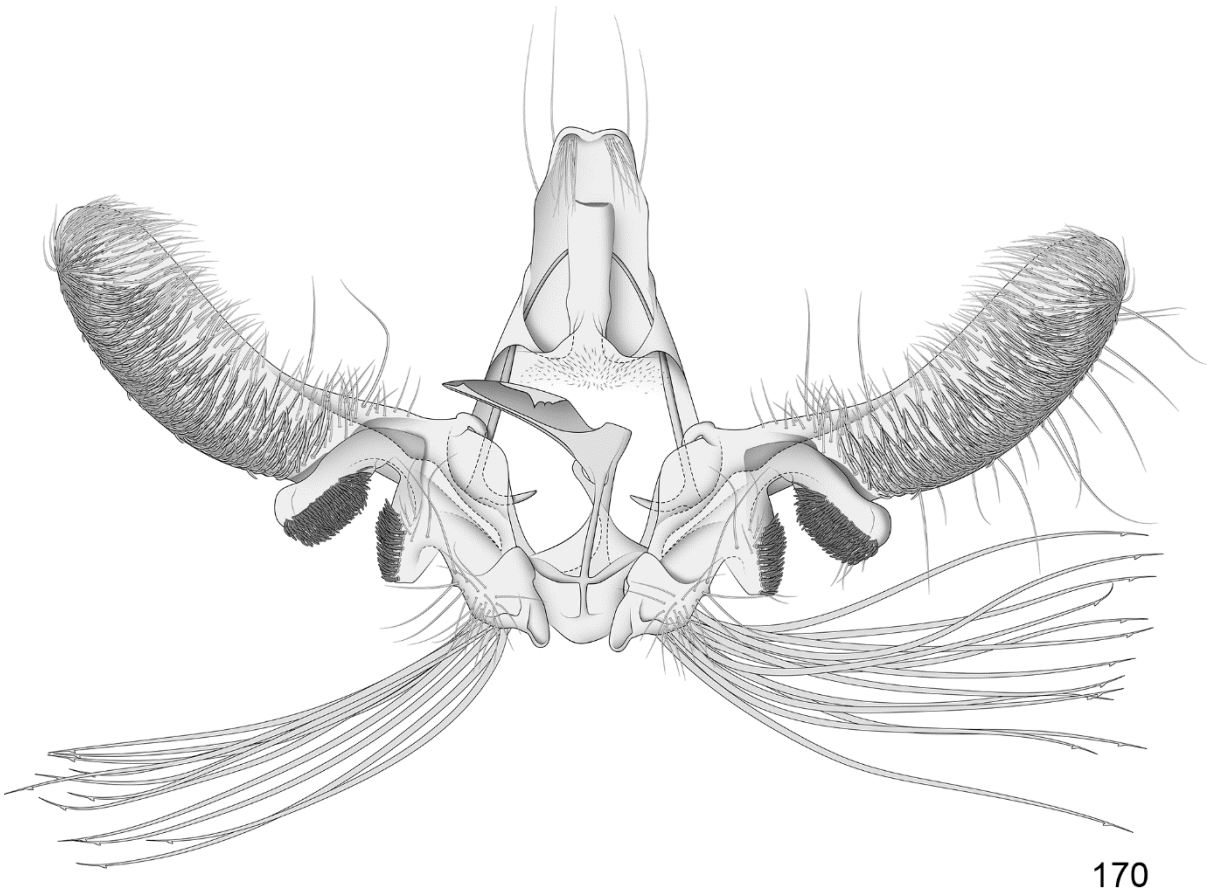
Fig. 168: male genitalia of *Paralobesia viteana*; Fig. 169: male genitalia of *P. monotropana.*



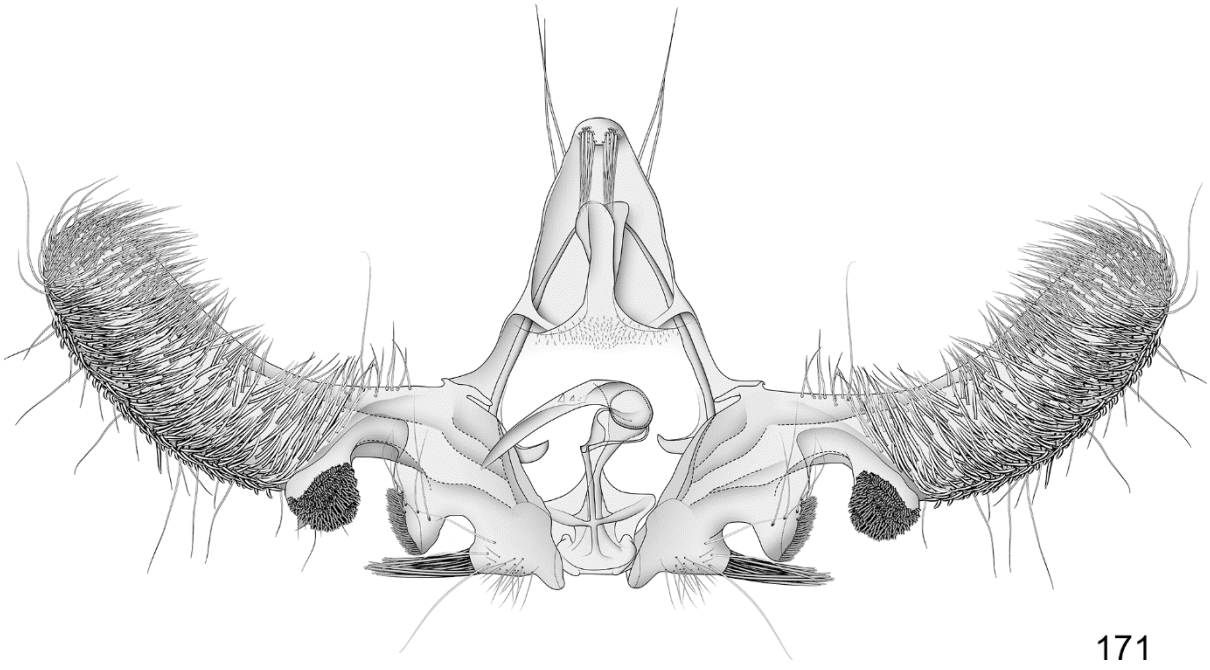
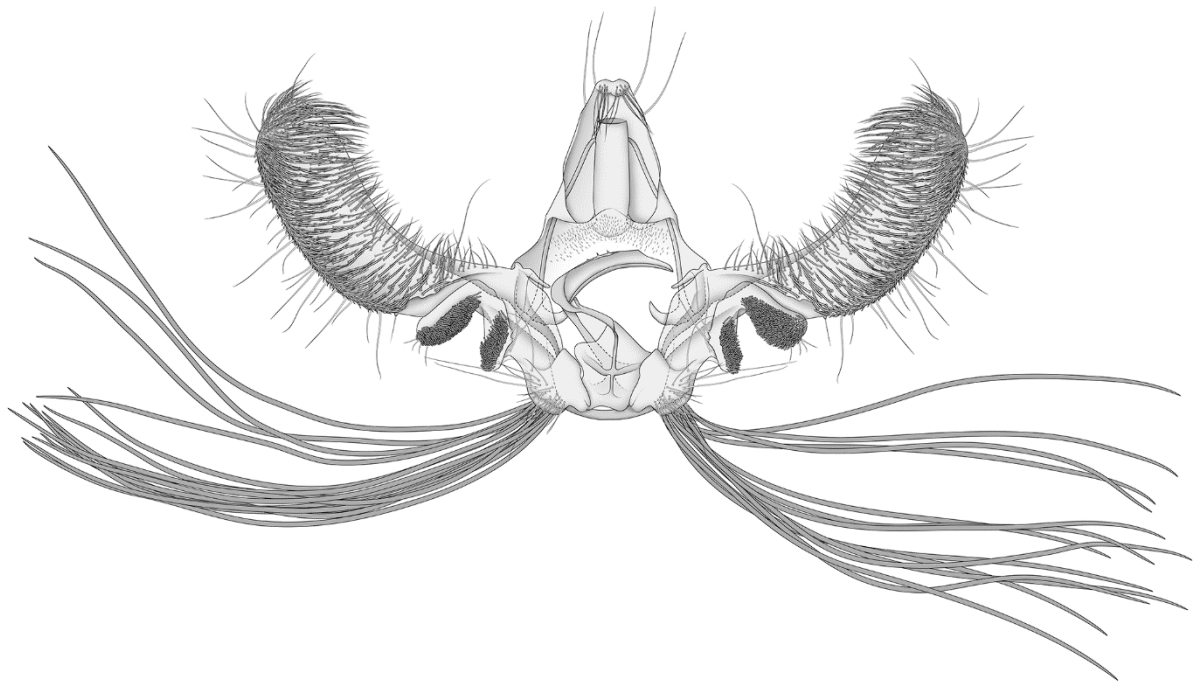


Fig. 170: male genitalia of *Paralobesia spiraeifoliana*; Fig. 171: male genitalia of *P. cypripediana.*



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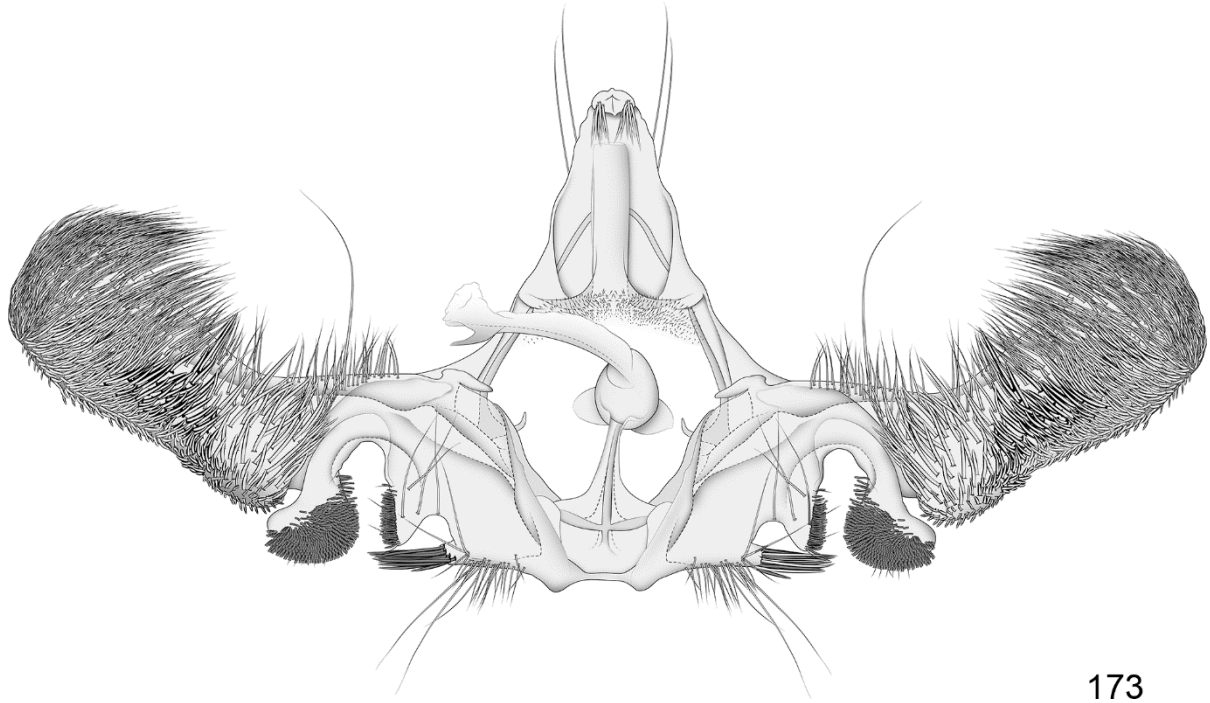

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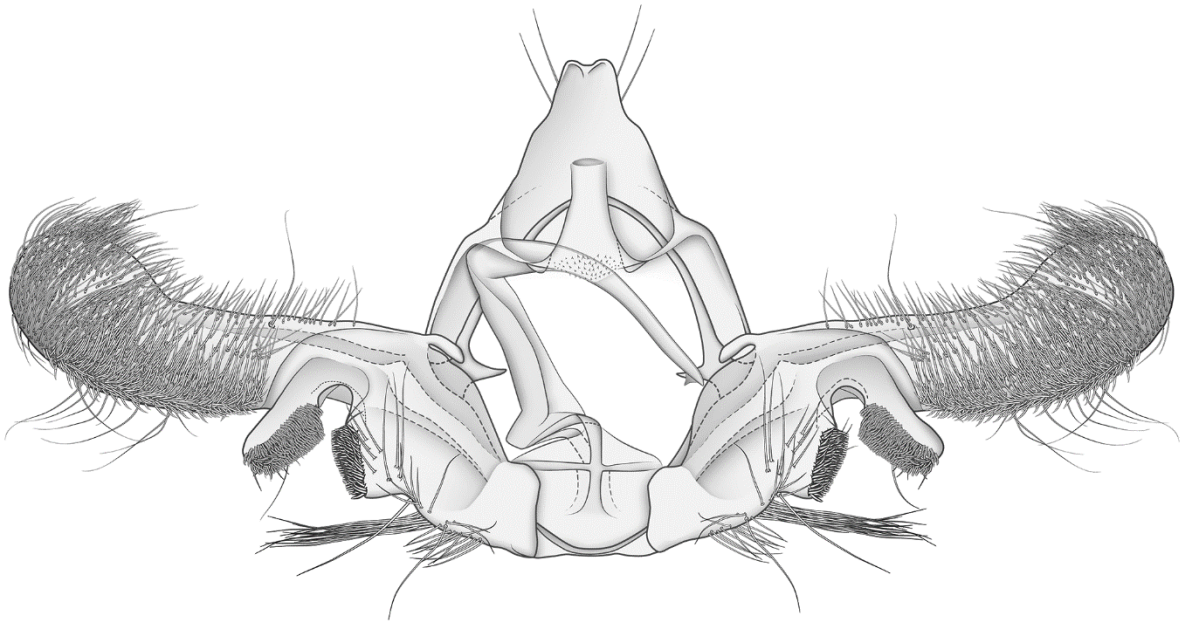
Fig. 172: male genitalia of *Paralobesia rhoifructana*; Fig. 173: male genitalia of *P. pallicirculus.*



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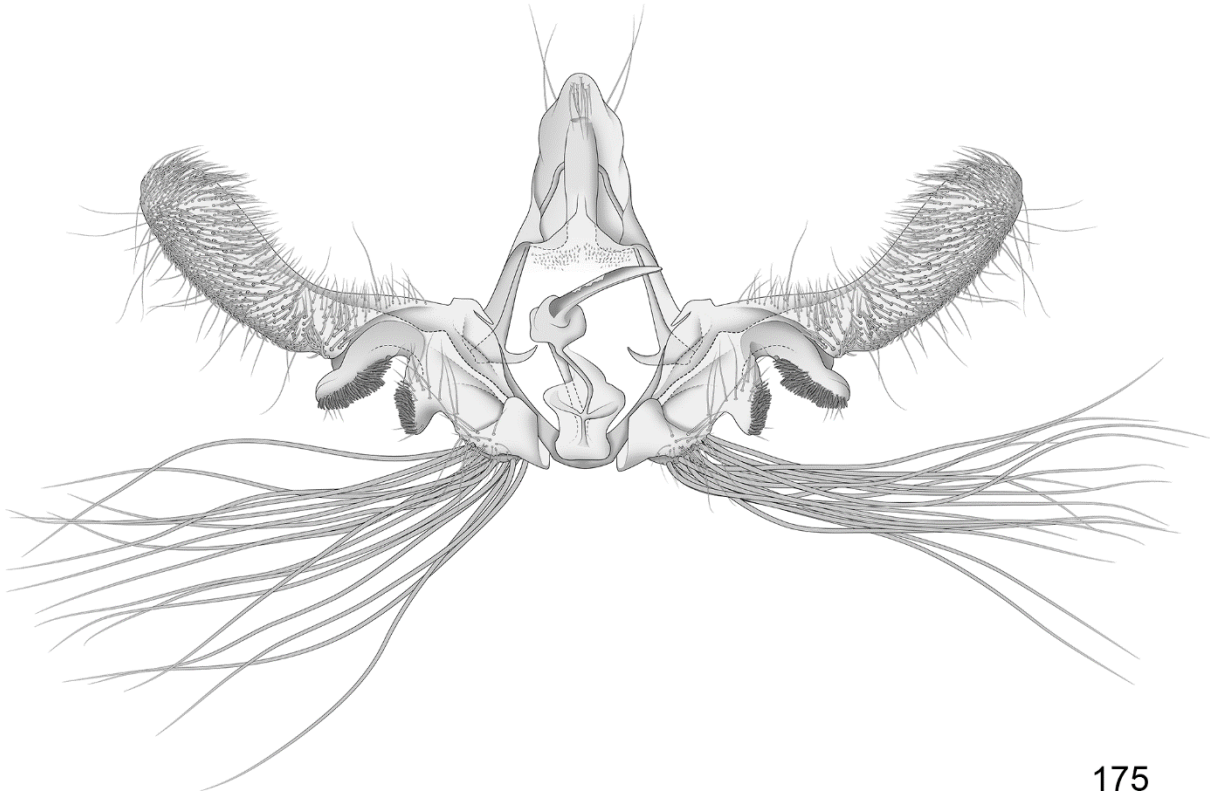

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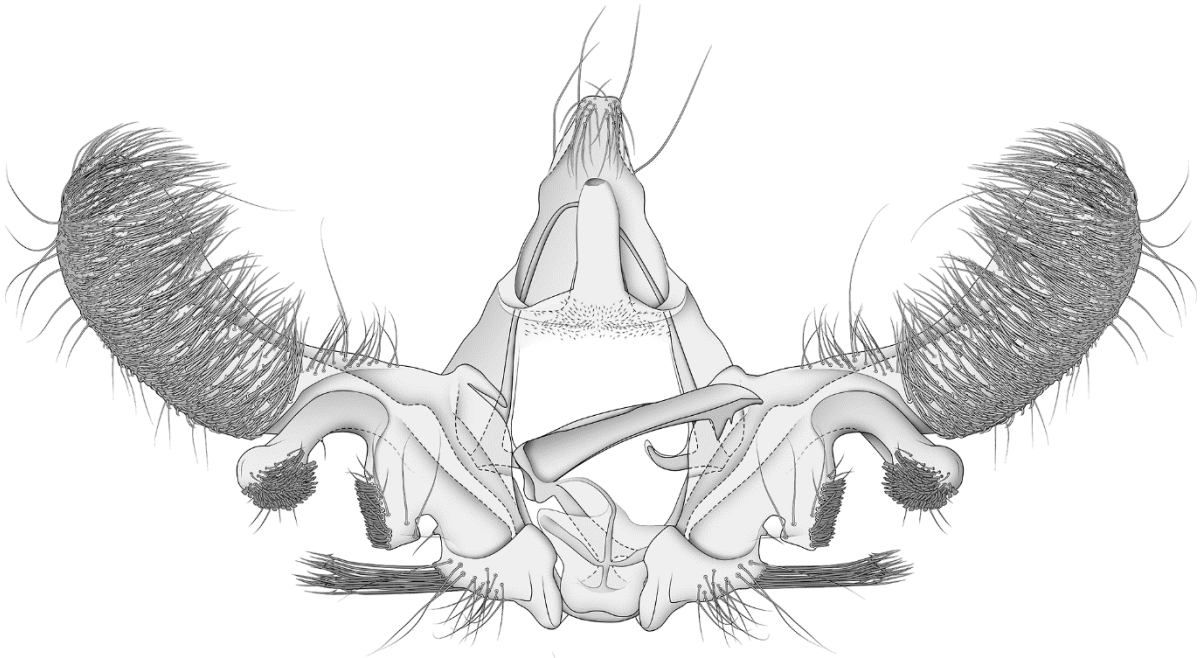
Fig. 174: male genitalia of *Paralobesia marilynae*; Fig. 175: male genitalia of *P. landryi.*



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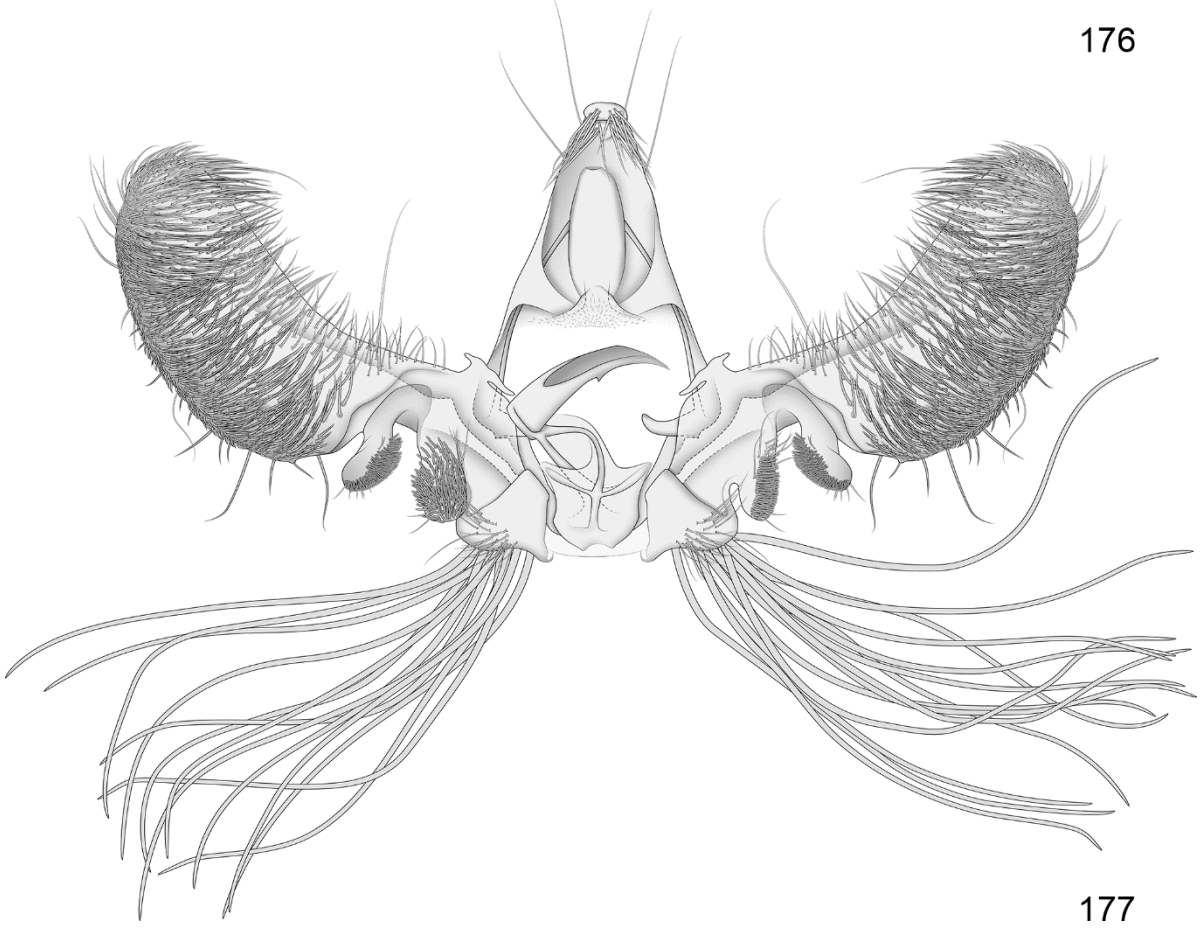

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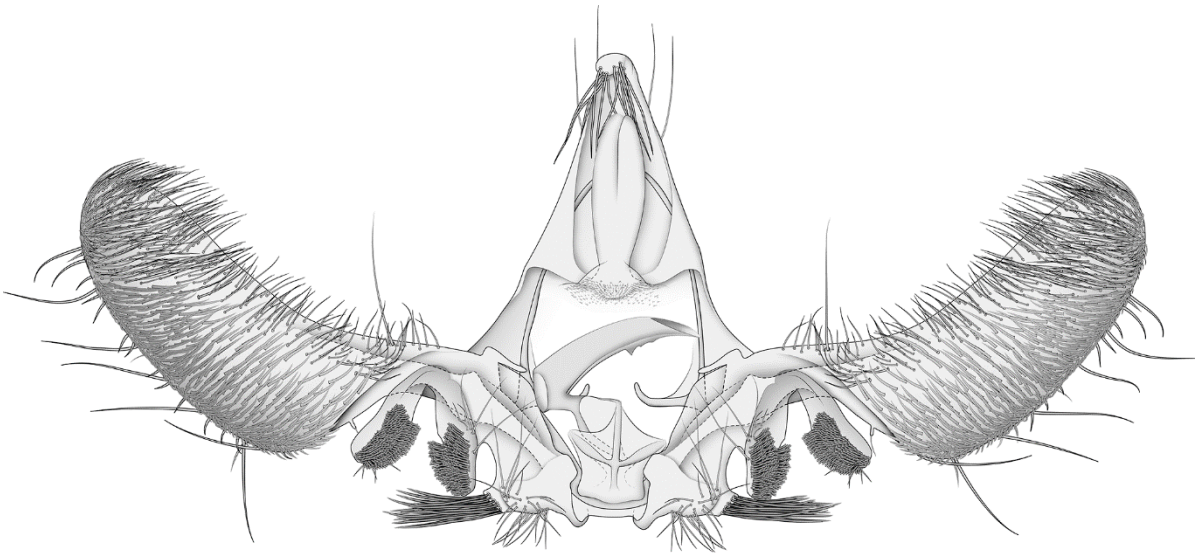
Fig. 176: male genitalia of *Paralobesia wontonana*; Fig. 177: male genitalia of *P. venoniana.*



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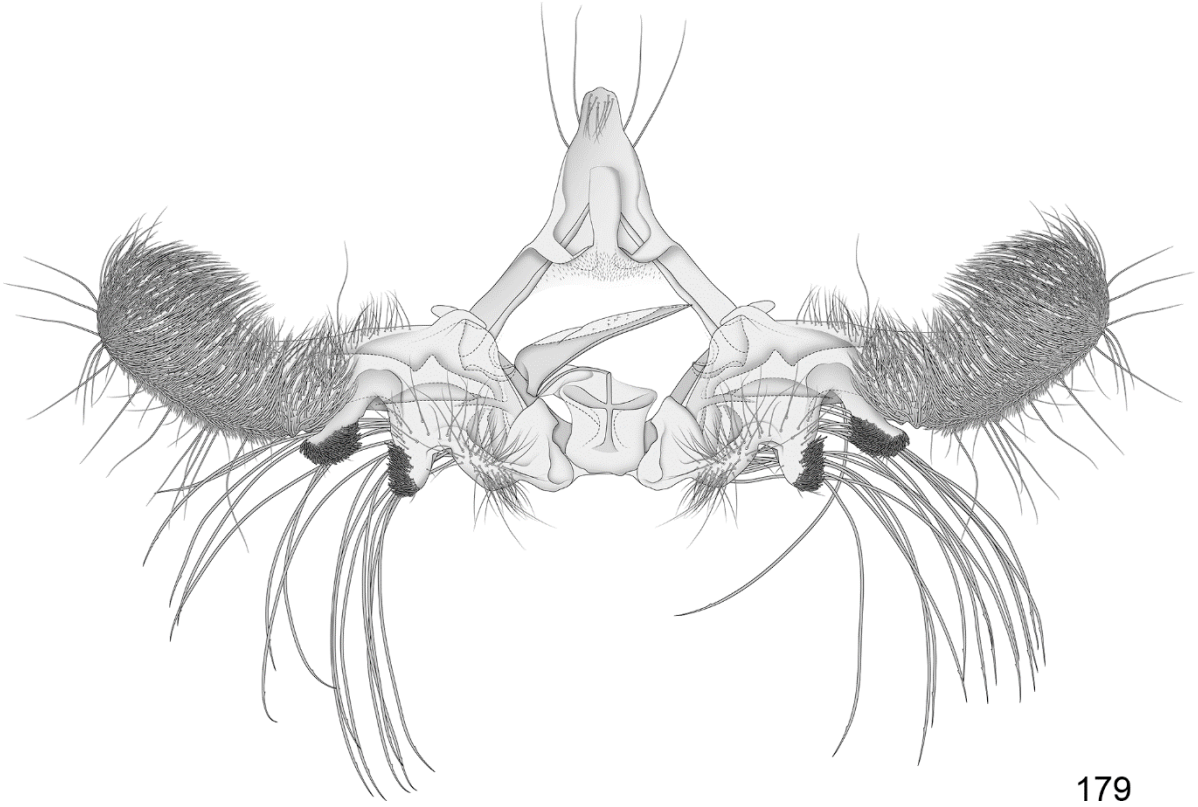

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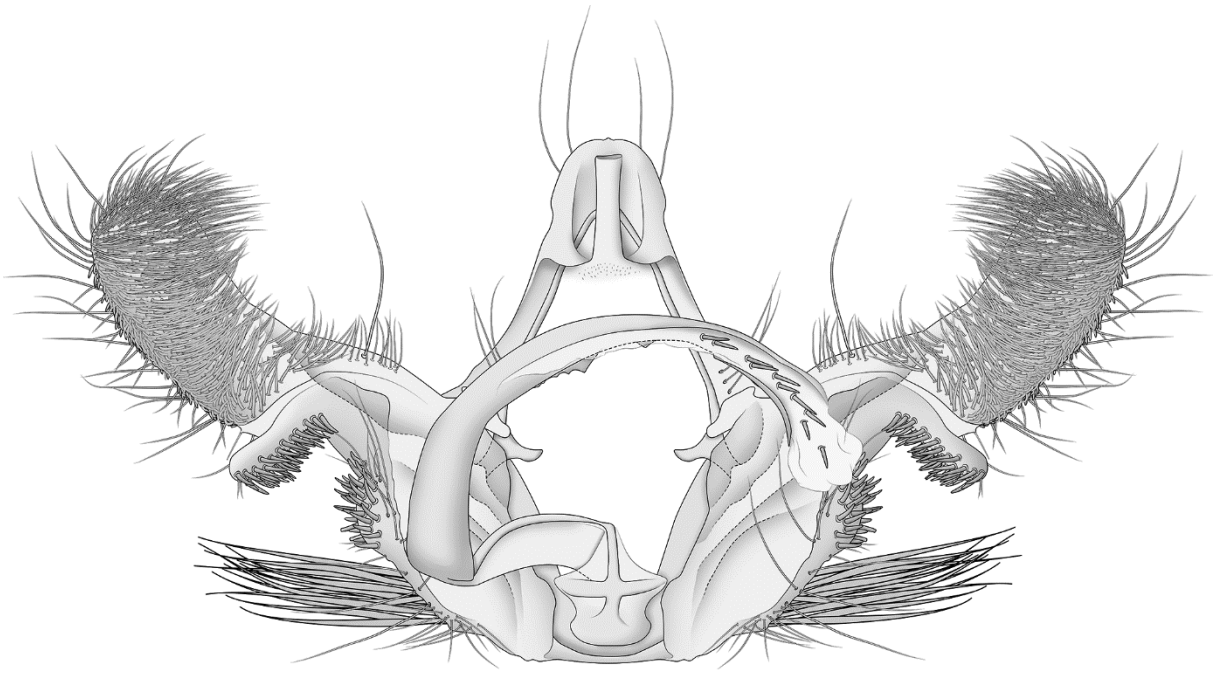
Fig. 178: male genitalia of *Paralobesia sambuci*; Fig. 179: male genitalia of *P. crispus.*



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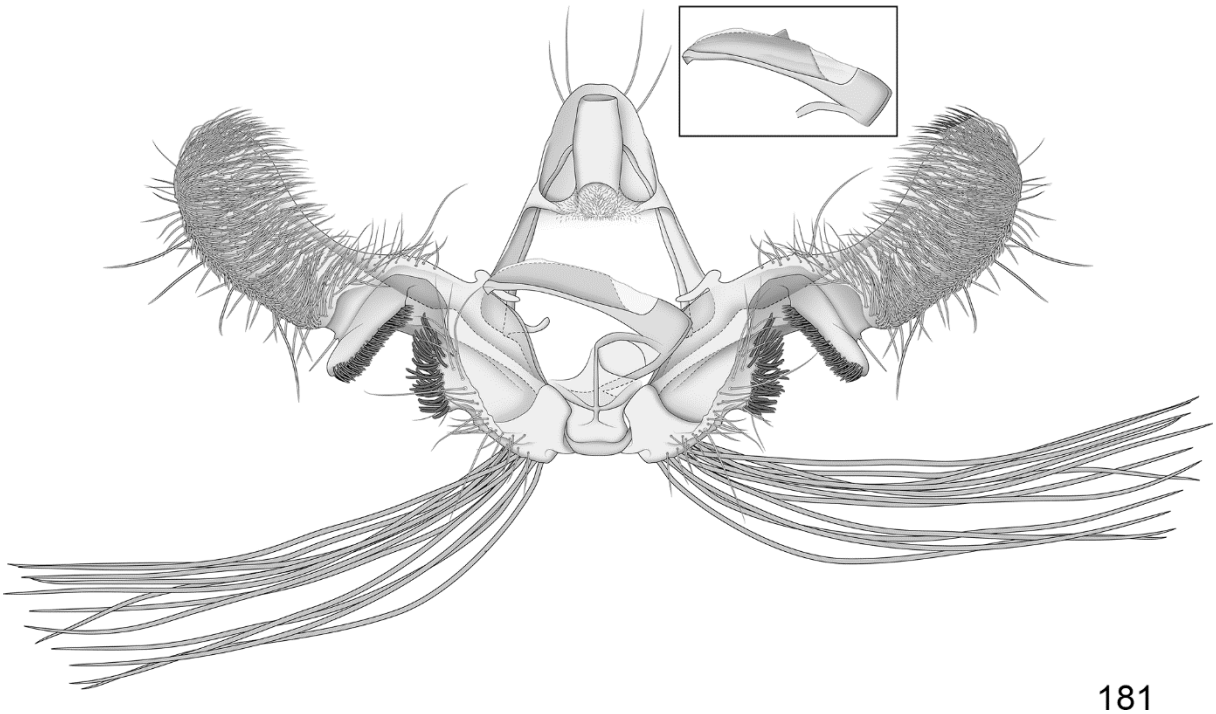

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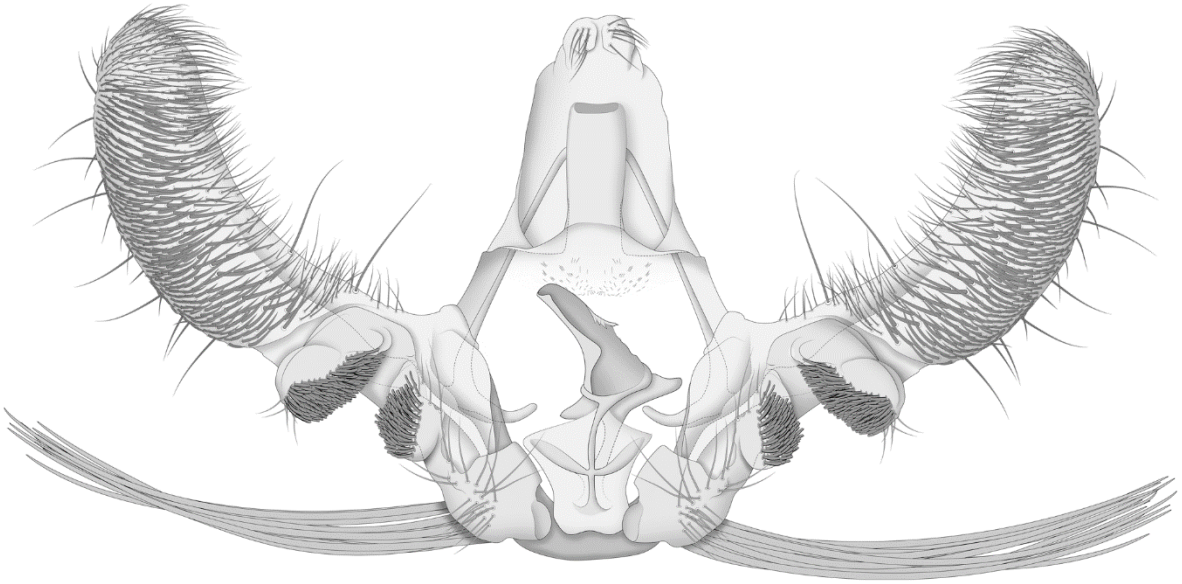
Fig. 180: male genitalia of *Paralobesia worthi*; Fig. 181: male genitalia of *P. palliolana.*



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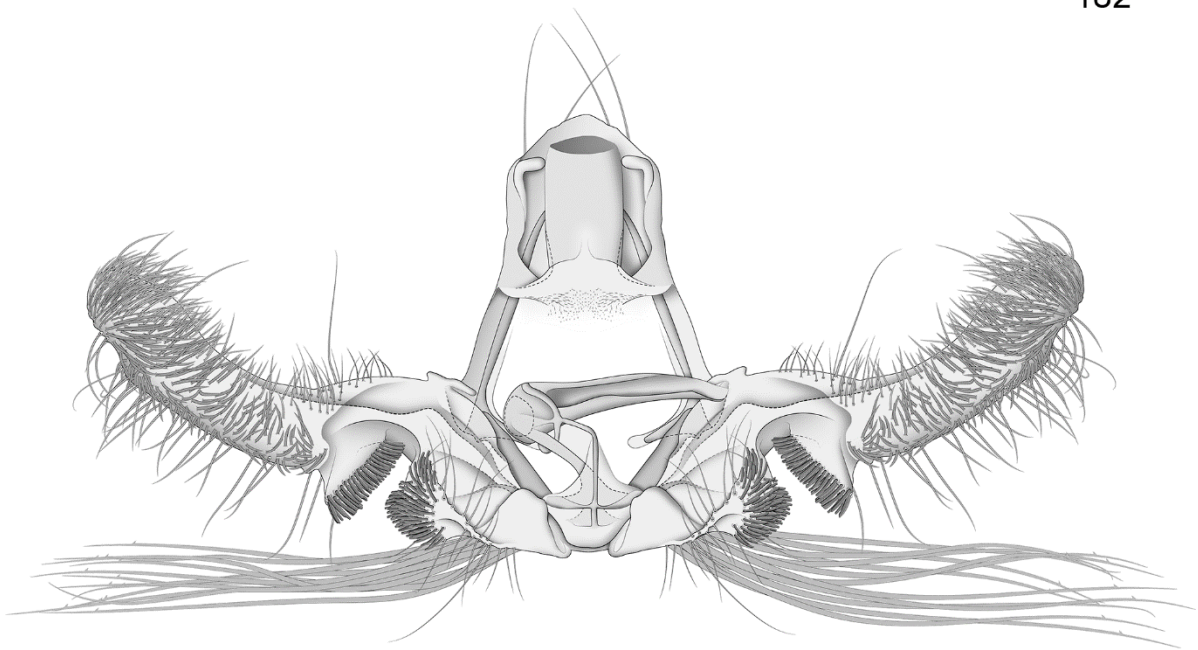

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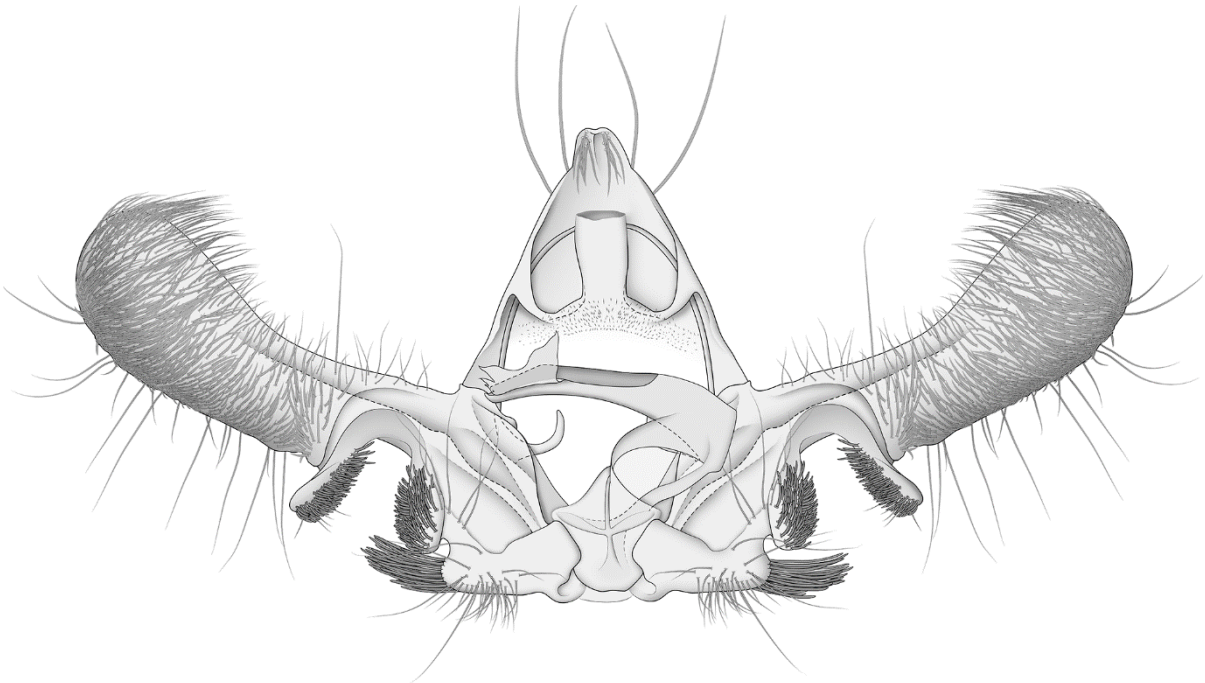
Fig. 182: male genitalia of *Paralobesia exasperana*; Fig. 183: male genitalia of *P. piperana.*



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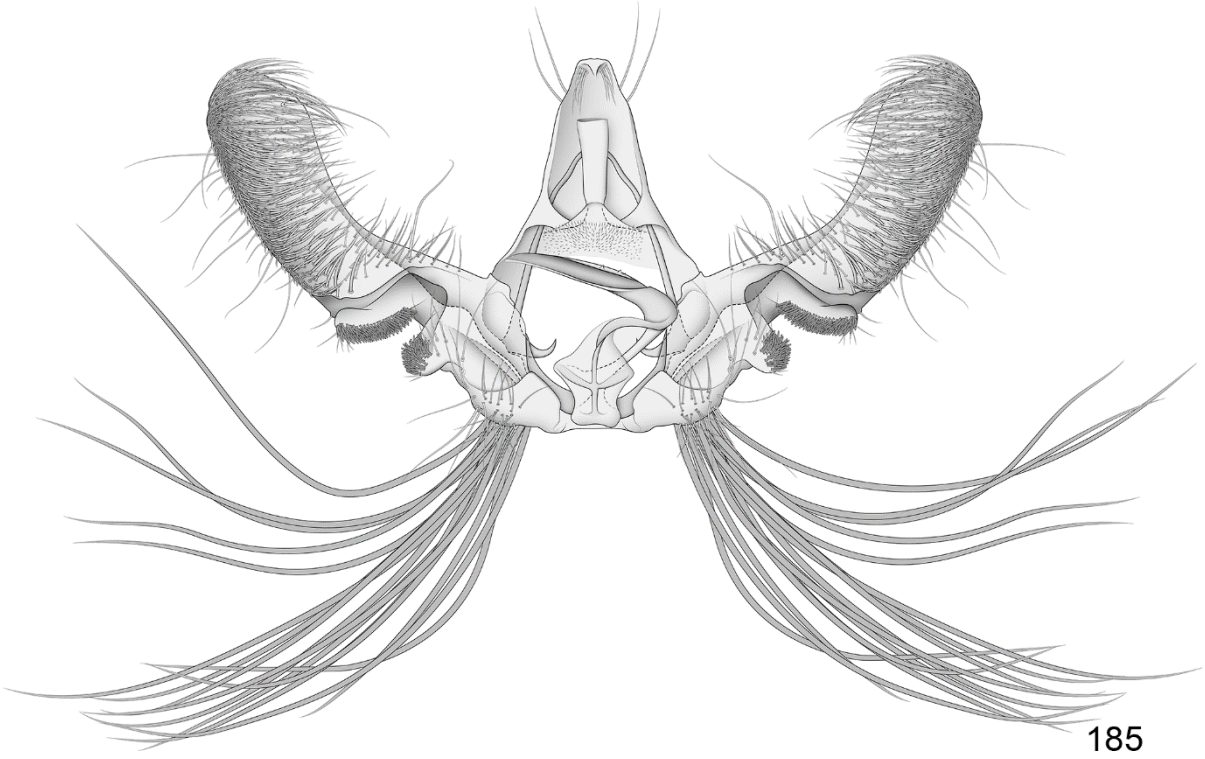

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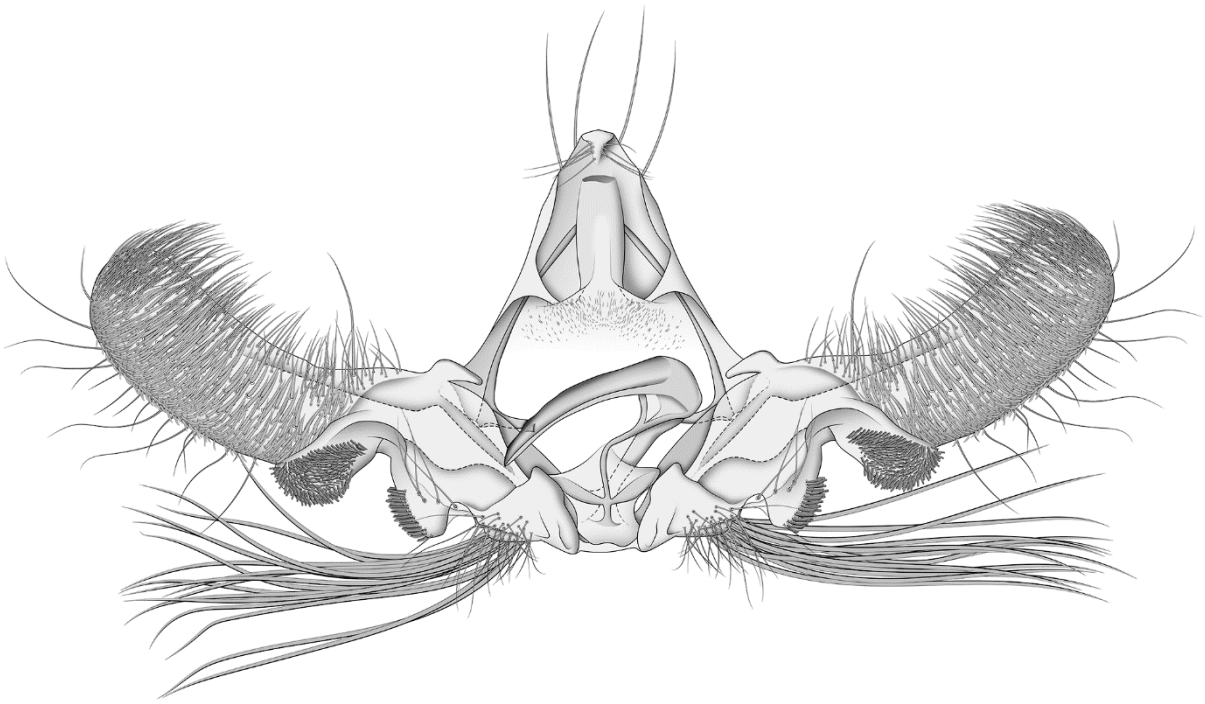
Fig. 184: male genitalia of *Paralobesia slingerlandana*; Fig. 185: male genitalia of *P. yaracana.*



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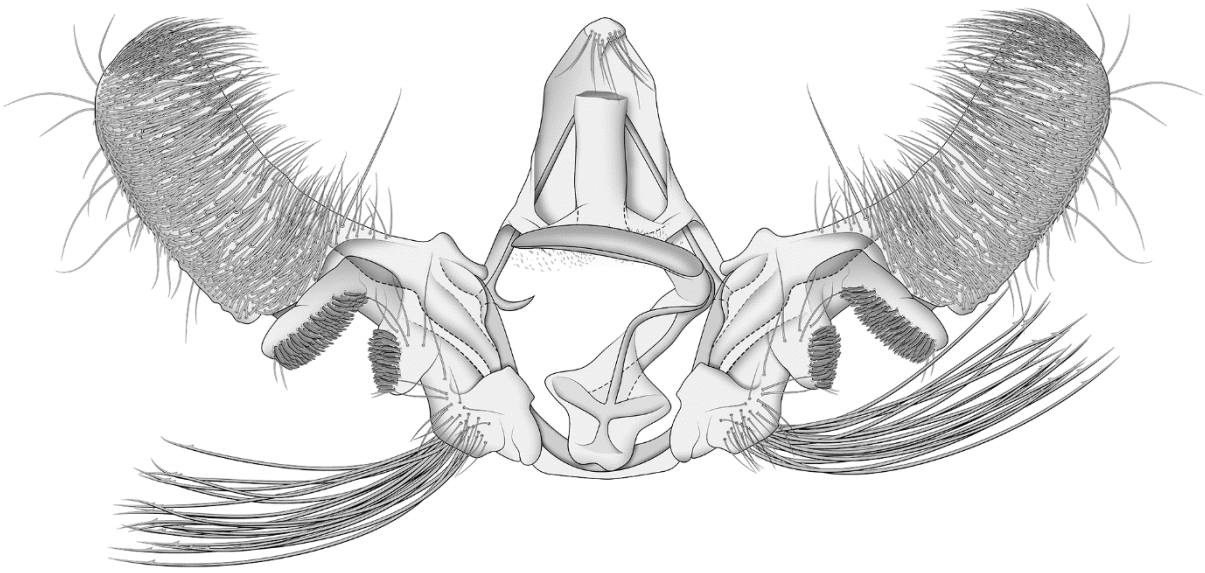

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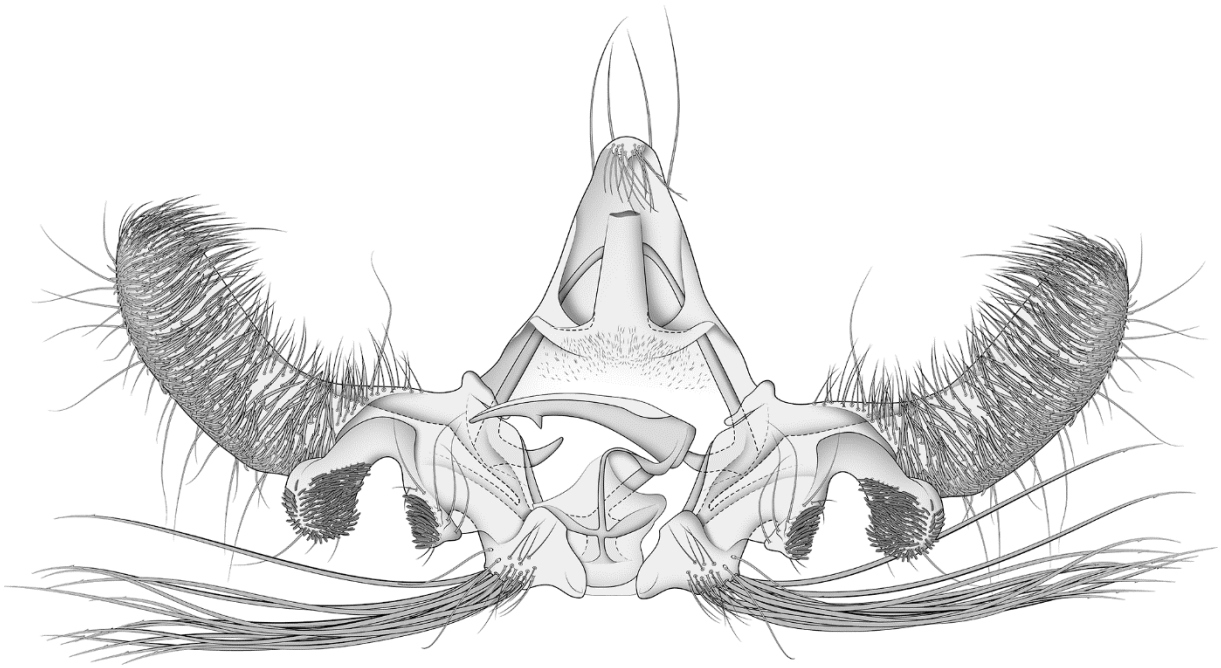
Fig. 186: male genitalia of *Paralobesia kearfotti*; Fig. 187: male genitalia of *P. hodgesi.*



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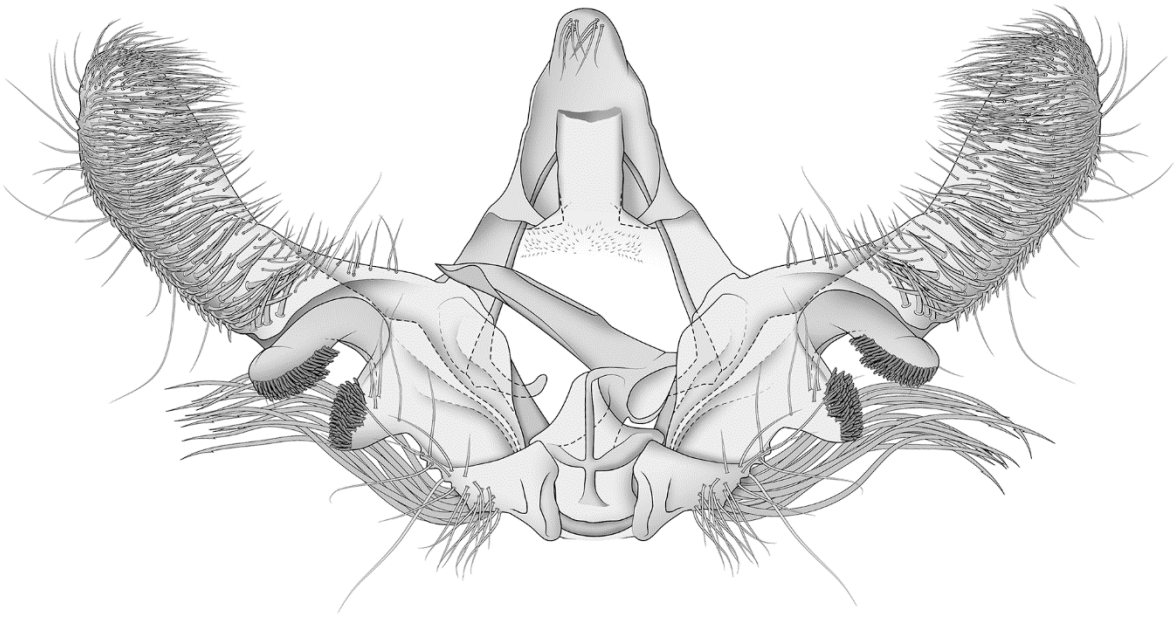

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Fig. 188: male genitalia of *Paralobesia glenni*; Fig. 189: male genitalia of *P. aruncana.*

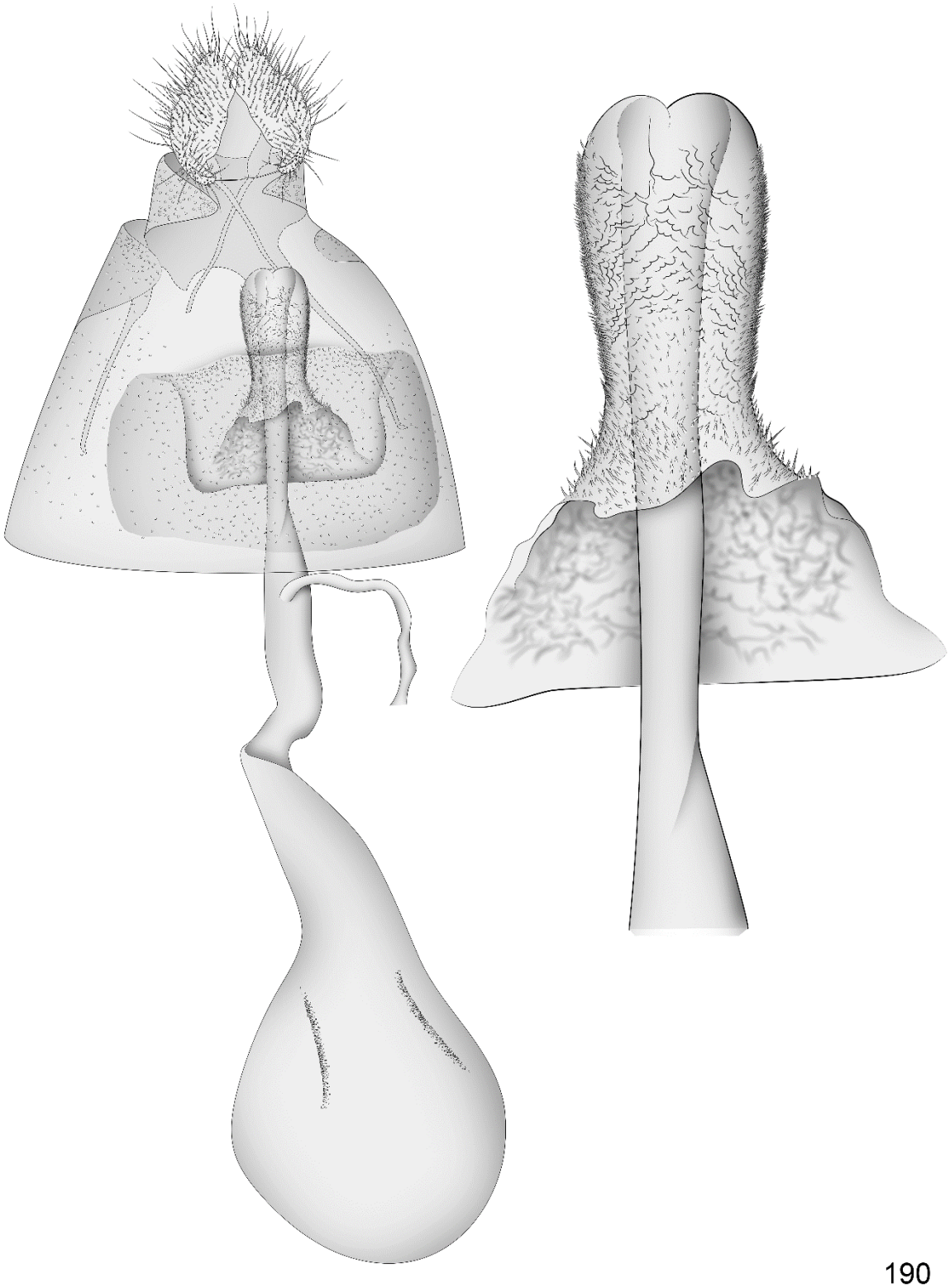

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Fig. 190: female genitalia (with sterigma enlarged) of *Paralobesia andereggiana*.

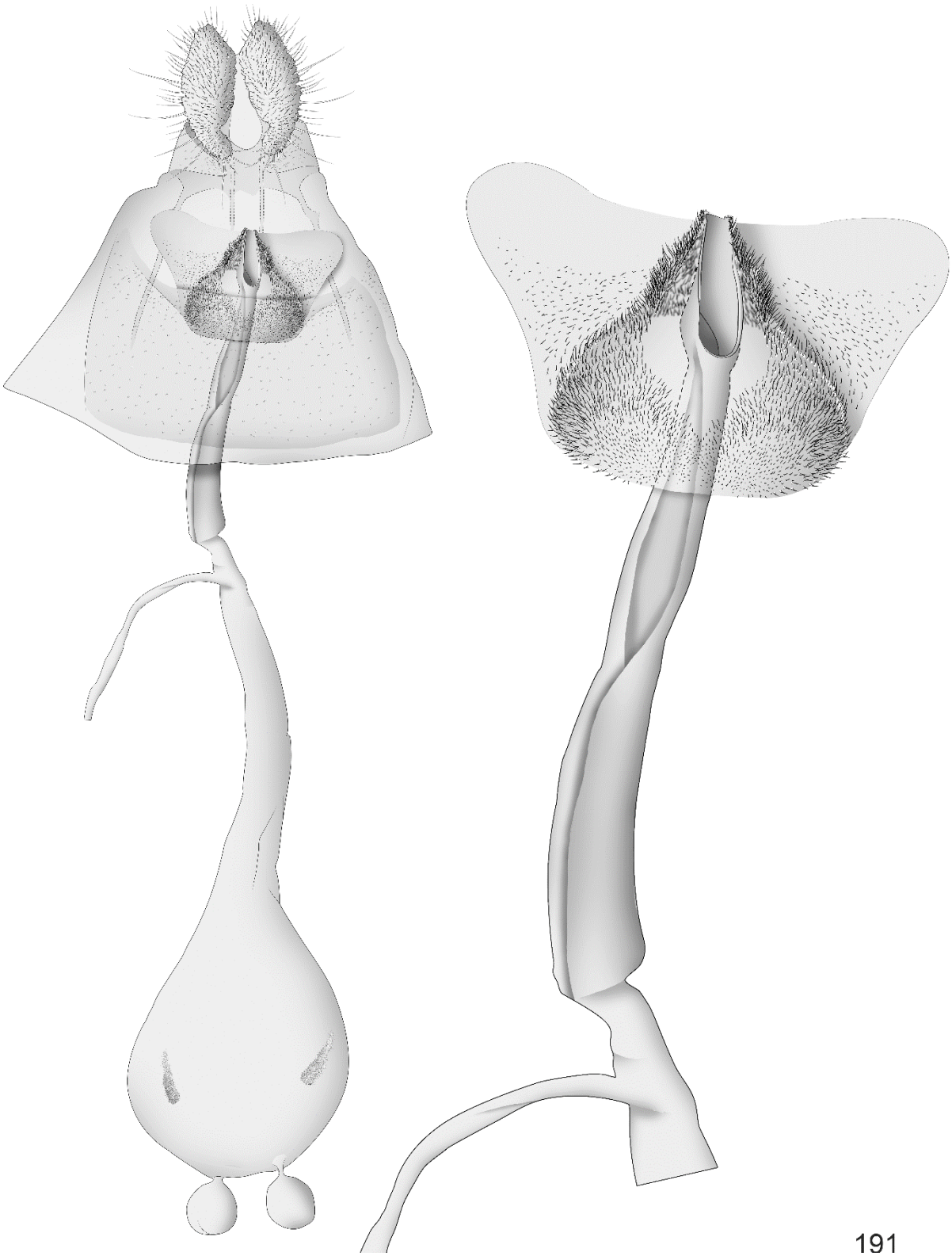

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Fig. 191: female genitalia (with sterigma enlarged) of *Paralobesia parsaurum*.

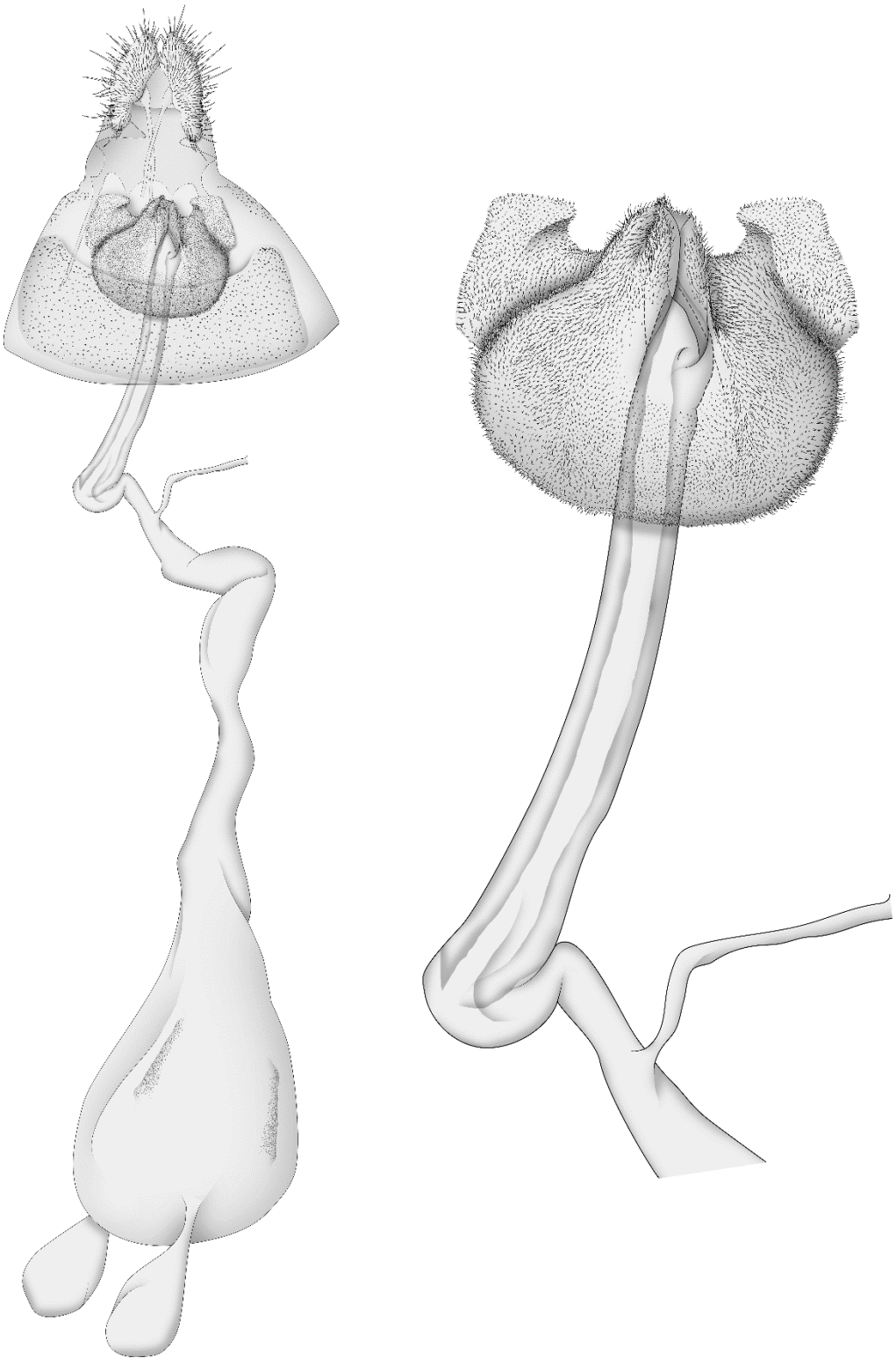

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Fig. 192: female genitalia (with sterigma enlarged) of *Paralobesia magnoliana*.

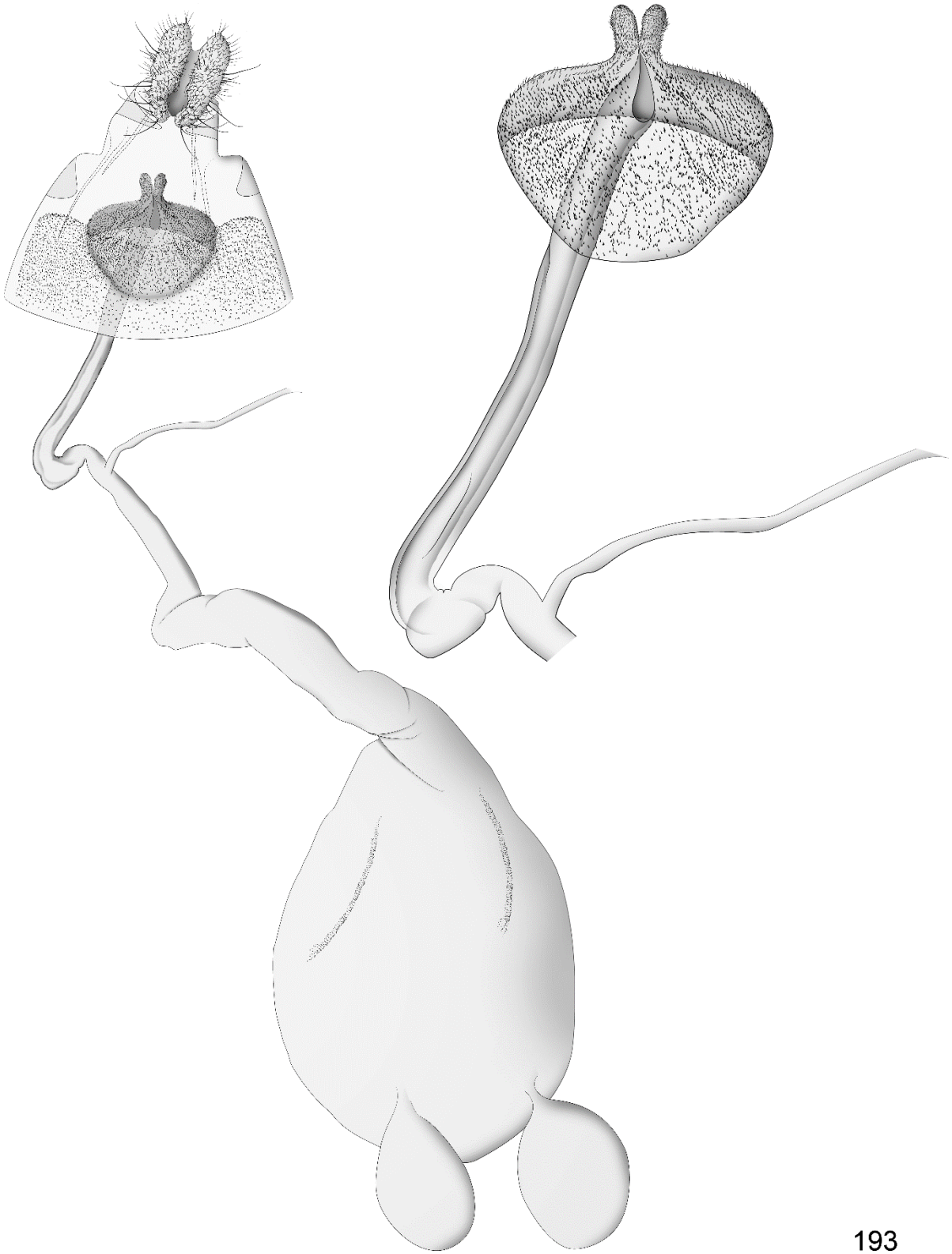

Fig. 193: female genitalia (with sterigma enlarged) of *Paralobesia liriodendrana*.

Fig. 194: female genitalia (with sterigma enlarged) of *Paralobesia albiterminana*.

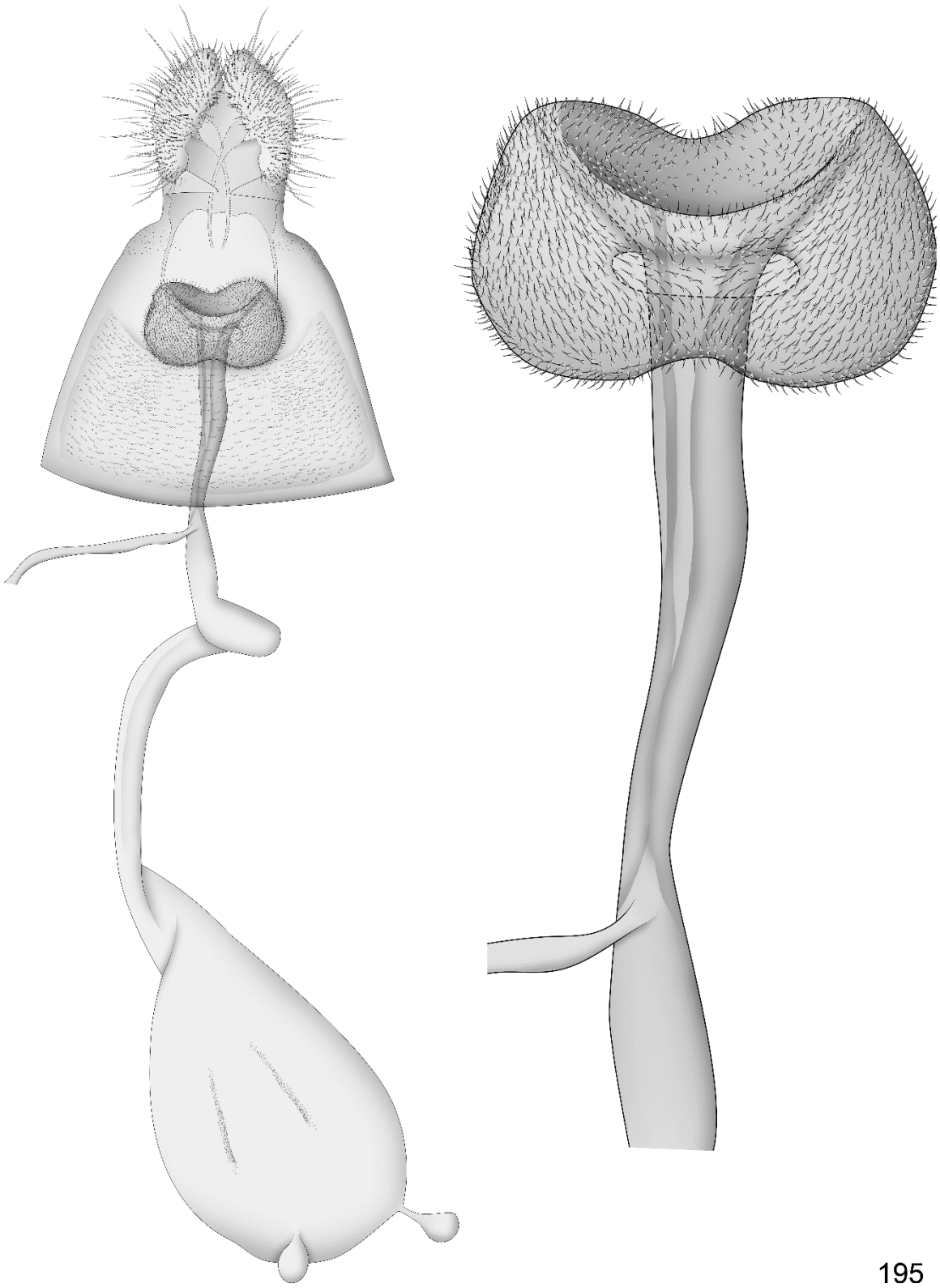

Fig. 195: female genitalia (with sterigma enlarged) of *Paralobesia cyclopiana*.

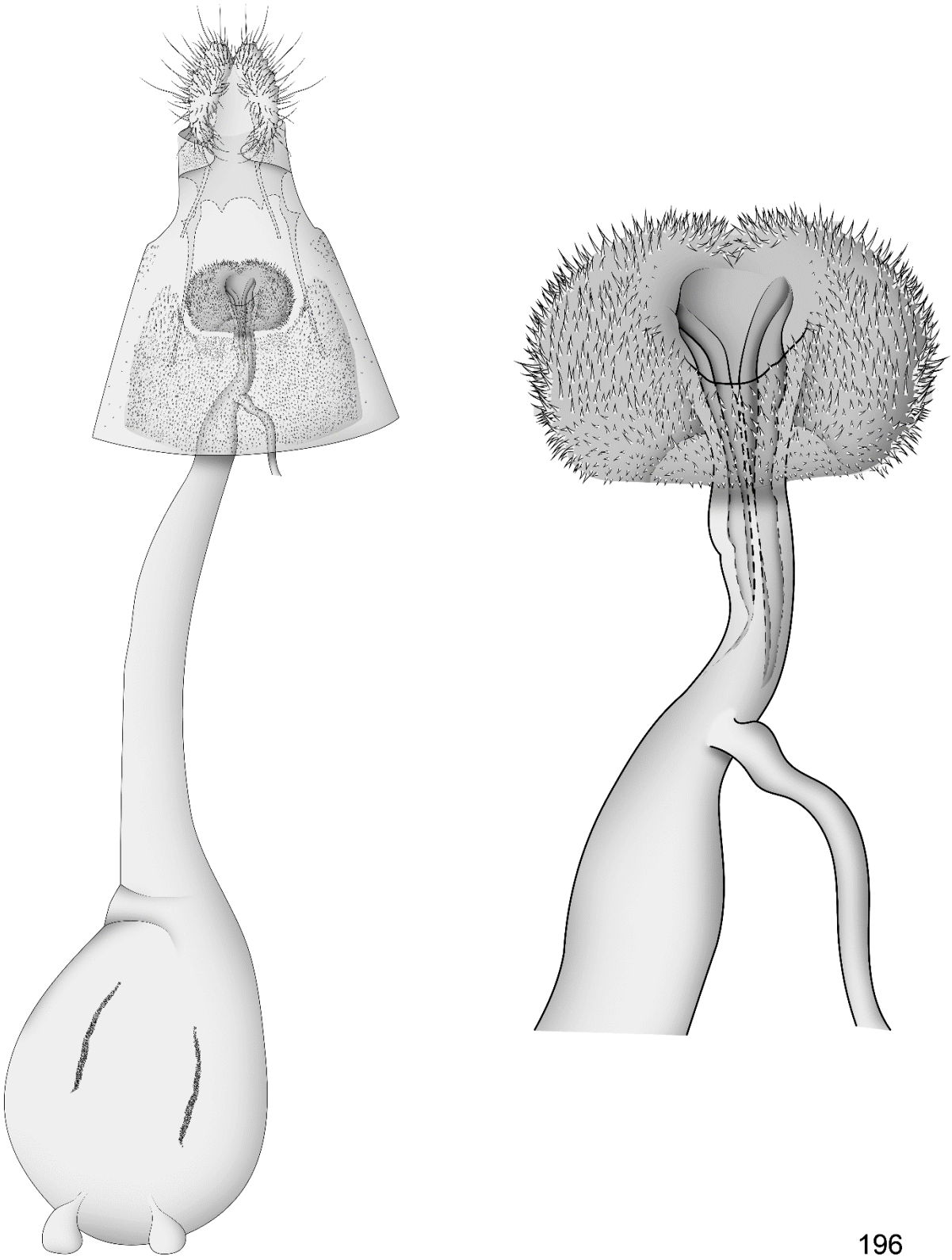

Fig. 196: female genitalia (with sterigma enlarged) of *Paralobesia carduana*.

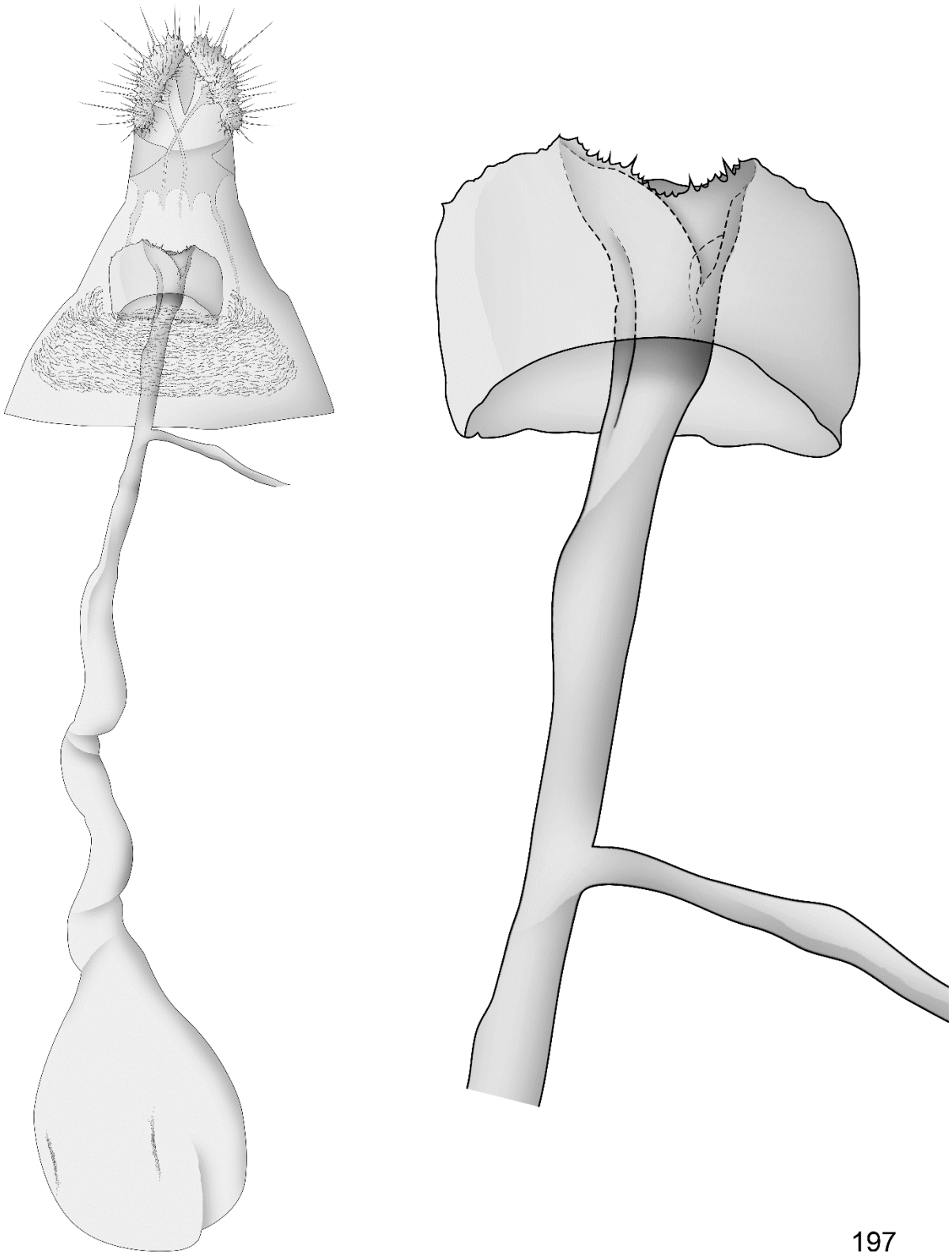

Fig. 197: female genitalia (with sterigma enlarged) of *Paralobesia crassus*.

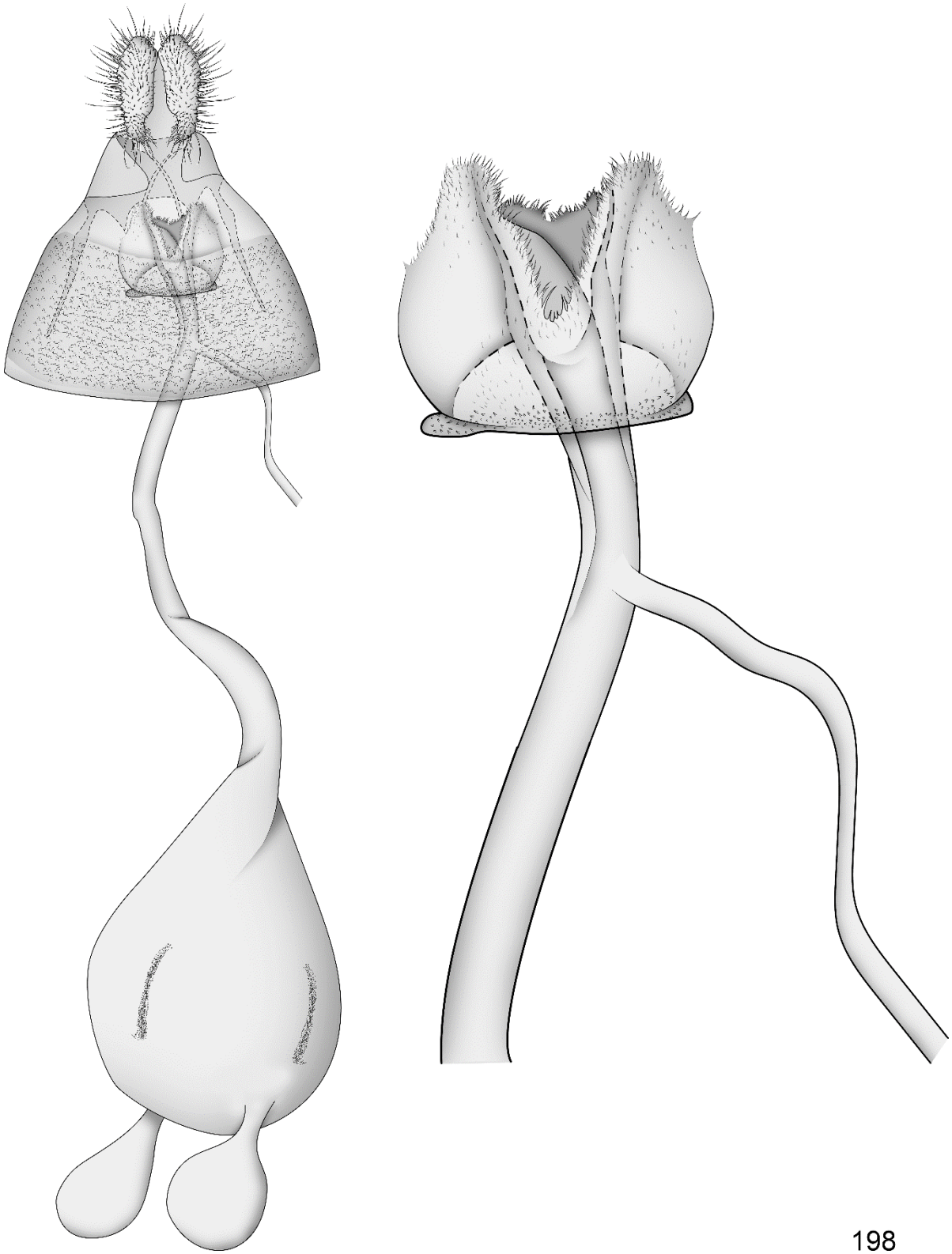

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Fig. 198: female genitalia (with sterigma enlarged) of *Paralobesia blandula*.

Fig. 199: female genitalia (with sterigma enlarged) of *Paralobesia aemulana*.

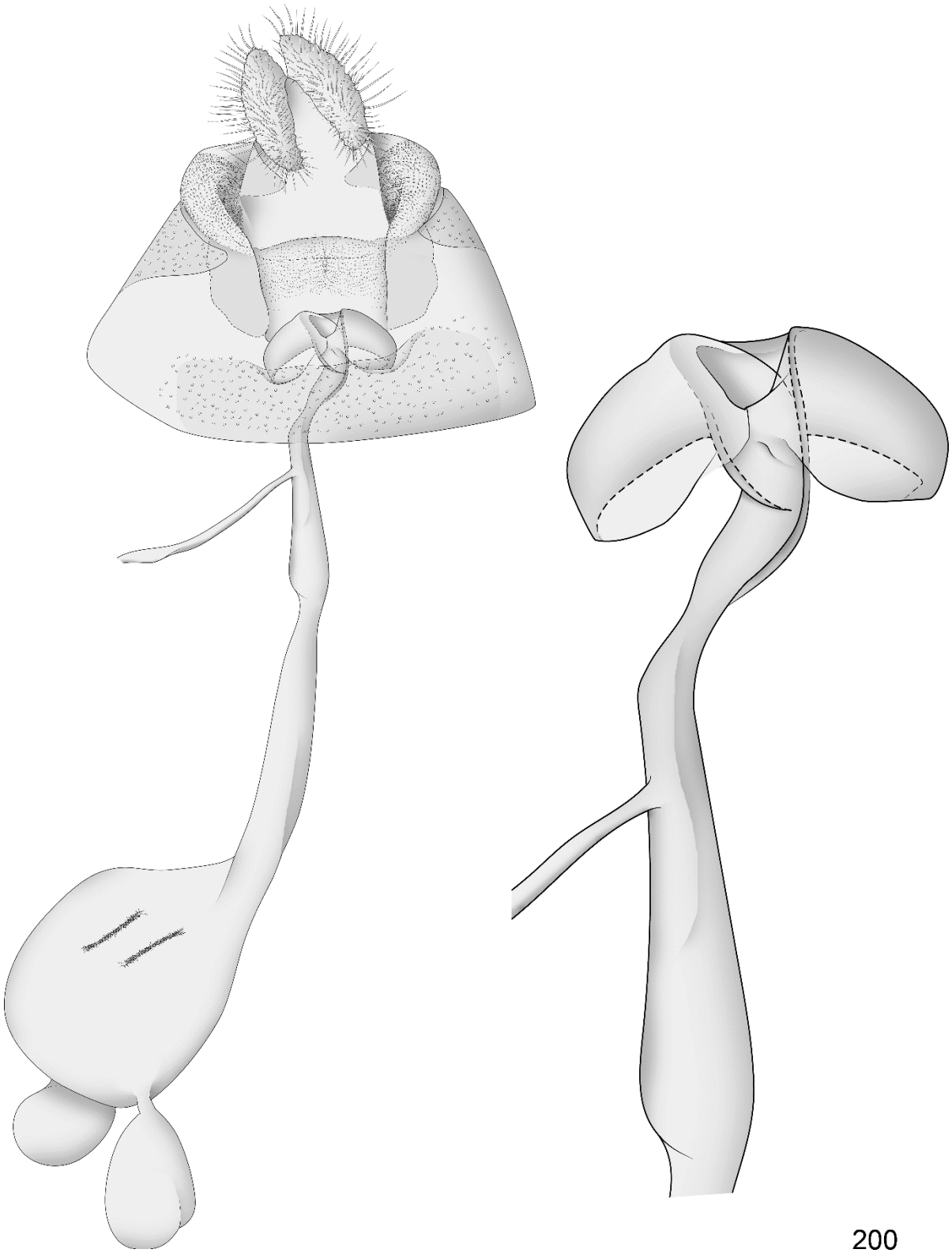

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Fig. 200: female genitalia (with sterigma enlarged) of *P. viteana*.

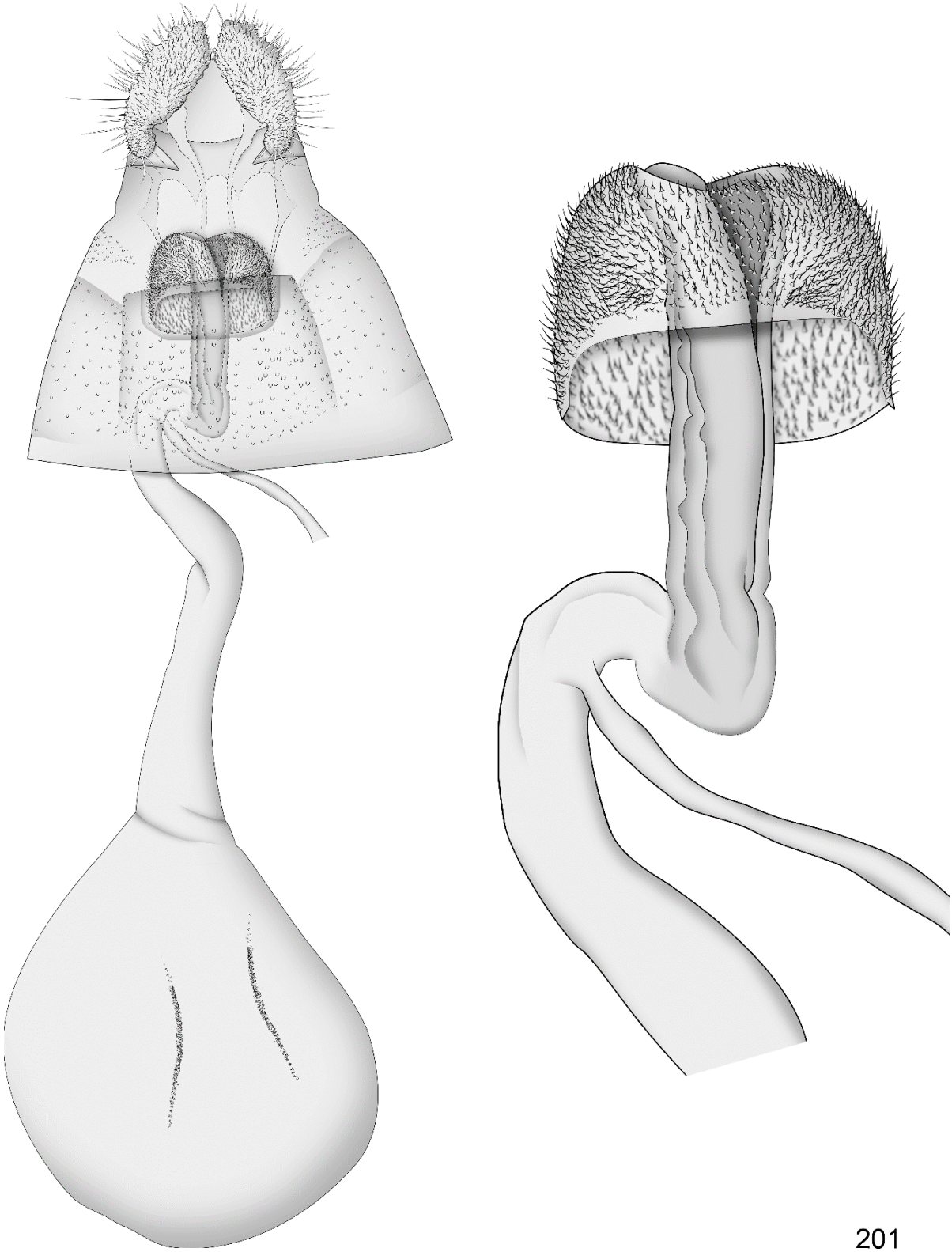

Fig. 201: female genitalia (with sterigma enlarged) of *P. rindingsana*.

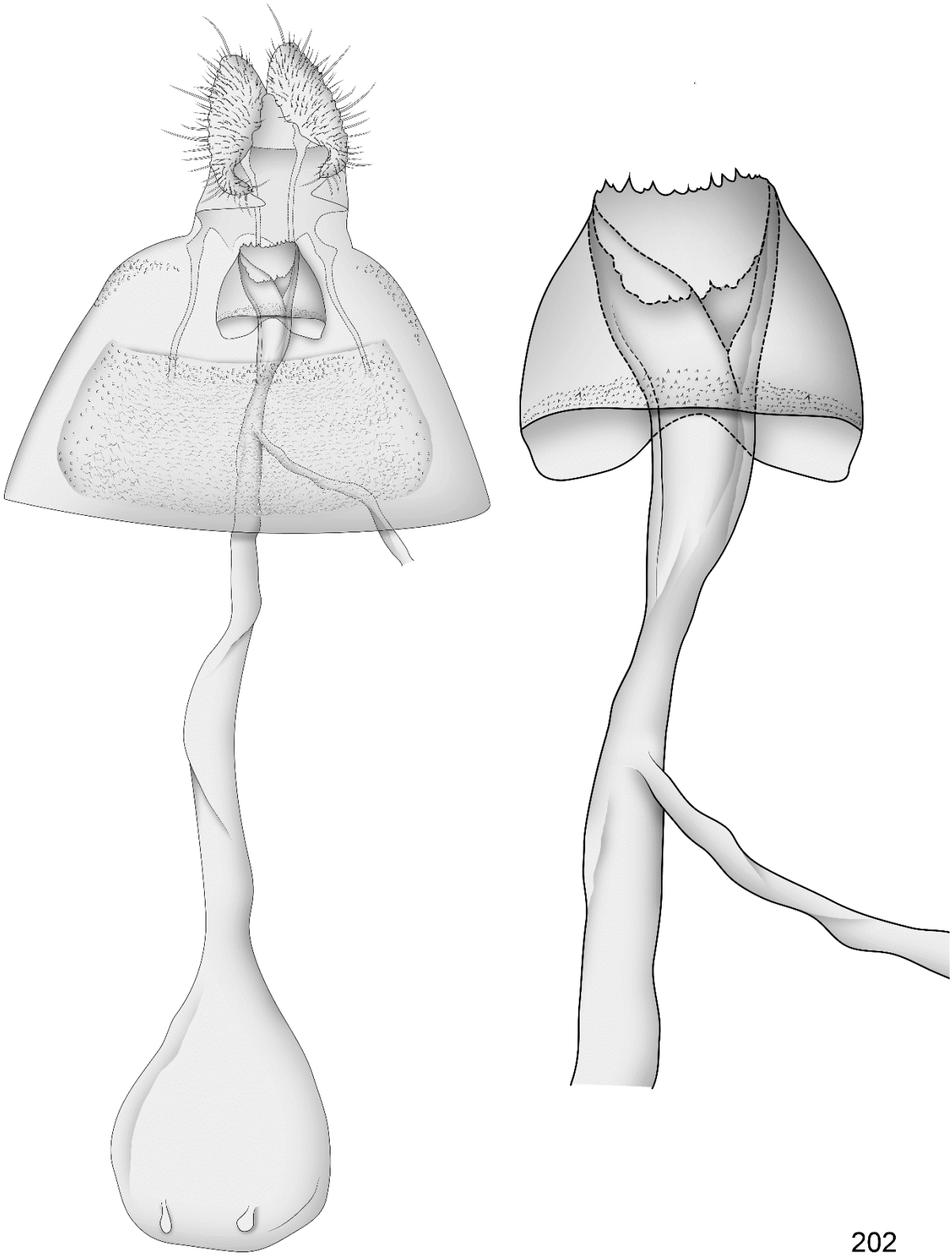

Fig. 202: female genitalia (with sterigma enlarged) of *Paralobesia monotropana*.

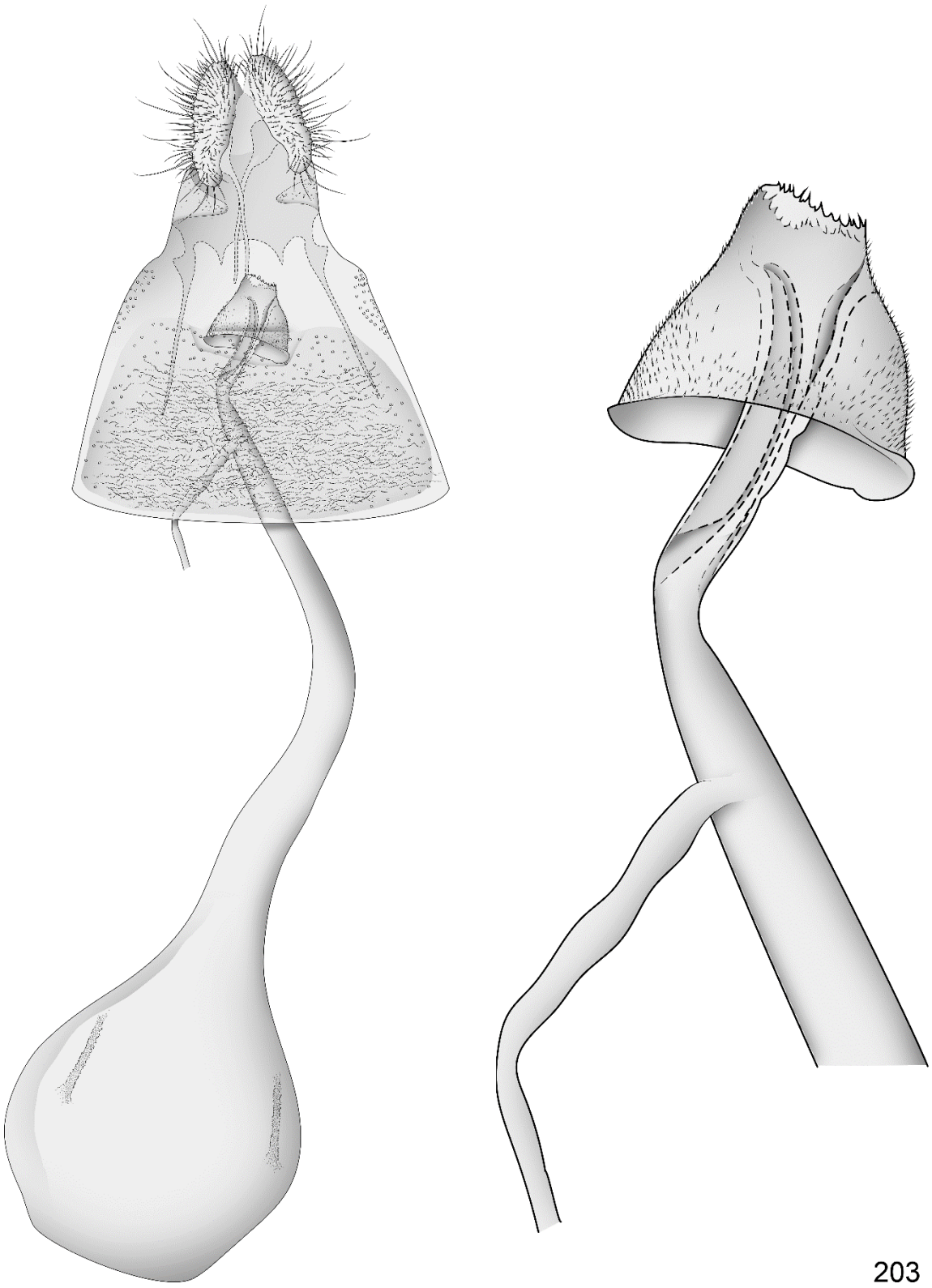

Fig. 203: female genitalia (with sterigma enlarged) of *Paralobesia spiraeifoliana*.

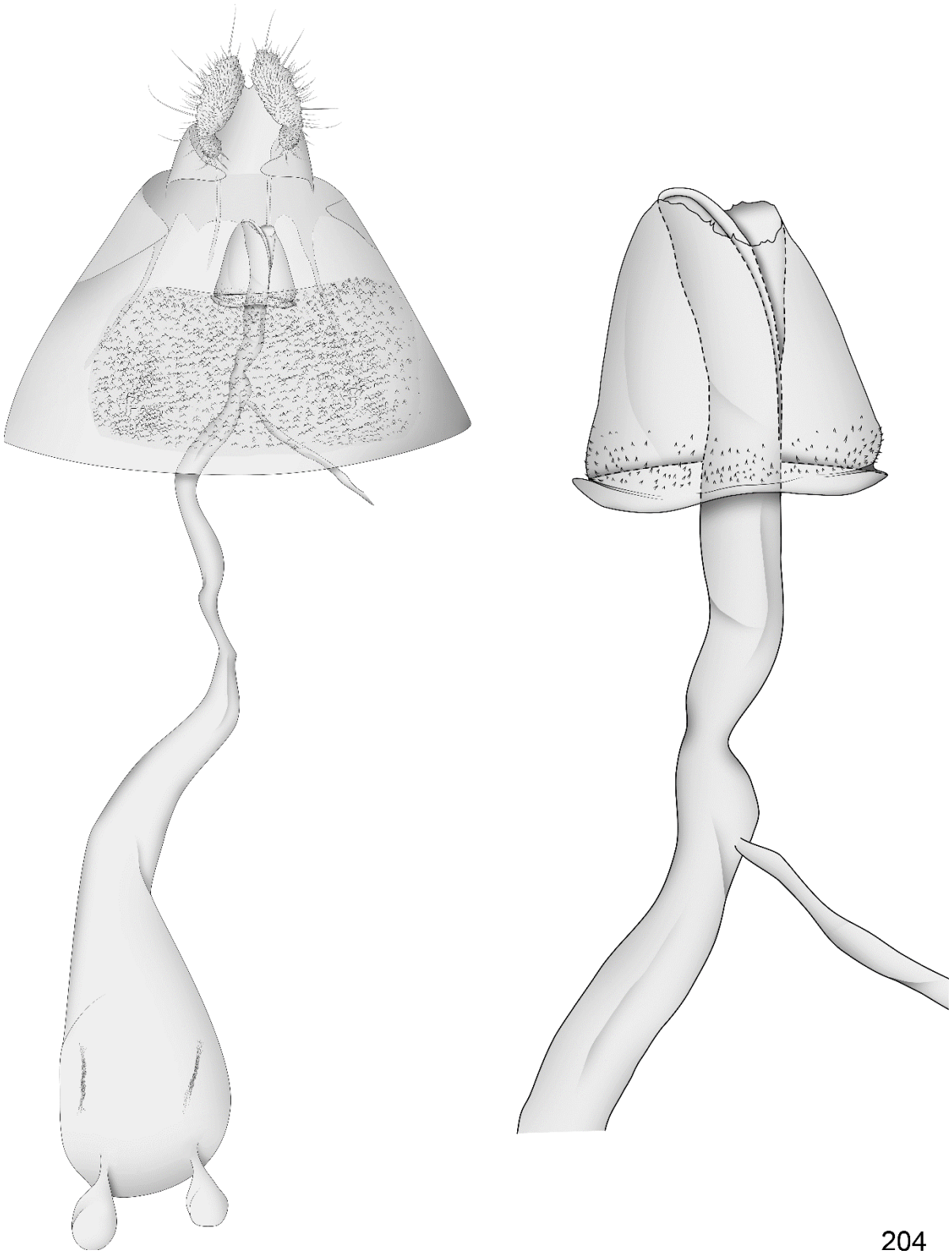

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Fig. 204: female genitalia (with sterigma enlarged) of *Paralobesia cypripediana*.

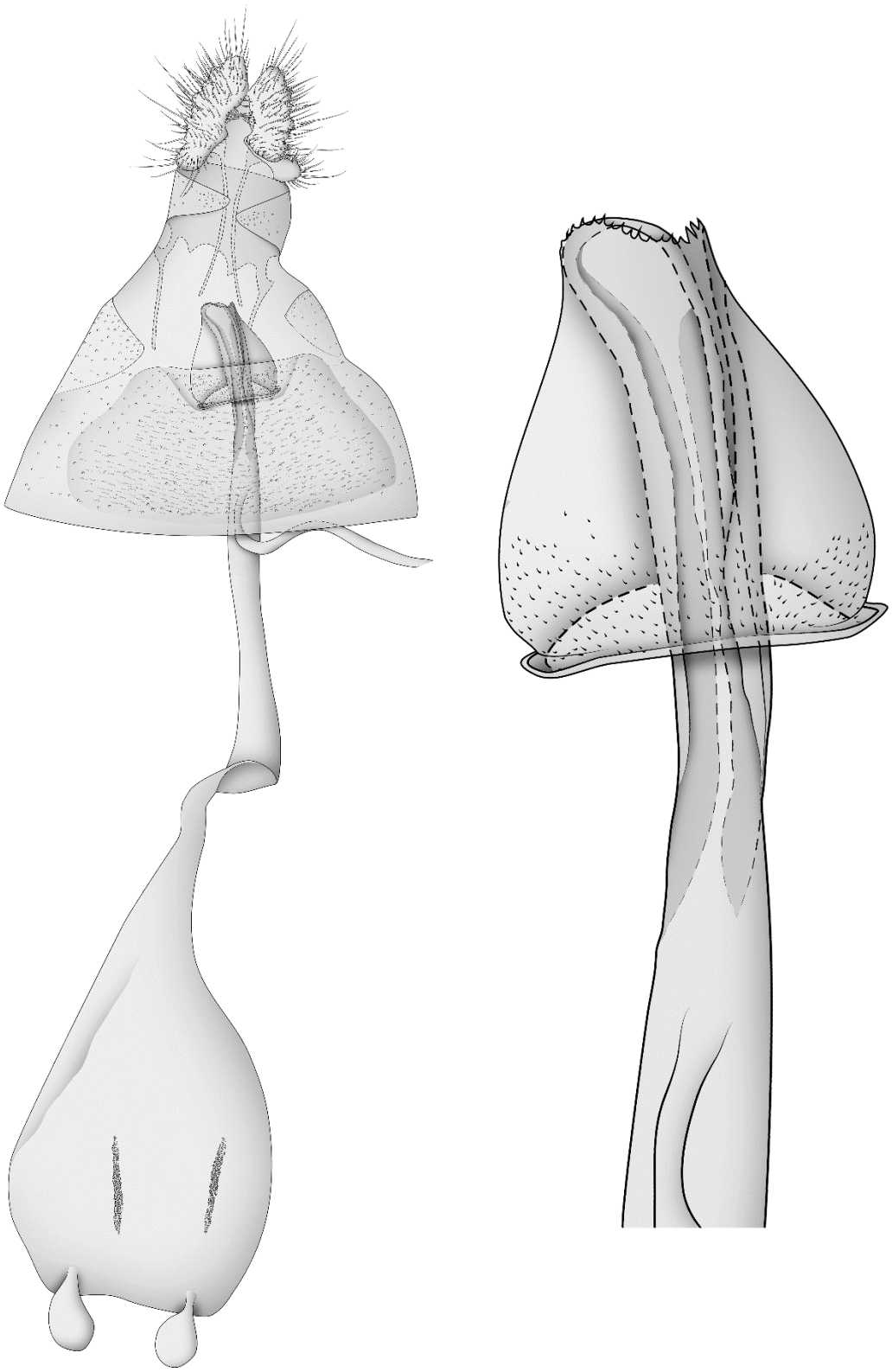

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Fig. 205: female genitalia (with sterigma enlarged) of *Paralobesia rhoifructana*.

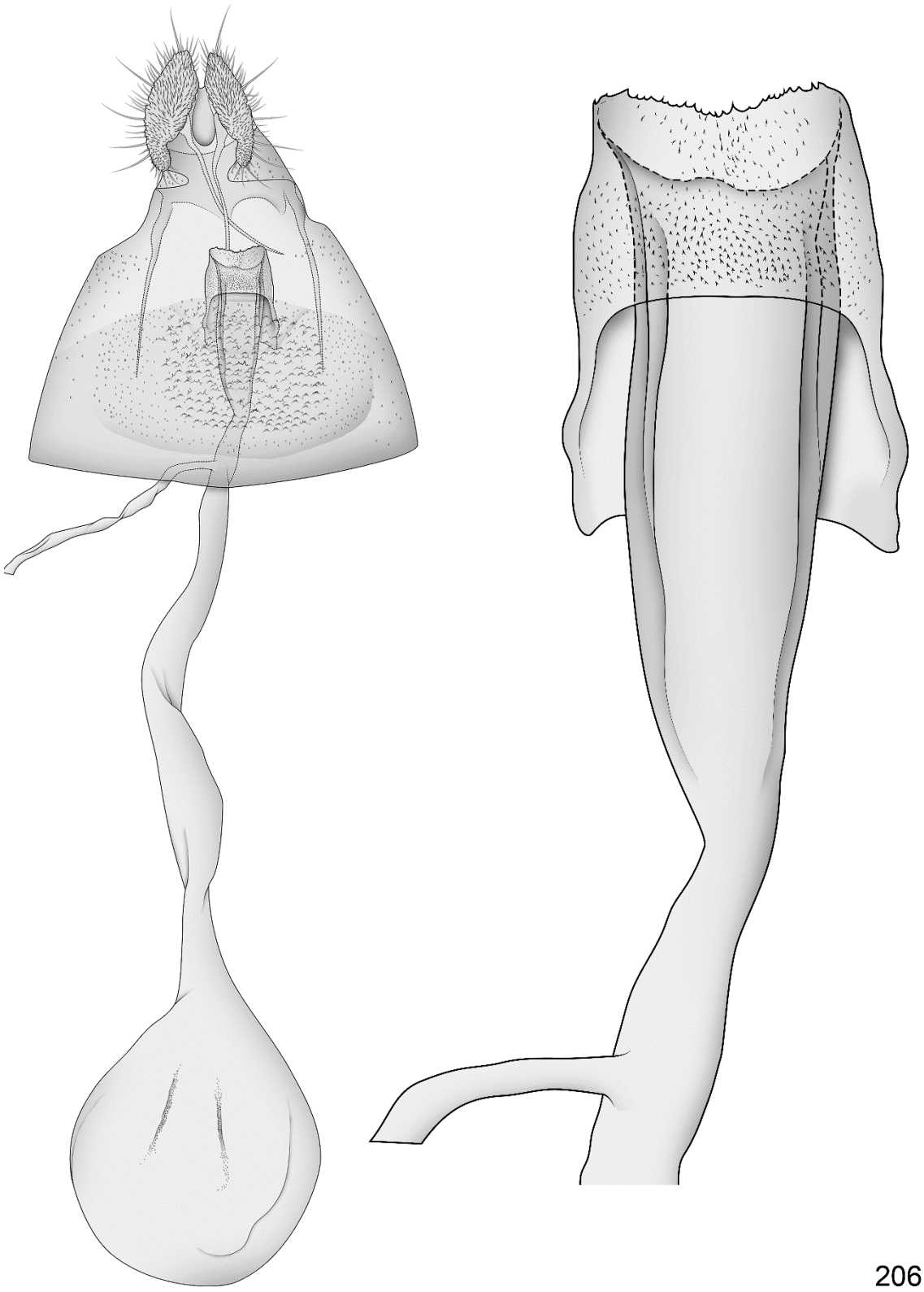

Fig. 206: female genitalia (with sterigma enlarged) of *Paralobesia pallicirculus*.

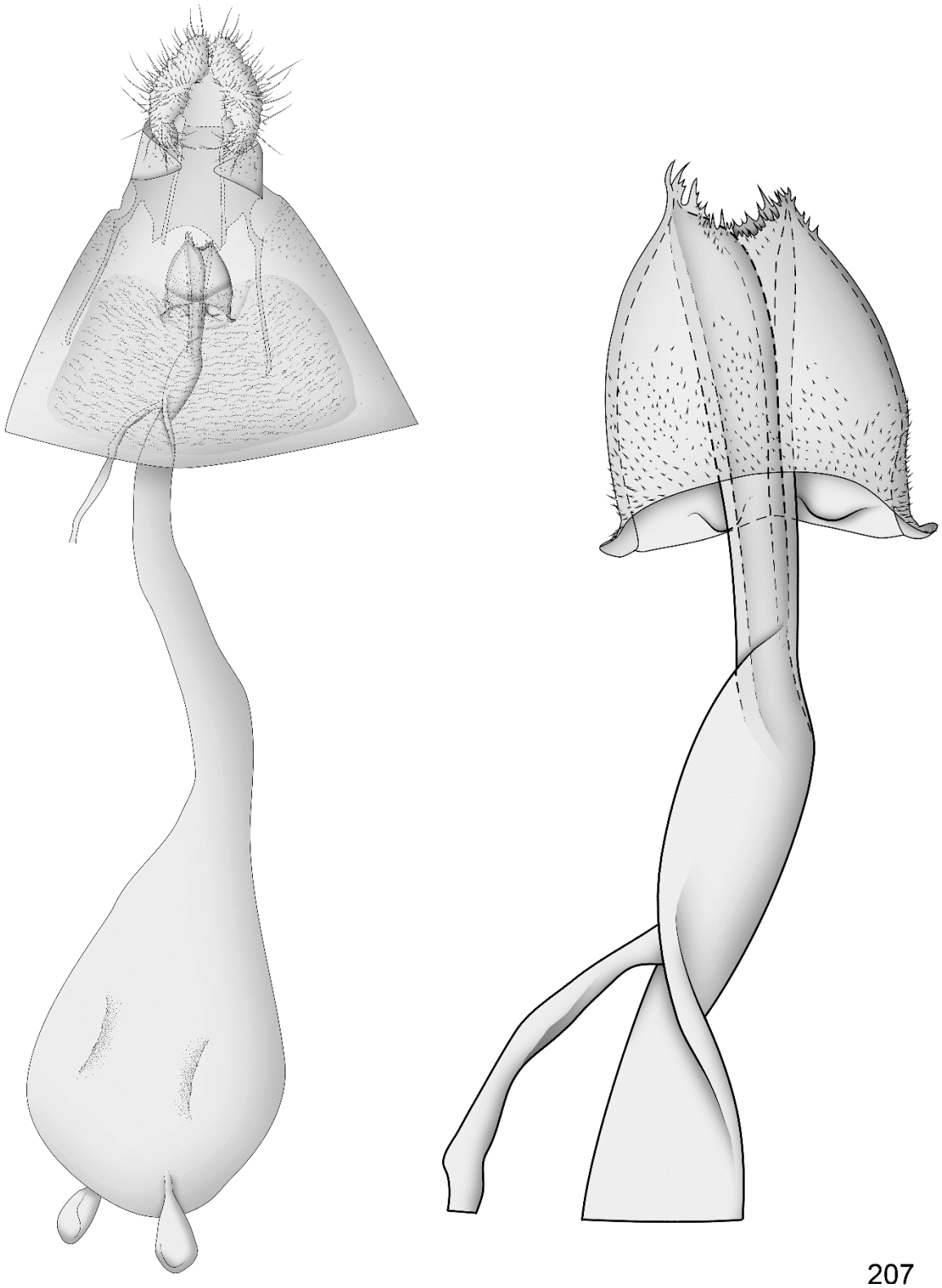

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Fig. 207: female genitalia (with sterigma enlarged) of *Paralobesia landryi*.

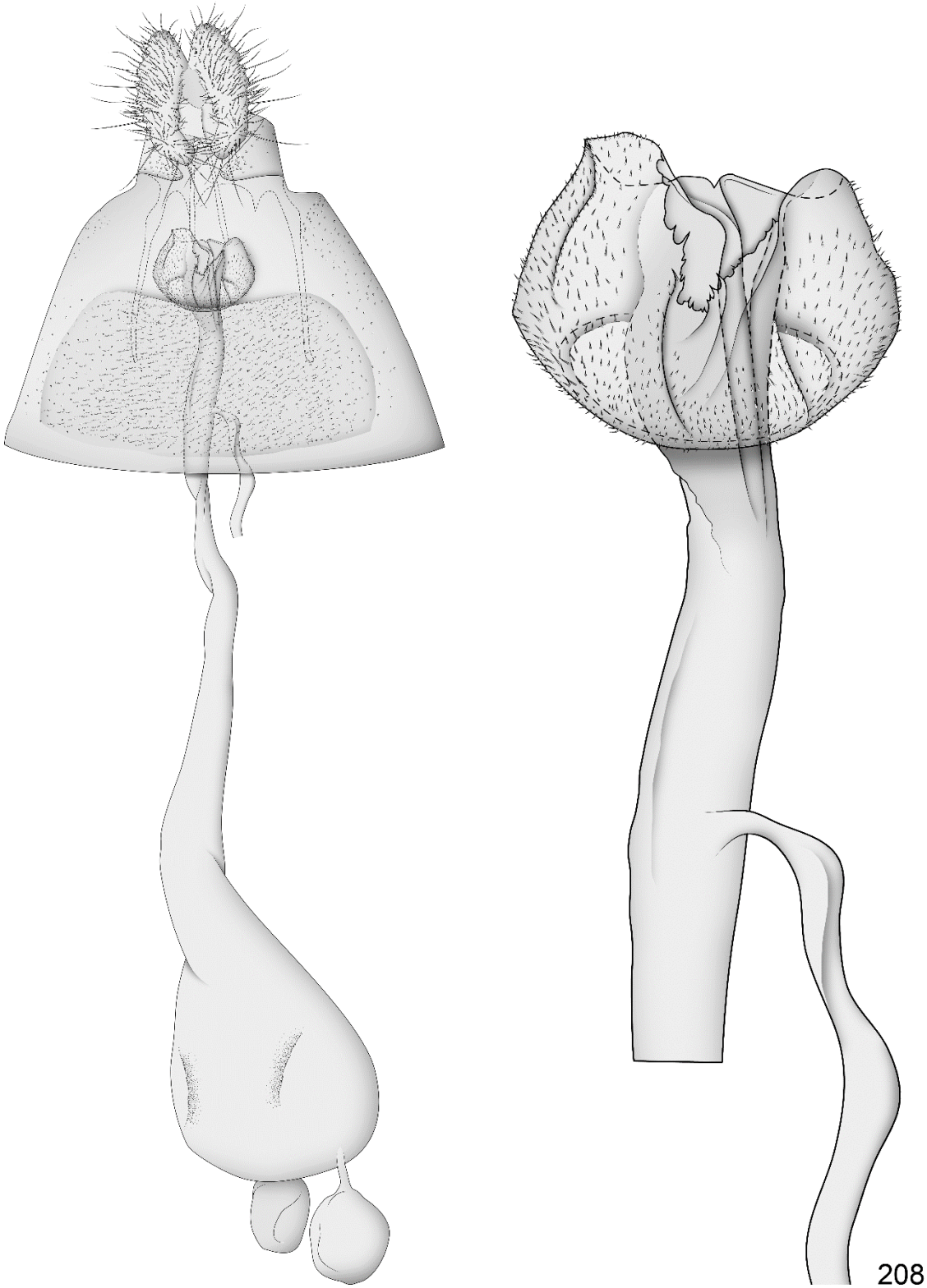

Fig. 208: female genitalia (with sterigma enlarged) of *Paralobesia wontonana*.

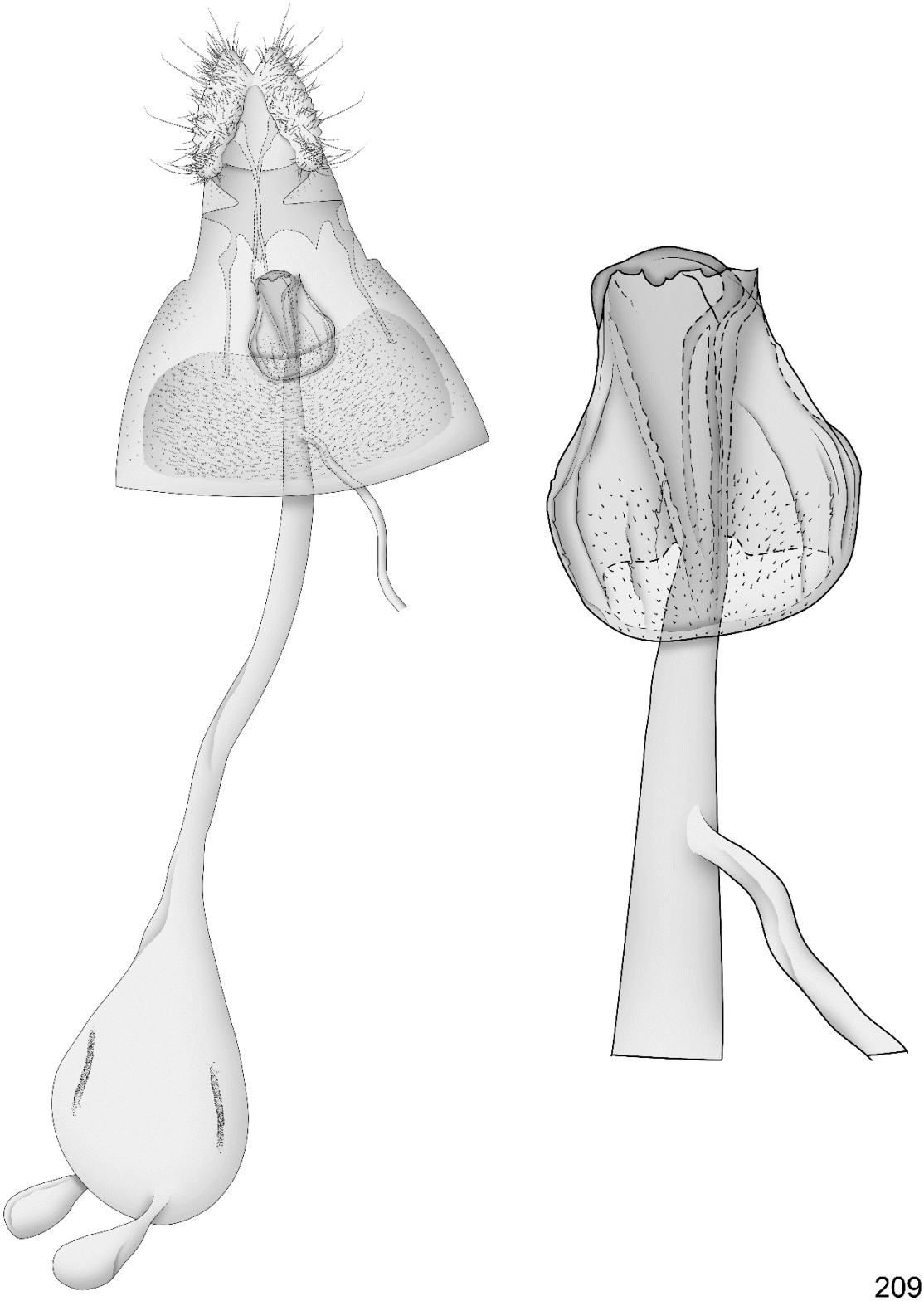

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Fig. 209: female genitalia (with sterigma enlarged) of *Paralobesia vernoniana*.

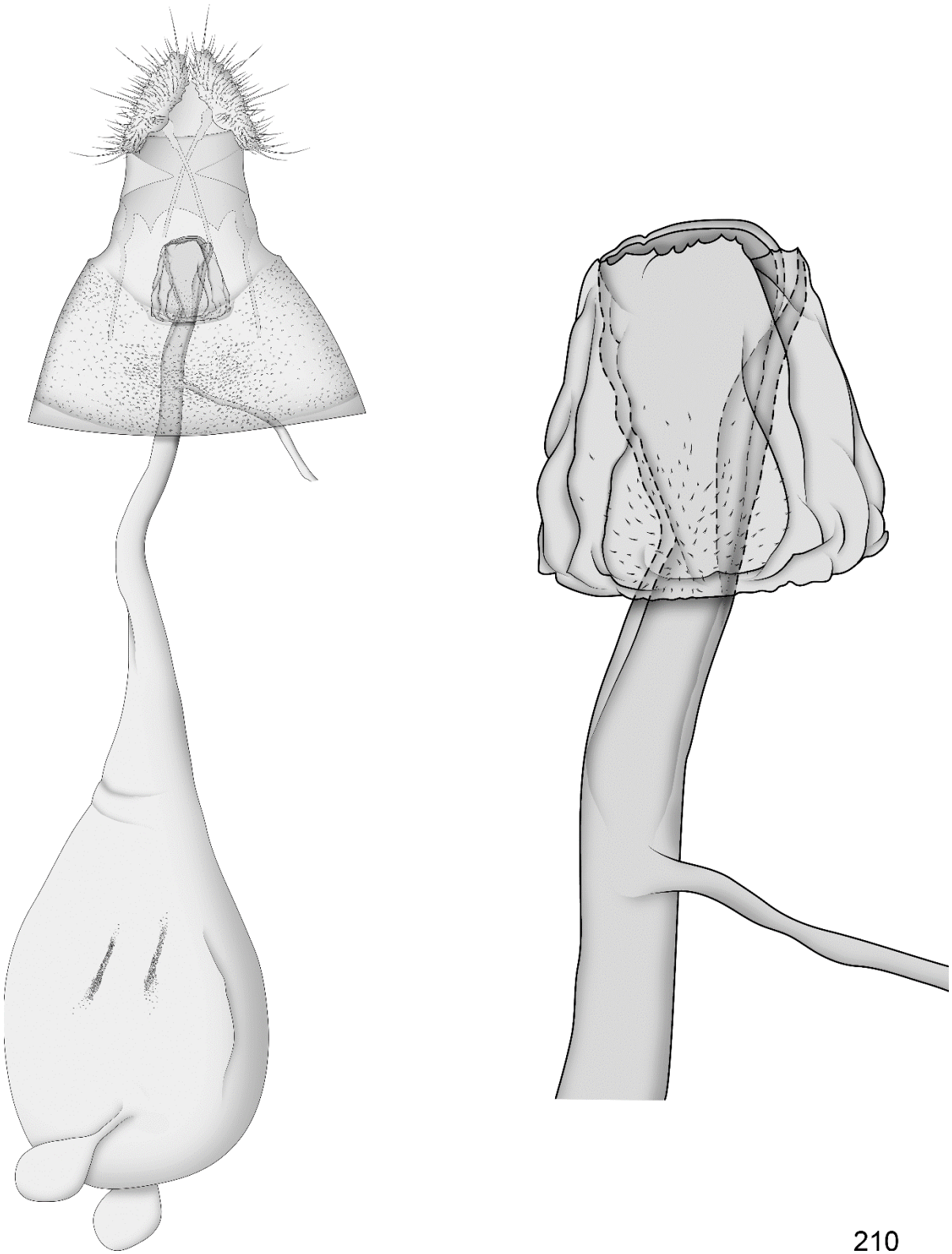

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Fig. 210: female genitalia (with sterigma enlarged) of *Paralobesia sambuci*.

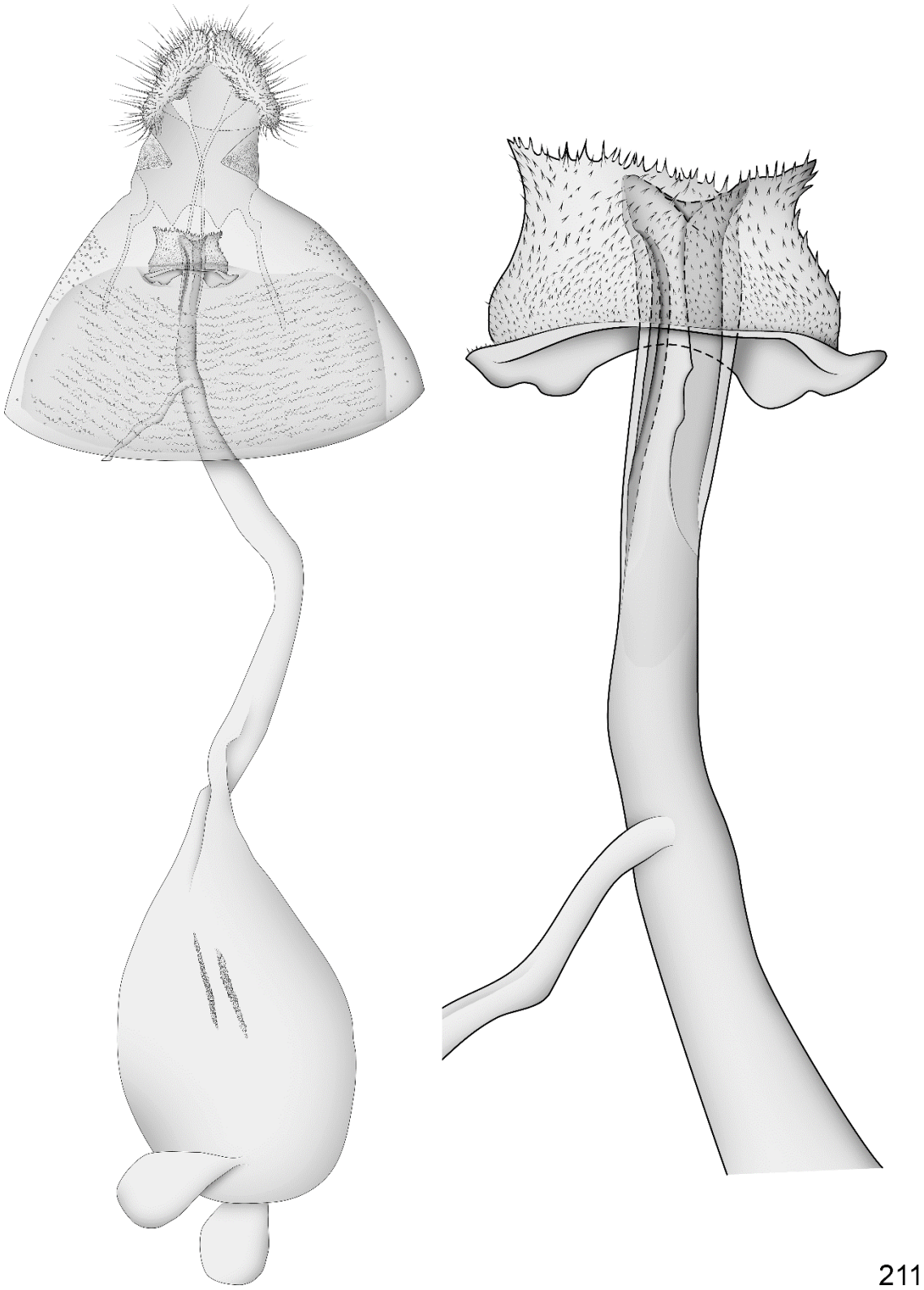

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Fig. 211: female genitalia (with sterigma enlarged) of *Paralobesia crispus*.

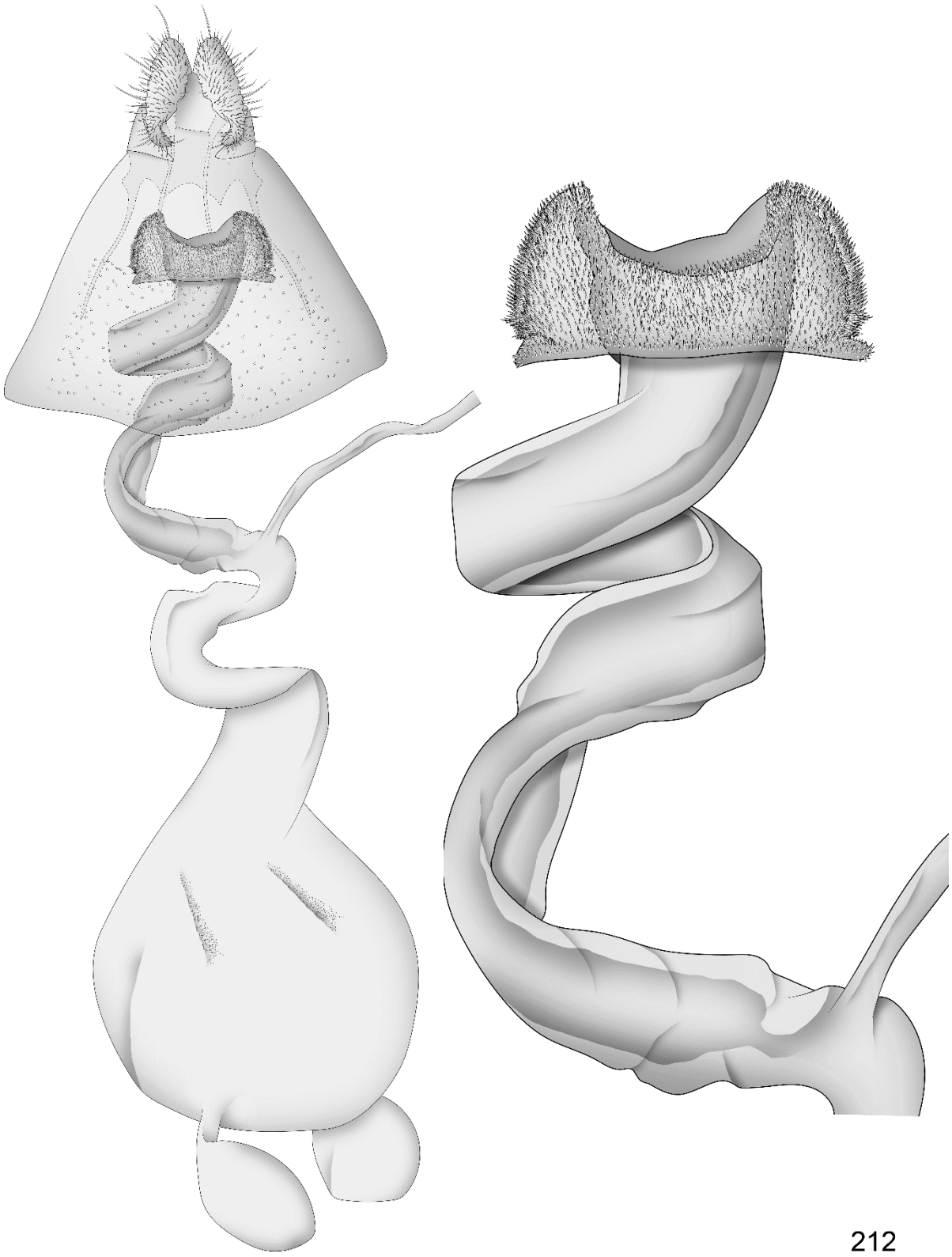

Fig. 212: female genitalia (with sterigma enlarged) of *Paralobesia worthi*.

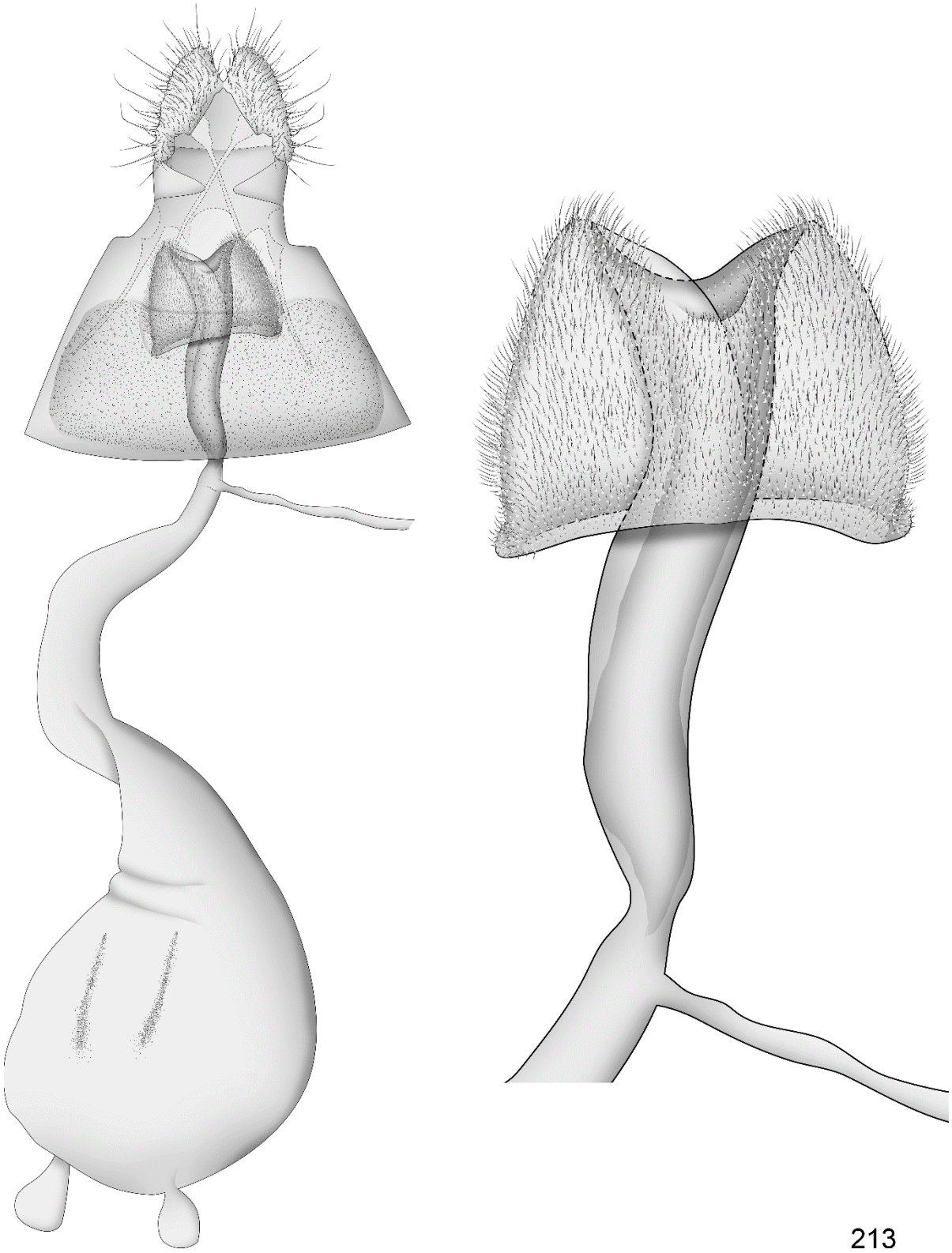

Fig. 213: female genitalia (with sterigma enlarged) of *Paralobesia palliolana*.

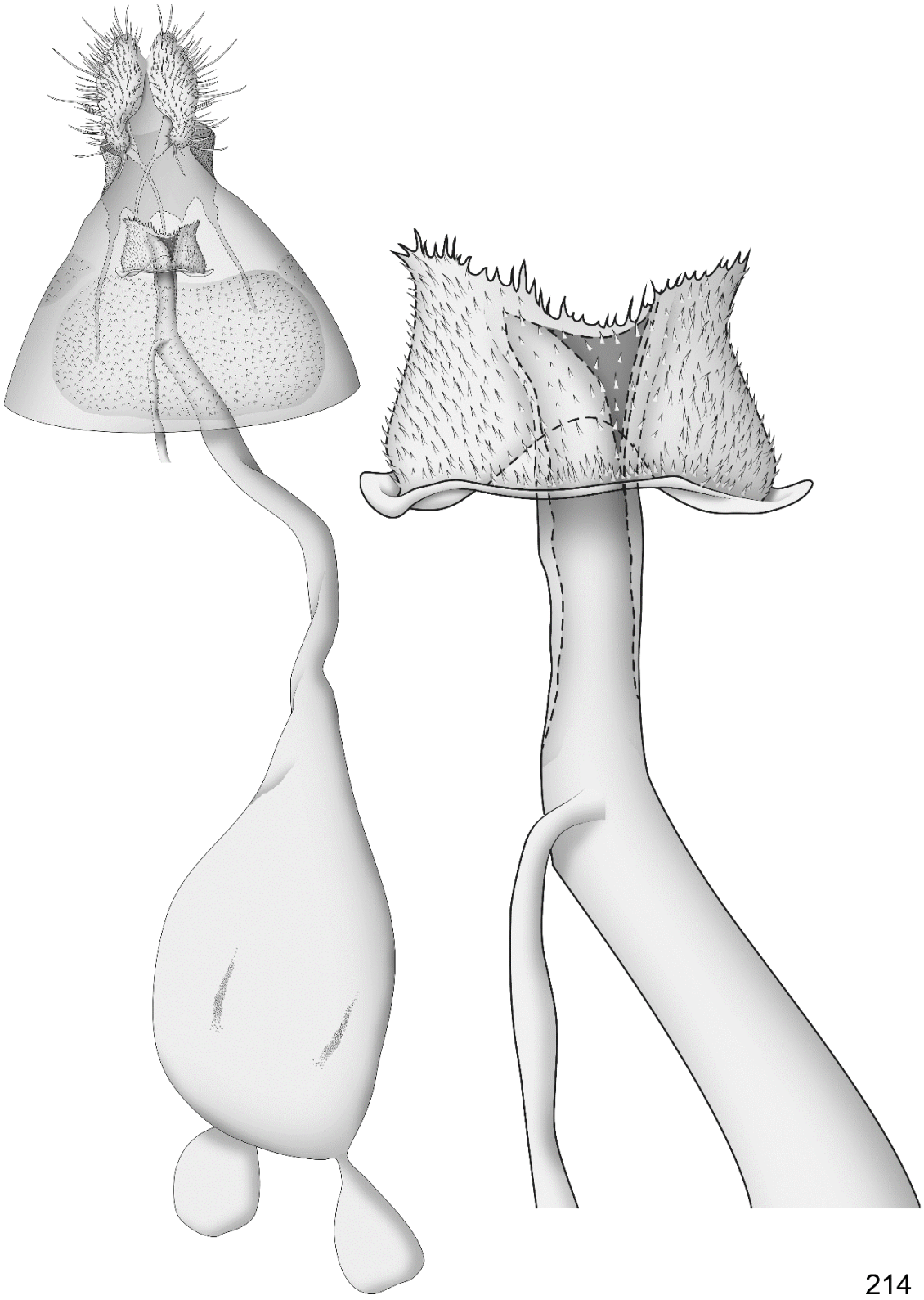

Fig. 214: female genitalia (with sterigma enlarged) of *Paralobesia exasperana*.

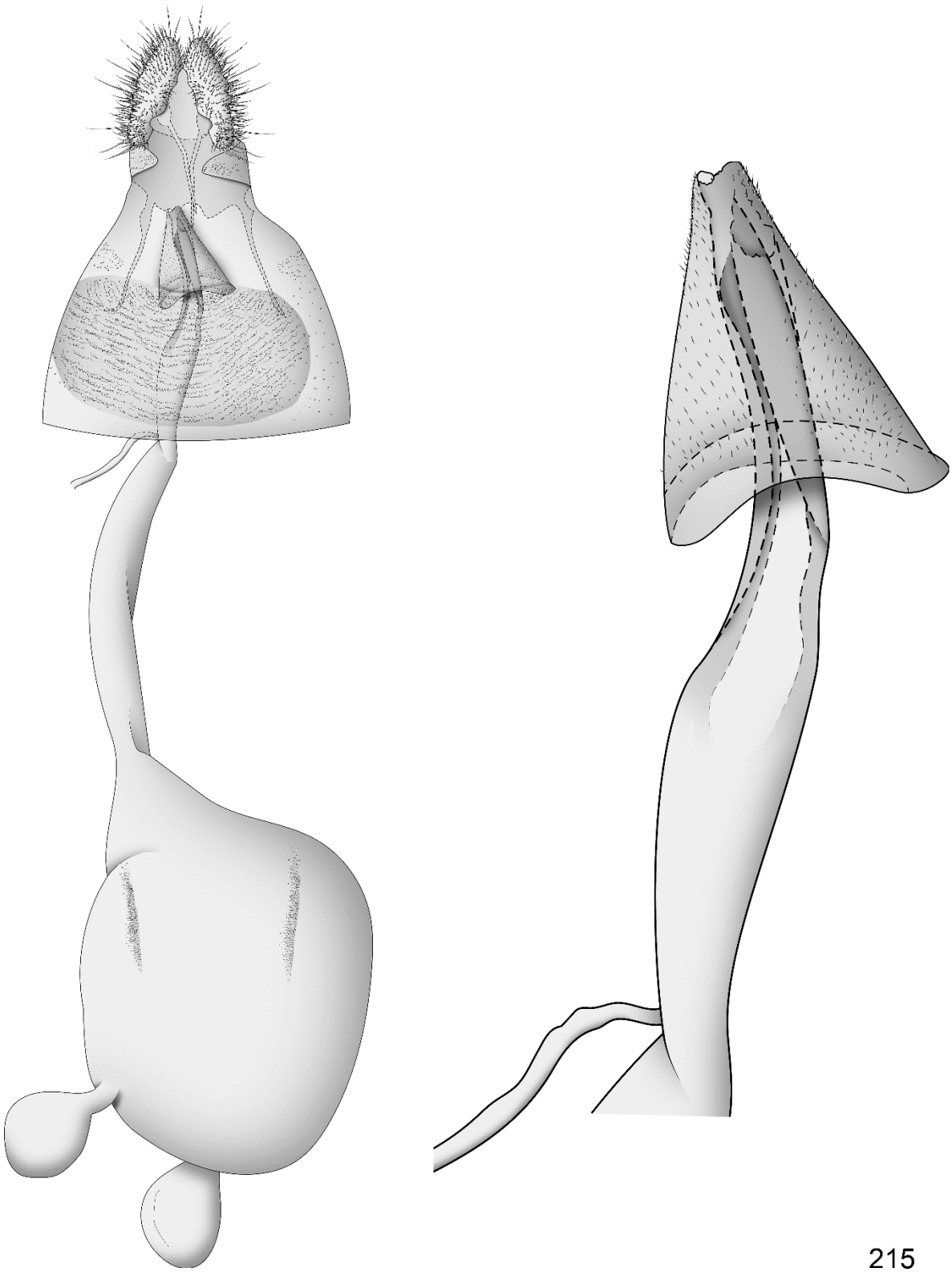

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Fig. 215: female genitalia (with sterigma enlarged) of *Paralobesia piperana*.

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Fig. 216: female genitalia (with sterigma enlarged) of *Paralobesia slingerlandana*.

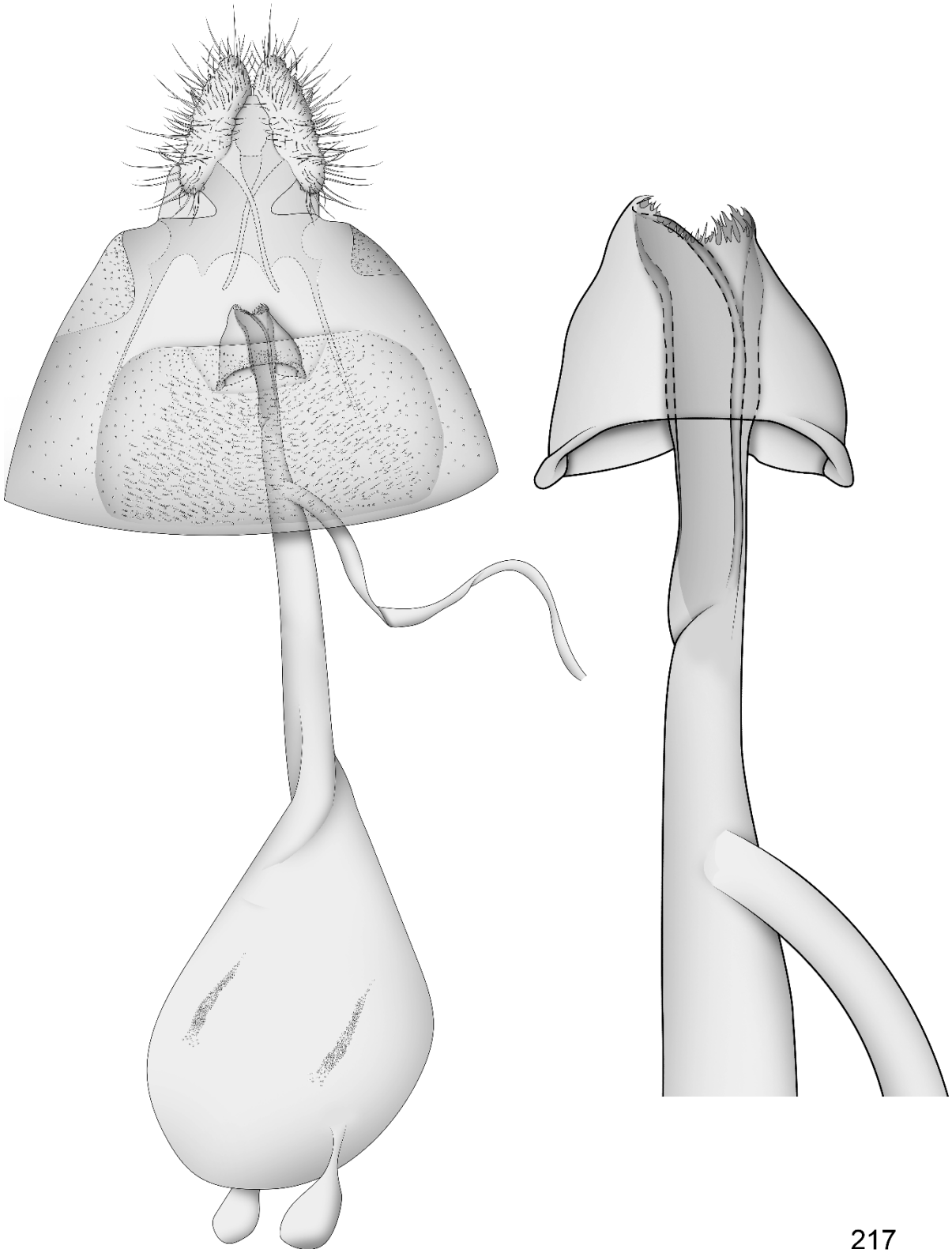

Fig. 217: female genitalia (with sterigma enlarged) of *Paralobesia yaracana*.

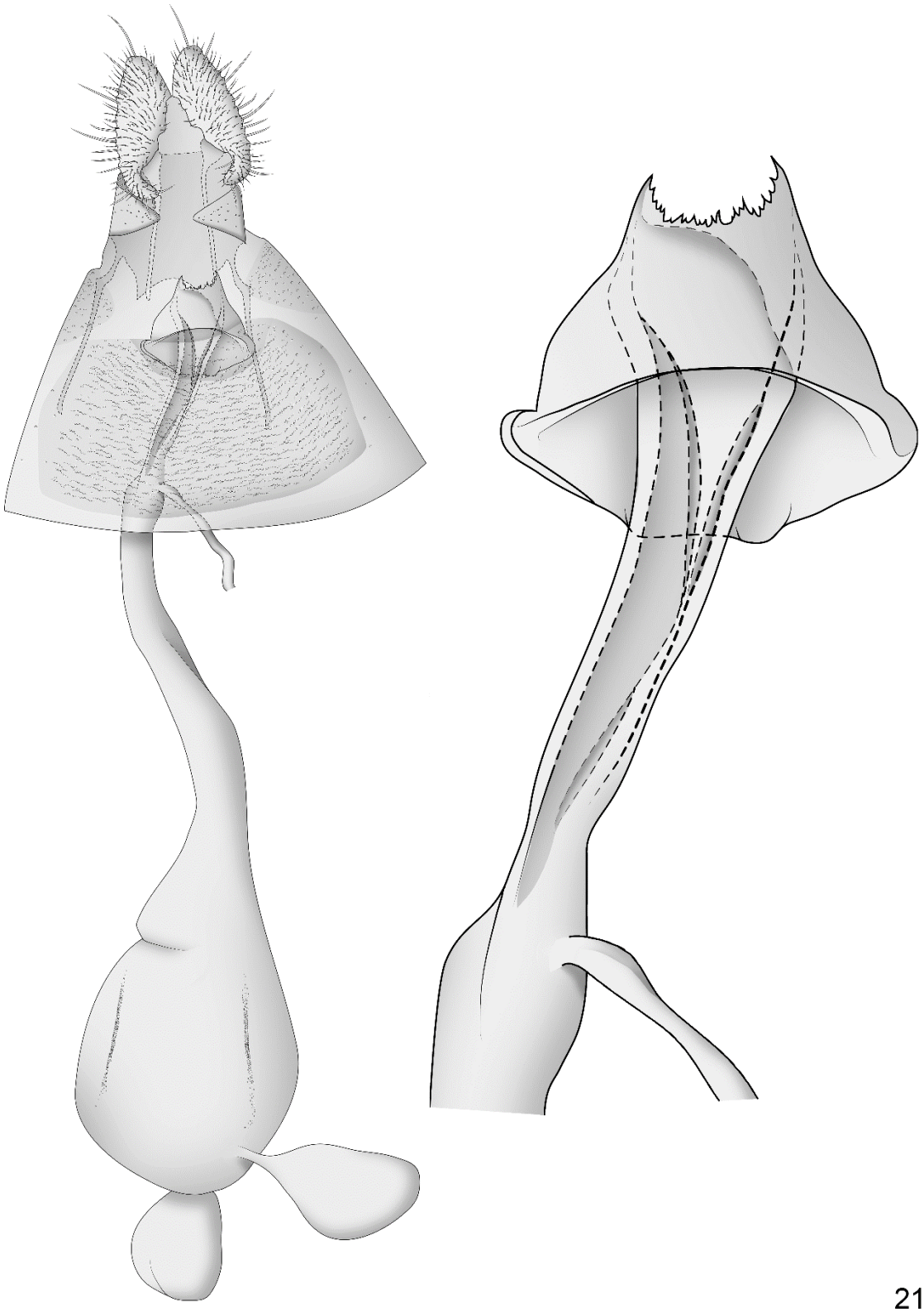

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Fig. 218 female genitalia (with sterigma enlarged) of *Paralobesia aruncana*.

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CHAPTER 4

SCREENING AIDS FOR THE COOPERATIVE AGRICULTURAL PEST SURVEY

Introduction

While the control and understanding of the biology and damage potential of invasive arthropod pests is a high priority for every part of our communities, the first essential step is the accurate identification of potential pests. The Cooperative Agricultural Pest Survey employs a number of methods to facilitate this process across the county. One particular tool is the screening aid. These documents are concise detailed packets of data on the basic biology, trap sorting, and identification of potential pests. They give photograph and dichotomous key based steps for differentiating between a specific target pest and others that they might be confused or trapped with. The CAPS program provides field and port of entry surveyors (also available to the public online) these screening aids for the quick identification of potential pest species, and the protocols to follow if any suspect pests are encountered in these surveys. Here I provide 12 screening aids created for this CAPS initiative.

Screening Aid

Yellow Peach Moth

Conogethes punctiferalis (Guenée)

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9 May 2017

This CAPS (Cooperative Agricultural Pest Survey) screening aid produced for and distributed by:
USDA-APHIS-PPQ National Identification Services (NIS)
This and other identification resources are available at: http://caps.ceris.purdue.edu/taxonomic_services

The yellow peach moth, *Conogethes punctiferalis* (Guenée), belongs to a complex of species native to India, Southeast Asia, and Australia. Larvae are highly polyphagous and feed on fruits in a wide variety of families. Intense feeding on fruits can render them unfit for commercial sale leading to economic losses. Recorded major hosts include, but are not limited to, peach (*Prunus persica*), cacao (*Theobroma cacao*), guava (*Psidium guajava*), durian (*Durio zibethinus*), pomegranate (*Punica granatum*), maize (*Zea mays*), apple (*Malus* ssp.), onion (*Allium cepa*), castor (*Ricinus communis*), and cardamom (*Elettaria cardamomum*). Boring by larvae can cause extensive damage and frass accumulation, but may also predispose fruits to secondary pathogens, adding to crop loss. Although not present in the continental U.S., there are records of this complex from Hawaii.

Fig. 1: *Conogethes punctiferalis* male (Photo by Christi Jaeger, MEM).

Fig. 2: Larval damage in peach (Photo by Masataka Qingdao).

Conogethes punctiferalis is a member of the Crambidae (Spilominae), a large group of moths formally placed in the Pyralidae that contains many pests. This species belongs to a complex that contains an unknown number of species that are very similar morphologically and have larvae that cause significant economic damage to a number of hosts. Adults have a forewing length of 9-15 mm with both fore- and hindwings colored pale straw yellow and marked with numerous black spots. Rows of black spots are present on the first four abdominal segments and males have black scales on abdominal segment 8. The yellow peach moth is somewhat similar in appearance to other yellow-colored moths within the subfamily Spilomelinae. Final identification requires dissection of adult male genitalic structures.

This aid is designed to assist in the sorting and screening *C. punctiferalis* suspect adults collected from CAPS pheromone traps in the continental United States. It covers basic sorting of traps and first, and second level screening, all based on morphological characters. Basic knowledge of Lepidoptera morphology is necessary to screen for *C. punctiferalis* suspects.

Conogethes punctiferalis pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths have a forewing length of 9-15 mm (0.3-0.6 in) (Fig. 3).

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3. Note that moths caught on their side or back may have a different outline.

3) Wings are a pale yellow with numerous dark brown to black spots (Fig. 4).

Note that the appearance of moths caught in sticky traps can vary substantially depending on the amount of sticky glue on the moth (most individuals usually appear darker when covered in glue). For this reason, any small, crambid-like moth meeting the above criteria should be sent forward to Level 1 Screening.

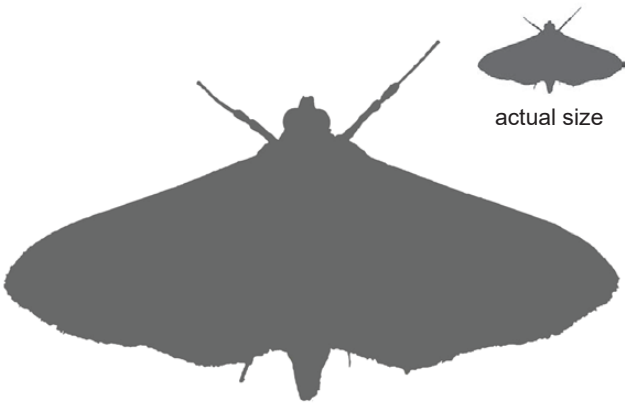

Fig. 3: Outline and size of a resting *C. punctiferalis*. Crambids have a a variety of resting postures, resting with wings spread to the sides or folded back.

Fig. 4: Wing pattern and coloration of *C. punctiferalis* male (top) and female (bottom). Males have black scales on the 8th abdominal segment (Top photo by Christi Jaeger, MEM).

Level 1 Screening

Yellow Peach Moth
Conogethes punctiferalis (Guenée)

Moths that meet the sorting requirements should be screened for suspect crambids. Level 1 Screening is difficult for small moths (like crambids) and may need to be performed by a trained Lepidopterist. When in doubt distinguishing or evaluating first-level screening characters, forward traps that have passed the sorting requirements to a trained taxonomist. Suspect crambids in traps should not be manipulated or removed for screening unless expertise is available.

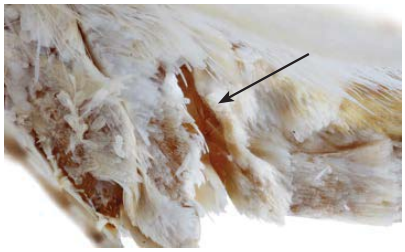

Fig. 5: Tympanum present at abdominal base of all Pyraloidea. (Photo by Hanna Royals)

Crambid moths can be identified by the following combination of characters (note that some characters may be difficult to see on specimens coated in sticky trap glue):

1) Tympanum present at base of abdomen and widely open anteriorly (Fig. 5). Noctuoidea have a tympanum on the thorax near the junction with the abdomen. Tympanal organs may be difficult to see without manipulating the specimen.

2) Labial palpi pointed and upturned (Fig. 6). Some species have very long labial palpi.

3) Proboscis (tongue) is scaled (Fig. 6). Members of the Tortricidae have an unscaled proboscis.

4) Chaetosema (patch of bristle-like setae) absent in the Spilomelinae (not shown). Note that the presence or absence of chaetosemata may be difficult to see without a high-quality microscope.

Fig. 6: Head of *Conogethes punctiferalis* showing scaled proboscis and upturned labial palpi. (Photo by Hanna Royals)

Moths meeting the above criteria should be moved to Level 2 Screening (Page 4). Traps to be forwarded to another facility for Level 2 Screening should be carefully packed following the steps outlined in Fig. 7. Traps should be folded, with glue on the inside, making sure the two halves are not touching, secured loosely with a rubber band, and placed in a plastic bag for shipment. Insert 2-3 styrofoam packing peanuts on trap surfaces without moths to cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. DO NOT simply fold traps flat or cover traps with transparent plastic wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

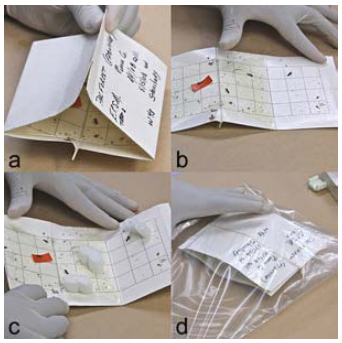

Fig. 7: Recommended packing method for shipment of sticky traps: a & b) open and unfold trap; c) place 2-3 packing peanuts in areas of trap with no moths; d) fold trap, secure with rubber band, and place in plastic bag.

Suspect crambids should be cleaned to identify suspect *C. punctiferalis* individuals. Instructions on cleaning specimens caught in sticky traps are found here: http://idtools.org/id/leps/tortai/dissections.html.

Level 2 Screening is based mainly on wing color and pattern. Genitalic dissection by a specialist is required for species-level identification.

Wing Pattern

North American non-targets that are most likely to be confused with *C. punctiferalis* (Fig. 8) are other yellow-colored moths within the subfamily Spilomelinae. These include several species in the genus *Polygrammodes* and *Phaedropsis stictigramma.* Two species, *Polygrammodes flavidalis* and *P. oxydalis* (both eastern U.S.), are similar in color but have indistinct dashes rather than dark wing spots as in *C. punctiferalis* (Figs. 9-10). *Polygrammodes elevata* (southern Florida) has wing spots similar to that of *C. punctiferalis*, but these are generally smaller and purple in color (Fig. 11). *Phaedropsis stictigramma* (central to southern Florida) lacks black spotting on the abdominal segments athough white bands are pesent on some segments; males have dark scales on abdominal segment 8, similar to *C. punctiferalis.* However, wings of *P. stictigramma* are deeper yellow, more sparsely spotted, and have a black outer margin that is not present in *C. punctiferalis* (Fig. 12).

Fig. 8: *C. punctiferalis*

Fig. 9: *Polygrammodes flavidalis*

Fig. 10: *Polygrammodes oxydalis*

Fig. 11: *Polygrammodes elevata*

Fig. 12: *Phaedropsis stictigramma*

Key and References

Key to Sort and Screen *Conogethes punctiferalis* Suspects in the United States

1. Moth forewing length 9-15 mm; overall shape is typical for a crambid (Fig. 3); and wings and abdomen a pale yellow with dark spots (Fig. 4) 2
1'. Moth forewing length larger or smaller than 9-15 mm; overall shape not typically crambid; or wings and abdomen not yellow with dark spots..... Not *C. punctiferalis*

2. Abdominal tympana present; labial palpi upcurved; and proboscis scaled..... ***C. puntiferalis* suspect**
2'. Abdominal tympana absent; labial palpi projecting forwards; or proboscis not scaled..... Not *C. punctiferalis*

Citation

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Screening Aid

Christmas Berry Webworm

Cryptoblabes gnidiella (Millière)

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The Christmas berry webworm, *Cryptoblabes gnidiella* (Millière), is an important pest in the Mediterranean region. This species is usually associated with other plant pests, especially various species of mealybugs and scale insects (Coccoidea) including the citrus mealybug (*Planococcus citri*) and a number of *Pseudococcus* species. Larvae feed on the sugary feces, or "honeydew," excreted by the mealybugs. Major larval hosts include various citrus species such as orange, grapefruit, and lemon (*Citrus* spp.), avocado (*Persea americana*), pomegranate (*Punica granatum*), and grape (*Vitis* spp.) In Hawaii, this pest has been recorded on coffee (*Coffea arabica*), corn (*Zea mays*), green beans (*Phaseolus vulgaris*) and *Sorghum*. On grape, *C. gnidiella* is usually found on plants damaged by other insects, including *Lobesia botrana* (Tortricidae; recently eradicated from California). If introduced into the continental United States, *C. gnidiella* is most likely to spread to wherever associated host plants and coccids are found and could pose a threat to grape and citrus production.

Fig. 1: *Cryptoblabes gnidiella* larva (Photo by Lyle Buss, University of Florida).

Cryptoblabes gnidiella is a member of the Phycitinae subfamily of snout moths (Pyralidae). A native of the Mediterranean regon, *C. gnidiella* is currently distributed through parts of Asia, Africa, Europe, South America, and the Caribbean. This species has also been introduced to Fiji, New Zealand, and Hawaii. USDA records indicate that *C. gnidiella* has been intercepted from numerous countries where it has not been reported, so it may be more widespread than the literature indicates. Adult forewing length ranges from 5.0-6.5 mm. The forewing is greyish brown with a variable amount of white coloring and scattered reddish-brown scales, giving a purplish appearance. The hindwing is shining white with conspicuous brownish-grey veins and white fringe. With its relatively simple and variable coloration, the honeydew moth can be confused with numerous other pyralids. *Duponchelia fovealis*, another invasive pyralid recently introduced into the U.S. from Europe, is attracted to the same pheromone lure.

This aid is designed to assist in the sorting and screening *C. gnidiella* suspect adults collected from CAPS pheromone traps in the continental United States. It covers basic sorting of traps and first level screening, all based on morphological characters. Basic knowledge of adult lepidopteran morphology is necessary to screen for *C. gnidiella* suspects. Genitalic dissection by a trained lepidopterist is necessary for a species-level identification.

Fig. 2: Top: Larval damage on grape clusters (Photos by Cristiane G. Manzoni and Jose M. Soares). Bottom: A mealybug (*Planococcus* sp.) commonly associated with *Cryptoblabes gnidiella* (Photo by Christian Fischer).

LEPIDOPTERA PYRALIDAE

Sorting

Christmas Berry Webworm
Cryptoblabes gnidiella (Millière)

Cryptoblabes gnidiella pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths are approximately 5-7 mm long (Fig. 3)

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3. Note that moths caught on their side or back may have a different outline.

3) Moth foreweing is a greyish-brown with a variable amount of white and red coloring. Hindwings are pale to white with darker brown scaling along the veins. (Fig. 4)

Note that the appearance of moths caught in sticky traps can vary substantially depending on the amount of sticky glue on the moth (most individuals usually appear darker when covered in glue). For this reason, any small, pyralid-like moth meeting the above criteria should be sent forward to Level 1 Screening.

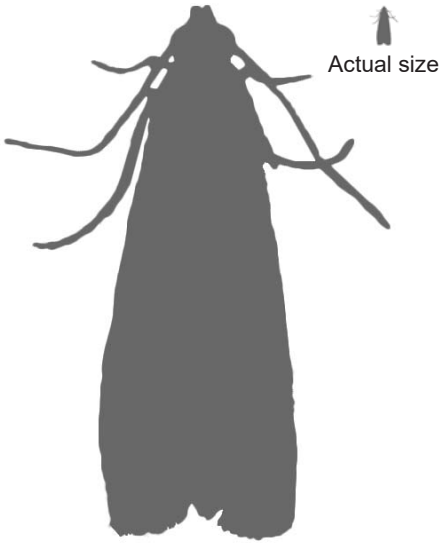

Fig. 3: Outline of a resting *Cryptoblabes gnidiella*. Pyralids have a a variety of resting postures, resting with wings folded over the back or spread to the sides.

Fig. 4: Typical coloration of an adult *Cryptoblabes gnidiella* (male) (Photo by Hanna Royals). Note the red/purple hues of the forewings and pale hindwings with darking scaling along wing veins.

Fig. 5: Typical resting posture of *Cryptoblabes gnidiella* (Photo by Pathpiva, Site de lépidoptères de France méridionale et de Corse, pathpiva.fr).

Level 1 Screening

Christmas Berry Webworm
Cryptoblabes gnidiella (Millière)

Moths that meet the sorting requirements should be screened for suspect pyralids. Level 1 Screening is difficult for small moths (like pyralids) and may need to be performed by a trained Lepidopterist. When in doubt distinguishing or evaluating first-level screening characters, forward traps that have passed the sorting requirements to a trained taxonomist. Suspect pyralids in traps should not be manipulated or removed for screening unless expertise is available.

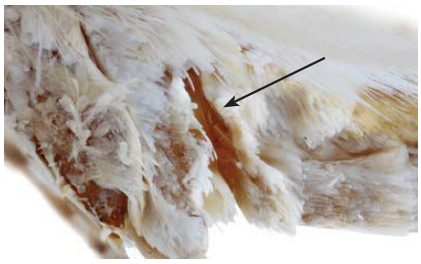

Fig. 6: Tympanum present at abdominal base of all Pyraloidea (Photo by Hanna Royals).

Pyralid moths can be identified by the following combination of characters (note that some characters may be difficult to see on specimens coated in sticky trap glue):

1) Tympanum present at base of abdomen (Fig. 6). Noctuoidea have a tympanum on the thorax near the junction with the abdomen. Tympanal organs may be difficult to see without manipulating the specimen.

2) Labial palpi pointed and porrect or upturned (Fig. 7). Some species have very long labial palpi.

3) Proboscis (tongue) is scaled (Fig. 7). Members of the Tortricidae have an unscaled proboscis.

Fig. 7: Head of *Cryptoblabes gnidiella* showing scaled proboscis and upturned labial palpi. (Photo by Hanna Royals)

Traps to be forwarded to another facility for additional Screening should be carefully packed following the steps outlined in Fig. 8. Traps should be folded, with glue on the inside, making sure the two halves are not touching, secured loosely with a rubber band, and placed in a plastic bag for shipment. Insert 2-3 styrofoam packing peanuts on trap surfaces without moths to cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. DO NOT simply fold traps flat or cover traps with transparent plastic wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

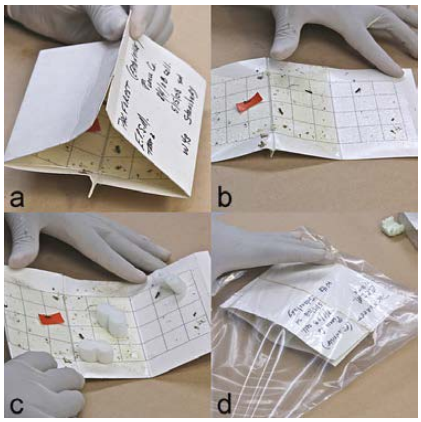

Fig. 8: Recommended packing method for shipment of sticky traps: a & b) open and unfold trap; c) place 2-3 packing peanuts in areas of trap with no moths; d) fold trap, secure with rubber band, and place in plastic bag.

In Italy, Bagnoli and Lucchi (2001) reported a variety of noctuids, tortricids, and other pyralids when trapping for *C. gnidiella* using a 4-component pheromone lure. However, CAPS surveys specify a 2-component lure, so it is unknown if the same range of species will be attracted.

The only non-target captured by Bagnoli and Lucchi (2001) present in the U.S. is *D. fovealis* (Figs. 11-12), the European pepper moth. This species is a greenhouse pest native to Europe that was first detected in California in 2005. It has since been found in Alabama, Arizona, Colorado, Florida, Georgia, Mississippi, New York, North Carolina, Oklahoma, Oregon, South Carolina, Tennessee, Texas, and Washington. The two species can be easily separated by forewing pattern: the forewings of *D. fovealis* are gray to grayish brown with white transverse lines, the outermost line projecting towards the termen.

Other pyralids are similar in color and size to *C. gnidiella*, such as *Cosipara tricoloralis* (Fig. 10). The wing pattern and color may be difficult to determine for moths covered in sticky glue. When in doubt, submit all specimens for identification that meet the criteria for Level 1 Screening.

Fig. 9: *Cryptoblabes gnidiella* (Photo by Hanna Royals)

Fig. 10: *Cosipara tricoloralis* (Photo by Hanna Royals)

Fig. 11: Male *Duponchelia fovealis* (Photo by Lyle Buss, University of Florida).

Fig. 12: Female *Duponchelia fovealis* (Photo by Lyle Buss, University of Florida).

Key and References

Key to Sort and Screen *Cryptoblabes gnidiella* Suspects in the United States

1. Moth forewing length 5-7 mm; overall shape typical pyralid-like (Fig. 3); and forewings mottled brown with white, red or purple scattered scaling as in Fig. 4 2
1'. Moth forewing length larger or smaller than 5-7 mm long; overall shape not typically pyralid; or forewings not mottled brown with white, red or purple scattered scaling ..... Not *C. gnidiella*

2. Abdominal tympana present; labial palpi upcurved; and proboscis scaled ..... ***C. gnidiella* suspect**
2'. Abdominal tympana absent; labial palpi projecting forwards; or proboscis not scaled ..... Not *C. gnidiella*

Citation

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Acknowledgments

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Screening Aid

Nettle Caterpillar
Darna pallivitta (Moore)

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The nettle caterpillar, *Darna pallivitta*, is well-known as a painful pest throughout much of Asia. It was first discovered in Hawaii in 2001 and, as of 2010, it has been reported from three Hawaiian Islands and intercepted as larvae and pupae in cargo en route to California. Larvae are highly polyphagous feeders, with at least 45 recorded hosts plants, and can cause extensive defoliation. The nettle caterpillar seems to prefer those plants in the palm (Arecaceae) and grasses (Poaceae) families but has been recorded feeding on many different weedy and ornamental plants in nurseries and at residences. In addition to plant damage, these larvae can cause extreme irritation to people who come into contact with its toxin-producing spines. Should it become established on the mainland, suitable habitat in the U.S. would likely be limited to the very southern states as *D. pallivitta* does not tolerate cooler temperatures.

Fig. 1. Dorsal view of late instar larva with characteristic 4 orange spines (Photo by Walter T. Nagamine, Hawaii Deptartment of Agriculture).

Fig. 2. Lorsal view of late instar larva (Photo by Hawaii Department of Agriculture).

Fig. 3. Larval damage on palm frond (Photo by Hawaii Department of Agriculture).

Darna pallivitta is a member of the Limacodidae, the slug caterpillar moths. Larval stages of this family often have stinging spines. Adults of *D. pallivitta* are different in size, females usually several millimeters larger than males. Males and females can also be distinguished by their bipectinate antennae in males and filiform antennae in females. The forewing of the nettle caterpillar moth is divided by a very conspicuous diagonal white line running from the apex down to the inner margin. The basal half of the divided forewing is rust-colored while the distal half is generally brown. Hindwings are lighter brown. Others species in the Limacodidae have similar lined markings on their forewings but all are quite distinct if observed closely. When resting, adult wings have a tulip shape; the wing shape might be difficult to observe in trapped specimens. While forewing pattern is a useful tool for identifying suspects, genitalic dissection should be performed for final identification.

This aid is designed to assist in the sorting and screening *D. pallivitta* suspect adults collected from CAPS pheromone traps in the continental United States. It covers basic sorting of traps and first and second level screening, all based on morphological characters. Basic knowledge of Lepidoptera morphology is necessary to screen for *D. pallivitta* suspects.

Sorting

Nettle Caterpillar
Darna pallivitta (Moore)

Darna pallivitta pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths have a forewing length of 8.0-12.0 mm (0.31-0.48 inches) with females being larger than males.

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3, but be aware that moths often do not die in a natural position when captured in traps.

3) Moth forewings are a rusty-brown, tulip-shaped, and have one or more lines running from the apex.

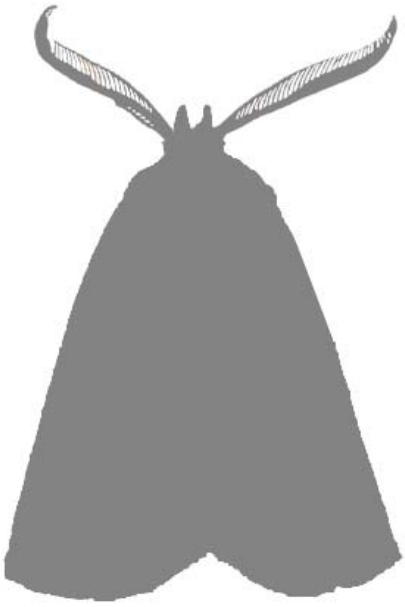

Fig. 3. Shape of resting adult male

Actual size

Fig. 4. Adult male

Fig. 5. Adult male

Fig. 6. Adult female

(Wing patterns of adult *D. pallivitta* are consistent between individuals and sex)

Level 1 Screening

Nettle Caterpillar
Darna pallivitta (Moore)

Commonly encountered North American non-targets for *D. pallivitta* likely include representatives from the family Limacodidae (slug caterpillar moths).

Moths that meet the sorting requirements should be screened for suspect limacodids. Level 1 Screening is difficult for small moths and may need to be performed by a trained Lepidopterist. When in doubt distinguishing or evaluating first-level screening characters, forward traps that have passed the sorting requirements to a trained taxonomist. Suspect moths in traps should not be manipulated or removed for screening unless expertise is available.

Fig. 7. Lateral view of densely-scaled head and forward-facing porrect labial palpi (note that males will have bipectinate antennae, not shown here).

Male limacodid moths can be identified by the following combination of characters (note that some characters may be difficult to see on specimens coated in sticky trap glue):

1) Body is stout, wings are rounded and densely scaled.

2) Maxillary palpi and proboscis are either vestigial or absent.

3) Labial palpi are are three-segmented and usually short and porrect.

4) Antennae are bipectinate.

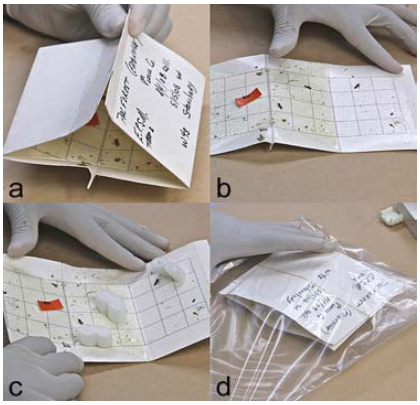

Fig. 8: Recommended packing method for shipment of sticky traps: a & b) open and unfold trap; c) place 2-3 packing peanuts in areas of trap with no moths; d) fold trap, secure with rubber band, and place in plastic bag (Photos by E. LaGasa, WSDA).

Moths meeting the above criteria should be moved to Level 2 Screening (Page 4). Traps to be forwarded to another facility for Level 2 Screening should be carefully packed following the steps outlined in Fig. 8. Traps should be folded, with glue on the inside, making sure the two halves are not touching, secured loosely with a rubber band or a few small pieces of tape. Plastic bags can be used unless the traps have been in the field a long time or contain large numbers of possibly rotten insects. Insert 2-3 styrofoam packing peanuts on trap surfaces without moths to cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. DO NOT simply fold traps flat or cover traps with transparent plastic wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

Level 2 Screening

Nettle Caterpillar
Darna pallivitta (Moore)

Suspect limacodids should be cleaned to identify suspect *D. pallivitta* individuals. Instructions on cleaning specimens caught in sticky traps can be found here: http://idtools.org/id/leps/tortai/dissections.html.

Cleaned specimens should be pinned and labeled. Level 2 Screening is based solely on forewing patten. While visual comparison should suffice to tentatively identify *D. pallivitta*, inspection of dissected genitalia by a specialist should be used for a more accurate species-level identification. Confusion is most likely to occur with other Limacodidae moths.

Forewing Pattern

The distinguishing feature of the forewings is the white or light-colored line that runs from the apex to the inner margin (Fig. 9). The basal half of the divided wing is rusty brown while the distal half is a duller brown color. Close comparison of forewings of other limacodids is important for identification as markings are similar. *Apoda rectilinea* (Fig. 11) also has a white line dividing the wing but this runs from the costa to the inner margin rather than starting at the apex as in *D. pallivitta* (Fig. 9). Other species have forewings with more than one line or more uniform coloring (Figs. 10 & 12).

Fig. 9. *Darna pallivitta*

Fig. 10. *Natada nasoni*

Fig. 11. *Apoda rectilinea*

Fig. 12. *Apoda y-inversa*

Fig. 13. *Apoda y-inversa*

Fig. 14. *Apoda y-inversa*

Fig. 15. *Adoneta spinuloides*

Fig. 16. *Apoda rectilinea*

Fig. 17. *Apoda rectilinea*

Fig. 18. *Packardia elegans*

Fig. 19. *Natada nasoni*

Fig. 20. *Natada nasoni*

Fig. 19. *Tortricidia testacea*

Figures 13-21 represent a variety of North American limacodid species that have similar forewing patterns or that might be encountered during *D. pallivitta* surveys. Non-targets will vary by region and these species have not been confirmed to be attracted to *D. pallivitta* pheromone lures.

References

Key to Sort and Screen *Darna pallivitta* Suspects in the United States

1. Moth forewings measure approximately 8-12 mm long; overall shape typical limacodid-like (Figs. 3-6); forewings brown with a white line 2
1'. Moth forewings are larger or smaller than 8-12 mm long; overall shape not typically limacodid-like; or forewing not brown and lacks lines ..... Not *D. pallivitta*

2. Antennae pectinate; labial palpi 3-segmented, short and porrect; proboscis and maxillary palpi absent 3
2'. Antennae filiform or not pectinate; labial palpi not short or porrect; or proboscis and maxillary palpi present ..... Not *D. pallivitta*

3. White line runs from apex to inner margin of forewing and divides forewing into a rust-colored basal half and a dull-brown distal half (Figs. 4-6, 9) ..... ***D. pallivitta* suspect**
3'. White line not present; or multiple lines present on forewing ..... Not *D. pallivitta*

Citation

Royals, H. R., T. M. Gilligan, S. C. Passoa and M. E. Epstein. 2016. Screening aid: Nettle caterpillar, *Darna pallivitta* (Moore). Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 6 pp.

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Screening Aid

Cherry Bark Tortrix

Enarmonia formosana (Scopoli)

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The cherry bark tortrix (CBT), *Enarmonia formosana* (Scopoli), is a minor pest in Europe that has become established in the Pacific Northwest of North America. It first appeared in British Columbia in 1990, rapidly spreading to neighboring Washington by 1991, and also now to Oregon. The larva feed on a wide variety of fruit trees. While CBT prefers those in *Prunus*, especially cherry, any woody shrub or tree in the Rosaceae family is at risk of infestation. Damage from larvae depends on the intensity of the infestation and can take years to kill a host plant, but feeding and other damage by larvae can provide the opportunity for secondary bacterial and fungal pathogen entry.The widespread presence of appropriate host plants in the northwestern U.S. could aid in the rapid spread of this moth. While there are two observed peaks of flying adults in the late summer, there is apparently only one annual generation. Various larval instars overwinter giving an appearance of subsequent multiple generations.

Fig. 1. *Enarmonia formosana* adult in resting position (Photo by Csaba Szaboxy, Bugwood.org: 5429104).

Enarmonia formosana is a member of the Tortricidae, the leaf-roller moths, one of the largest families of microlepidoptera with over 10,000 described species. The CBT resembles other species of the subfamily Olethreutinae but can be distinguished by careful inspection of the wing pattern and by the unique structures of the male and female genitalia. There is little sexual dimorphism in general habitus between male and female CBT. Forewing length is between 7.0-9.0 mm and forewing pattern consists of a black ground-color and silver and yellow markings with three conspicuous parallel black bars that form the “eye spot” near the end of the wings (Fig. 10). Hindwings are mostly dusky-gray to black. While many olethreutine species lack a defined eye spot, that of *E. formosana* is more well-defined and larger than in several common non-target species such as *Episimus argutanus* (Fig. 10c).

Fig. 2. Curled bark and frass tubes left by feeding larvae (Photo by Todd Morray, WSU:Skamania County Extension).

This aid is designed to assist in the sorting and screening *C T* suspect adults collected from CAPS pheromone traps in the continental United States. It covers basic sorting of traps and first and second level screening, all based on morphological characters. Basic knowledge of Lepidoptera adult morphology is necessary to screen for *C T* suspects.

Enarmonia formosana pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths have a forewing length of 7.0 - 9.0 mm (0.25-0.35 inches).

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3, but be aware that moths sometimes do not die in a natural position when captured in traps.

3) Moth forewings are black with intricate silver-grey and yellow markings (Figs. 4-7,10).

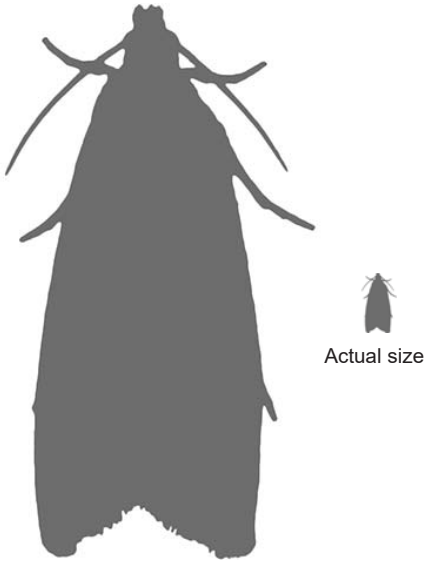


Fig. 3. General shape of resting adult. Dorsal view.

Fig. 4. Adult male

Fig. 5. Adult male

Fig. 6. Adult female

Fig. 7. Adult female

Figs. 4-7. Wing patterns of adult *E. formosana* are consistent between individuals and sex.

Level 1 Screening

Cherry Bark Tortrix
Enarmonia formosana (Scopoli)

Commonly encountered North American non-targets for *C T* include representatives from a number of families in addition to Tortricidae including: Gelechiidae, Geometridae, Lymantriidae, Oecophoridae, and Yponomeutidae. Moths that meet the sorting requirements should be screened for suspect tortricids. Level 1 Screening is difficult for small moths (like tortricids) and may need to be performed by a trained Lepidopterist. When in doubt distinguishing or evaluating first-level screening characters, forward traps that have passed the sorting requirements to a trained taxonomist. Suspect tortricids in traps should not be manipulated or removed for screening unless expertise is available.

Fig. 8: Tortricid head; ch = chaetosema; oc = ocellus; lp = labial palpi. Note that the chaetosema is above the compound eye behind the ocellus (Photo from Gilligan et al. 2008).

Tortricid moths can be identified by the following combination of characters (note that some characters may be difficult to see on specimens coated in sticky trap glue):

1) Antennae simple, threadlike, and never pectinate (comb-like).

2) Tympanum absent. Pyraloidea and Geometridae have a tympanum at the base of the abdomen. Noctuoidea have a tympanum on the thorax near the junction with the abdomen. Tympanal organs may be difficult to see without manipulating the specimen.

3) Labial palpi pointed and projecting forwards (Fig. 6). Some families (especially in the Gelechioidea) have long labial palpi that curve upwards over the head - these are not tortricids.

4) Maxillary palpi are very reduced and not visible in tortricids. Maxillary palpi are conspicuous in some commonly captured pyraloid species.

5) Proboscis (tongue) unscaled. Members of the Gelechioidea and Pyraloidea have a scaled proboscis.

6) Chaetosema (patch of bristle-like setae) present above the compound eye behind the ocellus (Fig. 6). Note that chaetosemata may be difficult to see without a high-quality microscope.

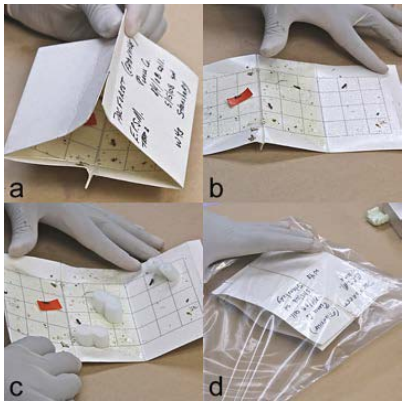


Fig. 9: Recommended packing method for shipment of sticky traps: a & b) open and unfold trap; c) place 2-3 packing peanuts in areas of trap with no moths; d) fold trap, secure with rubber band, and place in plastic bag (Photos by E. LaGasa, WSDA).

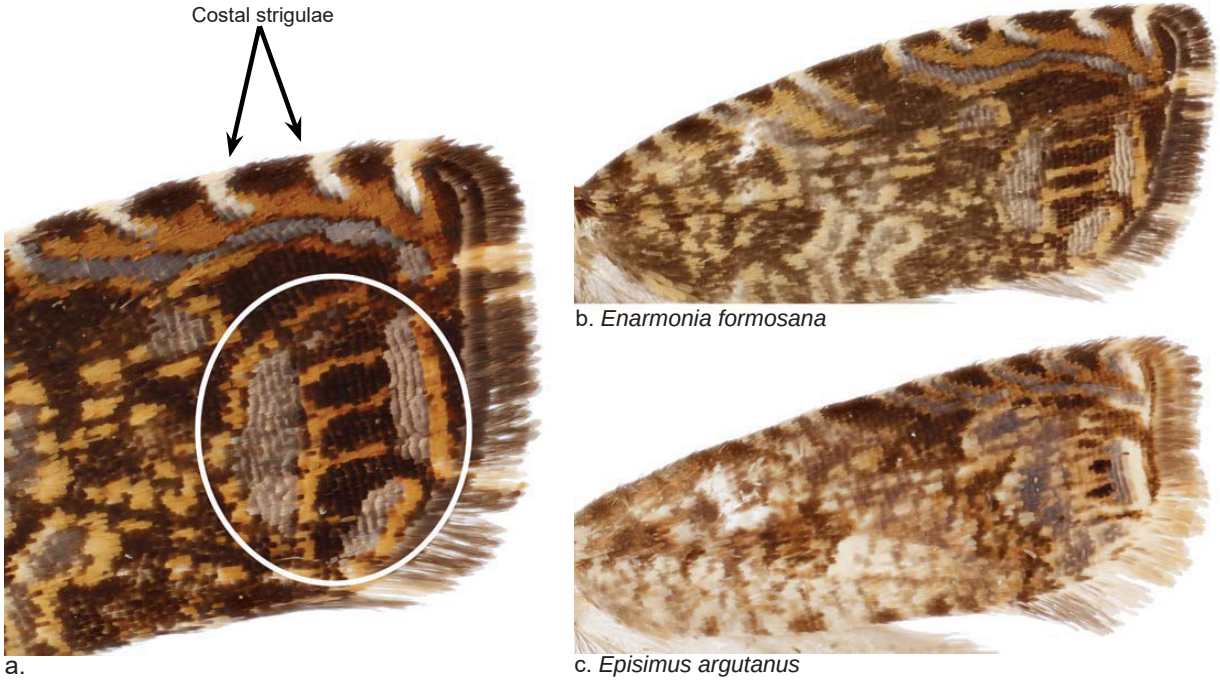
Moths meeting the above criteria should be moved to Level 2 Screening (Page 4). Traps to be forwarded to another facility for Level 2 Screening should be carefully packed following the steps outlined in Fig. 9. Traps should be folded, with glue on the inside, making sure the two halves are not touching, secured loosely with a rubber band or a few small pieces of tape. Plastic bags can be used unless the traps have been in the field a long time or contain large numbers of possibly decaying insects. Insert 2-3 styrofoam packing peanuts on trap surfaces without moths to cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. DO NOT simply fold traps flat or cover traps with transparent plastic wrap (or other material), as this will seriously damage or fragment specimens – making identification difficult or impossible.

Suspect tortricids should be cleaned to identify suspect *E. formosana* individuals. Instructions on cleaning specimens caught in sticky traps can be found here: http://idtools.org/id/leps/tortai/dissections.html.

Cleaned specimens should be pinned and labeled. Level 2 Screening is based almost exclusively on wing pattern. While visual comparison should suffice to properly identify *E. formosana*, inspection of dissected genitalia by a specialist can be used for more accurate species-level identification. Confusion is most likely to occur with *Episimus argutanus* one of the more common non-targets with a wing pattern similar to that of *E. formosana*, having a well-defined forewing eye spot.

Forewing Pattern

Forewings have a dark brown to black ground color and are intricately marked with yellow-orange and silver-grey patterning. A distinguishing feature of CBT is the conspicuous eye-spot, or ocellus, anterior to the tornus, about 1/2 as wide as the termen, with an outer ring that is golden-brown, a silver inner ring, and a center containing alternating brown or black and yellow-orange longitudinal dashes (Figs. 10a,b). Costal strigulae are well-defined and consist of shiny white comma-shaped streaks separated by black marks. The eye spot in *E. argutanus* is not as well-defined, with smaller black dashes (Fig. 10c).



a.

b. *Enarmonia formosana*

c. *Episimus argutanus*

Fig. 10. a) Costal strigulae and ocellus on forewing of adult *E. formosana.* b) Forewing patterns of *E. formosana* and c) *E. argutanus*.

Level 2 Non-targets

Cherry Bark Tortrix
Enarmonia formosana (Scopoli)

Fig. 11. *Episimus argutanus*

Fig. 12. *Ancylis ocellana*

Fig. 13. *Archips fuscopreanus*

Fig. 14. *Acleris holmiana*

Fig. 15. *lethreutes auricapitana*

Fig. 16. *lethreutes astrologana*

Fig. 17. *otocelia rosaecolana*

Fig. 18. *rapholita prunivora*

Fig. 19. *Eucosmomorpha nearctica*

Fig. 20. *Retinia picicolana**

Fig. 21. *Endothenia hebesana*

Fig. 22. *Choristoneura rosaceana*

Fig. 23. *Argyrotaenia franciscana*

Fig. 24. *Acleris variegana*

Fig. 25. *rapholita lunatana*

Fig. 26. *Cacoecimorpha pronubana*

A sampling of North American tortricid non-targets (Figs. 11-26). Names with an * denote species that were collected in CBT sticky traps in previous surveys. The most common tortricid non-target is *Episimus argutanus* (Fig. 11). CBT traps also capture other families of moths; see page 3 for instructions on screening tortricid suspects. Non-target data was obtained from Washington State Department of Agriculture CBT trap records (1991-2011) for the Pacific Northwest and Passoa (1991) for the Northeast.

References

Key to Sort and Screen *Enarmonia formosana* Suspects in the United States

1. Moth forewings measure approximately 7-9 mm long; overall shape typical tortricid-like (Fig. 3); and forewings mottled brown-black and yellow 2
1'. Moth forewings are larger or smaller than 7-9 mm long; overall shape not typically tortricid; or forewing color not mottled brown-black and yellow ..... Not *E. formosana*

2. Abdominal or thoracic tympana absent; antennae simple; labial palpi projecting forward; proboscis not scaled; and chaetosemata present 3
2'. Abdominal or thoracic tympana present; antennae pectinae; labial palpi upcurved; proboscis scaled; or chaetosemata absent ..... Not *E. formosana*

3. Forewing costal strigulae and ocular spot well-defined and markings and similar to those in Figs. 4-7, 10a, b ..... ***E. formosana suspect***
3'. Forewing costal strigulae and ocular spot absent or poorly-defined; or forewing pattern drastically different than illustrated in Figs. 4-7, 10a, b ..... Not *E. formosana*

Citation

Royals, H. R., T. M. Gilligan, C. Looney and S. C. Passoa. 2016. Screening aid: Cherry bark tortrix, *Enarmonia formosana* (Scopoli). Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 6 pp.

References for more information on *E. formosana* and non-targets

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Acknowledgments

We would like to thank USDA-APHIS-PPQ National Identification Services and the USDA-APHIS-PPQ-S&T Identification Technology Program for support of this work. Funding for this project was provided to H. Royals through section 10007 of the 2014 Farm Bill.

Screening Aid

Avocado Seed Moth

tenoma catenifer Walsingham

Hanna R. Royals[1], Todd M. Gilligan[1] and Steven C. Passoa[2]

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Version 2
20 January 2016

This CAPS (Cooperative Agricultural Pest Survey) screening aid produced for and distributed by:
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The avocado seed moth, *teno a catenifer* is one of the most important moth pests in avocado-growing regions of the world. Larvae feed on fruit flesh and burrow into the seed, producing large amounts of frass and causing the fruits to drop from the tree prematurely. Larval damage renders the fruits unfit for commercial sale, leading to significant economic losses. The avocado seed moth has only been recorded as feeding on members of the Lauraceae family, with *ersea a ericana* (avocado) as the major host and other secondary hosts: *schie eana* (coyo), wild *ersea* spp., and *eilsch e ia* spp. California accounts for the majority of avocado production in the U.S., followed by Florida and Hawaii.

Fig. 1. Dorsal (top) and ventral (bottom) views of 5th instar larva of *catenifer* (photo by Mark Hoddle, University of California Riverside)

teno a catenifer is a small moth with few distinguishing features as an adult. While higher taxonomy has changed over the years, the most recent literature places the avocado seed moth in the Depressariidae, a large and variable family with species worldwide. *teno a catenifer* forewings are tan in color with numerous black spots. The defining feature of the forewing pattern is an outline of black dots somewhat resembling a “C” a the distal end of the wing (Figs. 4-6). Hindwings are a uniform lighter tan than the forewings. The large labial palpi of the avocado seed moth have dark-brown/black scaling at the basal end of segment 2 that contrasts with the overall light coloration of the moth (Fig. 7). Adult females are generally several millimeters larger than males, although coloration is consistent between sexes.

Fig. 2. Larval damage on avocado fruit. (photo by Mark Hoddle, University of California Riverside)

This aid is designed to assist in the sorting and screening of *catenifer* suspect adults collected from CAPS pheromone traps in the continental United States. It covers basic sorting of traps and first and second level screening, all based on morphological characters. Basic knowledge of Lepidoptera morphology is necessary to screen for *catenifer* suspects.

teno a catenifer pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths have a forewing length of 8.0-15.0 mm (0.3-0.6 inches).

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3, but be aware that moths sometimes do not die in a natural position when captured in traps.

3) Moth forewings are yellowish-tan in color and may have dark spots (Figs. 4-7,10).

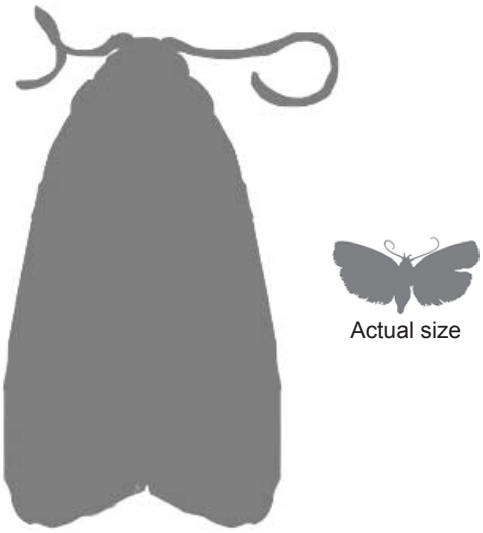

Fig. 3. Resting posture of adult.

Fig. 4. Adult male

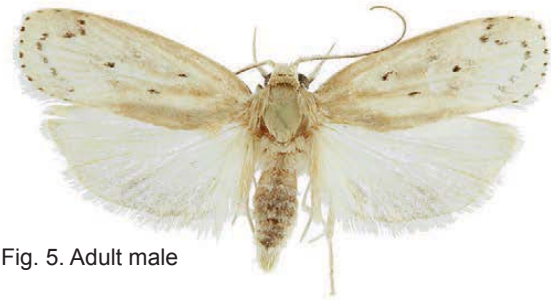

Fig. 5. Adult male

Fig. 6. Adult female

(Wing patterns of adult *catenifer* are consistent between individuals and sex)

Level 1 Screening

Avocado Seed Moth
tenoma catenifer Walsingham

Commonly encountered North American non-targets for *catenifer* include other representatives from the family Depressariidae or the superfamily Gelechioidea. Moths that meet the sorting requirements should be screened for suspect gelechioids. Level 1 Screening is difficult for small moths and may need to be performed by a trained Lepidopterist. When in doubt distinguishing or evaluating first-level screening characters, forward traps that have passed the sorting requirements to a trained taxonomist. Suspect moths in traps should not be manipulated or removed for screening unless expertise is available.

Gelechioid moths, including the Depressaridae can be identified by the following combination of characters (note that some characters may be difficult to see on specimens coated in sticky trap glue):

1) Antennae simple, threadlike, and never pectinate (feathery).

2) Tympanum absent. Pyraloidea and Geometridae have a tympanum at the base of the abdomen. Noctuoidea have a tympanum on the thorax near the junction with the abdomen. Tympanal organs may be difficult to see without manipulating the specimen.

3) Labial palpi are well developed and curve upwards over the head. (Fig. 7). Some families have labial palpi that project forwards - these are not gelechioids.

4) Maxillary palpi are small and inconspicuous. Maxillary palpi are large and conspicuous in some commonly captured pyraloid species.

5) Proboscis (tongue) is scaled (Fig. 7). Members of the Tortricidae have an unscaled proboscis.

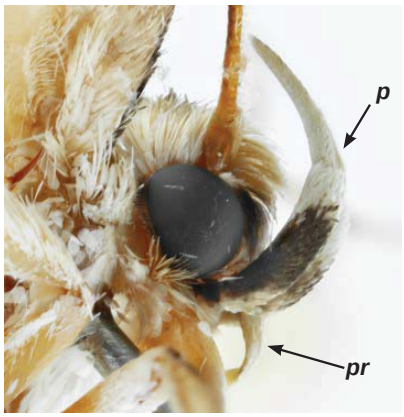

Fig. 7. Upturned labial palpi (lp) and scaled proboscis (pr) are typical of the superfamily Gelechioidea.

Adult moths meeting the above criteria should be moved to Level 2 Screening (Page 4). Traps to be forwarded to another facility for Level 2 Screening should be carefully packed following the steps outlined in Fig. 8. Traps should be folded, with glue on the inside, making sure the two halves are not touching, secured loosely with a rubber band or a few small pieces of tape. Plastic bags can be used unless the traps have been in the field a long time or contain large numbers of possibly rotten insects. Insert 2-3 styrofoam packing peanuts on trap surfaces without moths to cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. DO NOT simply fold traps flat or cover traps with transparent plastic wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

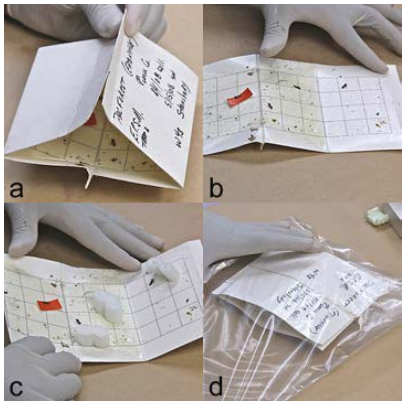

Fig. 8: Recommended packing method for shipment of sticky traps: a & b) open and unfold trap; c) place 2-3 packing peanuts in areas of trap with no moths; d) fold trap, secure with rubber band, and place in plastic bag (Photos by E. LaGasa, WSDA).

Suspect gelechioids should be cleaned to identify suspect *catenifer* individuals. Instructions on cleaning specimens caught in sticky traps can be found here: http://idtools.org/id/leps/tortai/dissections.html.

Cleaned specimens should be pinned and labeled. Level 2 Screening is based on forewing pattern and mouthparts. While visual comparison should suffice to properly identify *catenifer*, inspection of dissected genitalia by a specialist can be used for more accurate species-level identification. Confusion is most likely to occur with other moths in the Depressariidae.

Forewing Pattern

Forewings have a light-yellow or tan coloration with many dark spots throughout. These spots at the distal end of the wing form a rough outline of a “C” shape (Fig. 9). These characters are consistent between individuals and sexes.

Mouthparts

The most obvious character of gelechioids are the large 3-segmented labial palps (lp) that curve upwards over the head. In *catenifer* the palpi have dark scaling on the outside of the second segment. Also present are small maxillary palpi (mp) and a scaled proboscis (pr) (Fig. 10).

Fig. 9. Forewing of adult male showing characteristic “C” shape formed by dark spots.

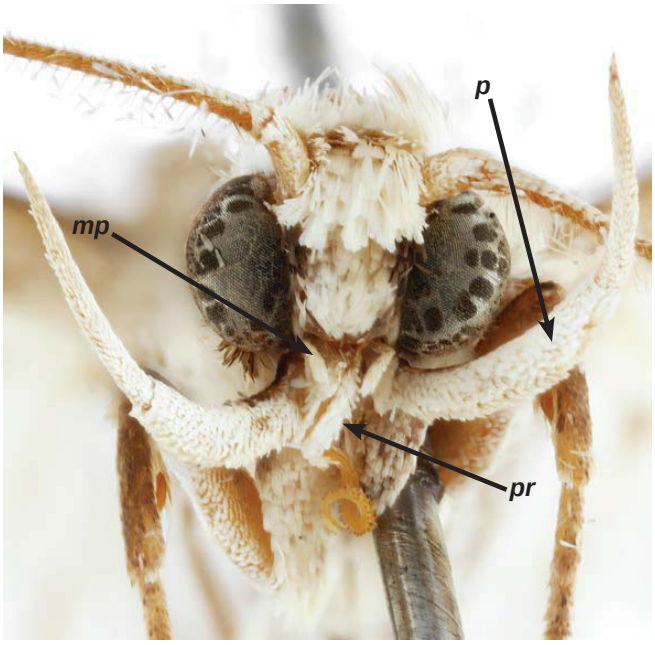

Fig. 10. Anterior view of head showing mouthparts typical of *catenifer*.

Fig. 11. *gonopteri cana ensis*

Fig. 12. *gonopteri cana ensis*

Fig. 13. *gonopteri costi acula*

Fig. 14. *gonopteri pul ipennella*

Fig. 15. *gonopteri ro iniella*

Fig. 16. *gonopteri ro iniella*

Fig. 17. *ntaeotricha unipunctella*

Fig. 18. *ntaeotricha unipunctella*

Fig. 19. *ntaeotricha osseella*

Fig. 20. *ntaeotricha osseella*

Fig. 21. *onioter a istrella*

Fig. 22. *onioter a istrella*

A sampling of possible North American non-targets. Because of a lack of sampling data for the U.S., the exact non-targets that would be attracted to the *catenifer* lure are unknown, and none of the above species have been verified to be found in *catenifer* traps. The most common non-targets from *catenifer* surveys in other countries are species of *ntaeotricha* (Figs. 17-20). Many of the *ntaeotricha* present in the U.S. can be distinguished from *catenifer* by their bright white wings with gray and black markings that resemble bird droppings.

Key and References

Avocado Seed Moth
teno a catenifer Walsingham

Key to Sort and Screen *tenoma catenifer* Suspects in the United States

1. Moth forewings measure approximately 8-15 mm long; overall shape typical for a .gelechioid (Fig. 3); forewings tan with black spots..... 2
1'. Moth forewings larger or smaller than 8-15 mm long; overall shape not typically gelechioid; or forewing color not tan with black spots.....Not *catenifer*

2. Abdominal or thoracic tympana absent; antennae simple; labial palpi large and curved up over head; and proboscis scaled as in Fig. 10 3
2'. Abdominal or thoracic tympana present; antennae pectinae; labial palpi straight or facing forward; or proboscis unscaled .....Not *catenifer*

3. Dark shading present on second segment of labial palpi; dark spots at the end of forewings create an outline of a "C" shape; color and markings similar to those illustrated in Figs. 4-6, 9..... ***. catenifer* suspect**
3'. No dark shading on labial palpi; dark spots at the end of forewings absent or not as an outline of a "C" shape; or forewing pattern drastically different than those illustrated in Figs. 4-6, 9.....Not *catenifer*

Citation

Royals, H. R.,T. M. Gilligan and S. C. Passoa. 2016. Screening aid: Avocado seed moth, *teno a catenifer* Walsingham. Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 6 pp.

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Acknowledgments

We would like to thank USDA-APHIS-PPQ National Identification Services and the USDA-APHIS-PPQ-S&T Identification Technology Program for support of this work. Funding for this project was provided to H. Royals through section 10007 of the 2014 Farm Bill.

Screening Aid

Guatemalan Potato Moth

Tecia solanivora (Povolný)

Hanna R. Royals[1], Todd M. Gilligan[1] and Steven C. Passoa[2]

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2) USDA-APHIS-PPQ, USDA-FS Northern Forest Research Station and Ohio State University, 1315 Kinnear Road, Columbus, Ohio 43212 U.S.A. (Email: Steven.C.Passoa@aphis.usda.gov)

Version 1.0
16 May 2017

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The Guatemalan potato moth, *Tecia solanivora* (Povolný) is a member of the potato tuber moth (PTM) complex, a group of three moths in the Gelechiidae that are important pests of potatoes (*Solanum tuberosum*) in both the field and in storage. Although a native of Central America, *T. solanivora* has been introduced to Mexico, South America (Colombia, Ecuador, Venezuela, and Peru), and the Canary Islands of Spain. Larvae feed inside potato tubers, leaving behind frass, exuviae, and promoting rot that renders the crop unfit for sale or consumption. Signs of damage are not visible in above-ground plants and only become obvious in tubers as small exit holes once the larvae leave to pupate.

Fig. 1: Adult male of *Tecia solanivora* showing longitudinal lines on forewings (Photo by Hanna Royals).

The moths making up the PTM complex are members of the Gelechiidae (Lepidoptera), one of the largest families of microlepidoptera with about 500 genera worldwide. These moths are characterized by long upturned labial palpi, a scaled proboscis, and hindwings with a falcate or pointed apex.

Tecia solanivora males are dark brown with 2-3 dark spots in the discal cell and faint longitudinal lines along the forewings. Females are lighter brown than males with 2-3 spots and conspicuous longitudinal marking along the forewing. Forewing length ranges from 8-13 mm, and females are typically larger than males. *Tecia solanivora* resembles many other species of gelechiids, but can be distinguished by their relatively large size and forewing pattern. However, forewing coloration and markings are often difficult to observe in trapped specimens and species-level identification should be performed by a specialist based on genitalic dissection. Two other gelechiids, *Phthorimaea operculella* and *Symmetrischema tangolias*, comprise the remainder of the PTM complex and are also commonly refered to as potato tuber moths, generating some confusion in the literature when only the common name is used. Both *P. operculella* and *S. tangolias* occur in the United States.

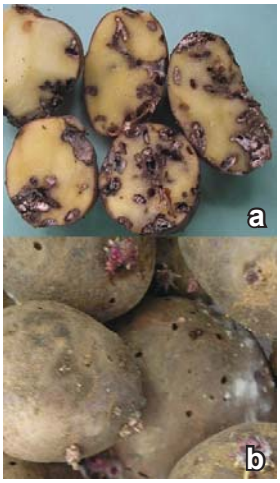


Fig. 2: Symptoms of larval infestation of *Tecia solanivora*: (a) galleries inside tubers and (b) exit holes of emerging larvae outside of tubers (Photos: Courtesy of CIP).

This aid is designed to assist in the sorting and screening *T. solanivora* suspect adults collected from CAPS pheromone (sticky) traps in the continental United States. It covers basic sorting of traps and first level screening, all based on morphological characters. Basic knowledge of Lepidoptera adut morphology is necessary to screen for *T. solanivora* suspects.

Sorting

Guatemalan Potato Moth
Tecia solanivora (Povolný)

Tecia solanivora pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths have a forewing length of 8-13 mm (Fig. 3).

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3. Note that moths caught on their side or back may have a different outline.

3) Moth forewings are lanceolate, dark to light brown, and have variable markings (Fig. 4).

Note that the appearance of moths caught in sticky traps can vary substantially depending on the amount of sticky glue on the moth (most individuals usually appear darker when covered in glue). For this reason, any small, gelechiid-like moth meeting the above criteria should be sent forward to Level 1 Screening.

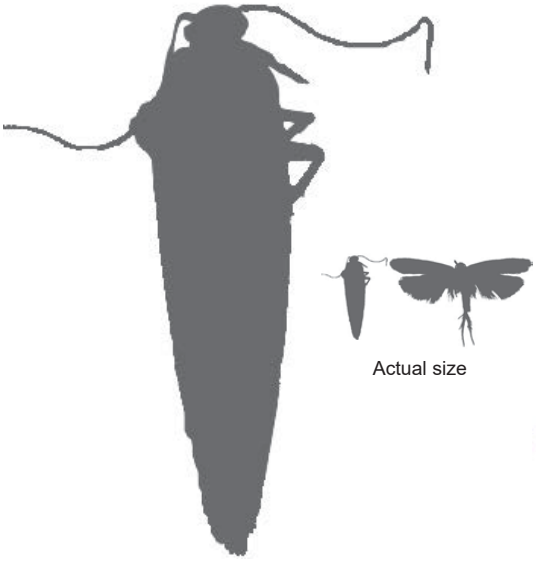


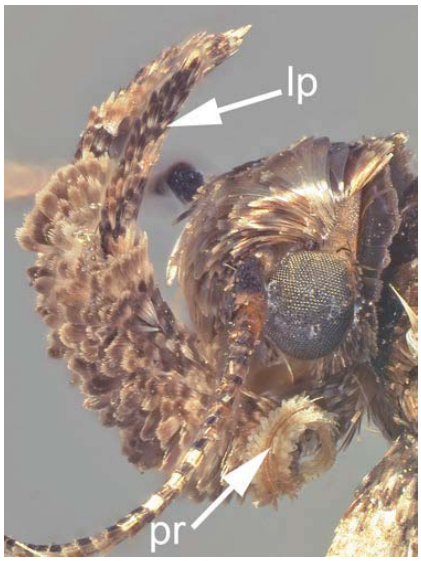
Fig. 3: Outline and size of a resting *T. solanivora*. Many gelechiids that resemble *T. solanivora* have a similar appearance: resting with wings held in a roof-like position over the body.

Fig. 4: Sexual size difference of *T. solanivora* adults (top = male; bottom = female). Females are larger than males, lighter in color, and have conspicuous longitudinal markings along forewing. Males are darker, with more prominent spots in the discal cell. Longitudinal markings may be difficult to see in males due to darker coloration.

Level 1 Screening

Guatemalan Potato Moth
Tecia solanivora (Povolný)

Moths that meet the sorting requirements should be screened for suspect gelechiids. Level 1 Screening may be difficult for small moths (like gelechiids) and may need to be performed by a trained Lepidopterist. When in doubt distinguishing or evaluating first-level screening characters, forward traps that have passed the sorting requirements to a trained taxonomist. Suspect gelechiids in traps should not be manipulated or removed for screening unless expertise is available.



Figs. 5: Upcurved labial palpi (lp) of *Tecia solanivora* and scaled proboscis (pr) (Photo by James Hayden, Microlepidoptera on Solanaceae, www.idtools.org)

Gelechiid moths can be identified by the following combination of characters (note that some characters may be difficult to see on specimens coated in sticky trap glue):

1) Thread-like elongate antennae (Figs. 3-4).

2) Forewing lanceolate to elongate–ovate (Fig. 4).

2) Hindwing subrectangular to trapezoidal with a falcate or pointed apex (Fig. 4).

3) Long, strongly upcurved labial palpi (Fig. 5).

4) Scaled proboscis (tongue) (Fig. 5).

Moths meeting the above criteria should be forwarded for additional identification. Traps to be forwarded to another facility should be carefully packed following the steps outlined in Fig. 6. Traps should be folded, with glue on the inside, making sure the two halves are not touching, secured loosely with a rubber band, and placed in a plastic bag for shipment. Insert 2-3 styrofoam packing peanuts on trap surfaces without moths to cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. DO NOT simply fold traps flat or cover traps with transparent plastic wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

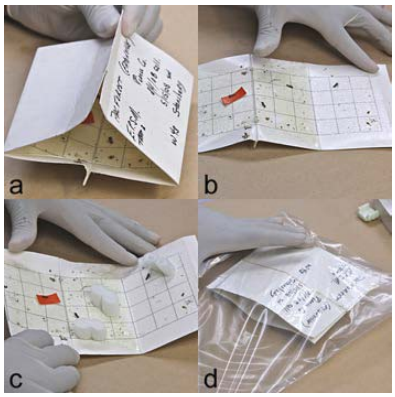


Fig. 6: Recommended packing method for shipment of sticky traps: a & b) open and unfold trap; c) place 2-3 packing peanuts in areas of trap with no moths; d) fold trap, secure with rubber band, and place in plastic bag.

Fig. 7: *Aristotelia* sp.

Fig. 8: *Chionodes mediofuscella*

Fig. 9: *Chionodes thoraceochrella*.

Fig. 10: *Coleotechnites* sp.

Fig. 11: *Prolita variabilis*

Fig. 12: *Prolita invariabilis*

Fig. 13: *Scrobipalpopsis tetradymiella*

Fig. 14: *Teleiopsis baldiana*

Some of the North American gelechiid non-targets that could be confused with *T. solanivora* are shown in Figs. 7-14. Note that these species have not been verified to be attracted to *T. solanivora* pheromone traps and non-targets vary in different parts of the country (Photos by Hanna Royals, Figs. 7-12,14; Jean-Francois Landry, CNC, Fig. 13). Information on the two species in the potato tuber moth complex currently present in the U.S. is listed on Page 5.

Potato Tuber Moth Complex

Guatemalan Potato Moth

Tecia solanivora (Povolný)

The potato tuber moth (PTM) complex refers to three moths in the family Gelechiidae that are important pests of potatoes in many parts of the world. The complex consists of *Phthorimaea operculella* (Zeller) (Fig. 15), *Symmetrischema tangolias* (Gyen) (Fig. 16), and *Tecia solanivora* (Povolný) (Fig. 17), collectively referred to as the "potato tuber moths" or "potato tuberworms." The use of these common names in the literature can be confusing because all three species are native to Central and South America and their larvae cause similar damage.

Fig. 15: *Phthorimaea operculella* (Photo by James Hayden, Microlepidoptera on Solanaceae, www.idtools.org).

Phthorimaea operculella, the potato tuber moth, is a native of South America that has spread throughout the New World and has been introduced to Europe, Africa, Australasia, and generally anywhere in the world where potatoes are grown. It is widespread in the U.S., occuring from California across the southern states and in much of the East. This species feeds on potatoes and a variety of other plants in the Solanaceae. It is also a pest of tobacco and is also referred to as the tobacco splitworm.

Fig. 16: *Symmetrischema tangolias* (Photo by James Hayden, Microlepidoptera on Solanaceae, www.idtools.org).

Symmetrischema tangolias, the South American potato tuber moth, is a native of South America that has been introduced to North America and Australasia. In the U.S., it has been recorded from California, Washington, and Louisiana. Larvae are recorded feeding on a variety of solanaceous hosts, but in the U.S. they appear to prefer weeds such as *Solanum nigrum* (black nightshade) instead of crops.

Fig. 17: *Tecia solanivora* (Photo by Hanna Royals).

Tecia solanivora, the Guatemalan potato moth, is a native of Central America that has been introduced to Mexico, South America (Colombia, Ecuador, Venezuela, and Peru), and the Canary Islands of Spain. It has not been recorded from the U.S. Larvae are monophagous and *Solanum tuberosum* (Irish potato) is the only recorded host.

It is not know if *P. operculella* and *S. tangolias* are attracted to *T. solanivora* pheromone traps, although *S. tangolias* shares one of the same pheromone components. Because identification to species is difficult for this group, forward for identification any specimens that meet the critera for Level 1 Screening.

Key and References

Guatemalan Potato Moth
Tecia solanivora (Povolný)

Key to Sort and Screen *Tecia solanivora* Suspects in the United States

1. Moths approximately 8-13 mm long; overall shape typical gelechiid-like (Fig. 3); and forewings dark or light brown with longitudinal markings and darker spots (Fig. 4) 2
1'. Moths larger or smaller than 8-13 mm long; overall shape not typically gelechiid; or forewing color not dark or light brown with longitudinal markings and darker spots .....Not *T. solanivora*

2. Antennae filiform; hindwings subrectangular with a pointed apex; labial palpi long and strongly upcurved; and proboscis scaled.....***T. solanivora suspect***
2'. Antennae not filiform; hindwings not subrectangular with a pointed apex; labial palpi not long and strongly upcurved; or proboscis not scaled.....Not *T. solanivora*

Citation

Royals, H. R., T. M. Gilligan and S. Passoa. 2017. Screening aid: Guatemalan potato moth: *Tecia solanivora* (Povolný). Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 6 pp.

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Acknowledgments

We would like to thank USDA-APHIS-PPQ National Identification Services and the USDA-APHIS-PPQ-S&T Identification Technology Program for support of this work. Funding for this project was provided to H. Royals through section 10007 of the 2014 Farm Bill.

Screening Aid

Stem Borers
Chilo spp.

Hanna R. Royals[1], Todd M. Gilligan[1] and Steven C. Passoa[2]

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Version 2.5
15 May 2017

This CAPS (Cooperative Agricultural Pest Survey) screening aid produced for and distributed by:
USDA-APHIS-PPQ National Identification Services (NIS)
This and other identification resources are available at: http://caps.ceris.purdue.edu/taxonomic_services

The stem borers, *Chilo* spp. are some of the most important pests of cereal crops throughout Asia. Larvae cause serious damage to rice, corn, sorghum, and sugar-cane by boring into the leaf funnels during the seedling growth stage (causing “dead-heart”) and later by feeding on internal stem tissue and inflorescences during the reproductive growth stage. Feeding by *Chilo* larvae can result in significant reduction in yields or destruction of the entire crop. *Chilo suppressalis* is one of the most important rice pests in East Asia, India, and Indonesia, and it has been introduced to Africa, Spain, and Hawaii. *Chilo partellus* is a pest of sorgum, corn, and rice in the Middle East, India, and parts of Africa. Several other species, such as *C saccharіphagus* and *C aga e non*, are pests of corn and rice throughout Asia and Africa.

Fig. 1: *Chilo suppressalis* resting (Photo by International Rice Research Institute Archive, Bugwood.org).

Chilo is a genus included in the Crambidae (Crambinae), a large group of moths formally placed in the Pyralidae that contains many pests. *Chilo* consists of more than 40 described species, but only four are present in North America. *Chilo* spp. are characterized by long, porrect (forward extending) labial palpi, ocelli present on the head (behind the antennae), and yellow or brown forewings. In many species, there is variable black scaling throughout the forewings. Species within *Chilo* are very similar to each other and to other species in closely related genera such as *iatraea*. A genitalic dissection by a specialist is necessary for a species-level identification. *iatraea* is separated from *Chilo* by the absence of ocelli on the head; this character can be used to eliminate *iatraea* captured in *Chilo* sticky traps.


Fig. 2: Male *C suppressalis*.

This aid is designed to assist in the sorting and screening *Chilo* suspect adults collected from CAPS pheromone (sticky) traps in the continental United States. It covers basic sorting of traps and first level screening, all based on morphological characters. Basic knowledge of Lepidoptera morphology is necessary to screen for *Chilo* suspects. Although USDA CAPS surveys target either *C partellus* or *C suppressalis*, any unknown *Chilo* should be forwarded for identification.

Chilo pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths are approximately 10-18 mm (0.35-0.7 inches) long (Fig. 3).

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3. Note that moths trapped on their side or back may have a different outline.

3) Moth forewings are pale brown to pale yellow with relatively few markings - see the comparison of forewing colors in Figs. 1-2 and 4-5.

Note that the appearance of moths caught in sticky traps can vary substantially depending on the amount of sticky glue on the moth (most individuals usually appear darker when covered in glue). For this reason, any small, crambidlike moth meeting the above criteria should be sent forward for screening.

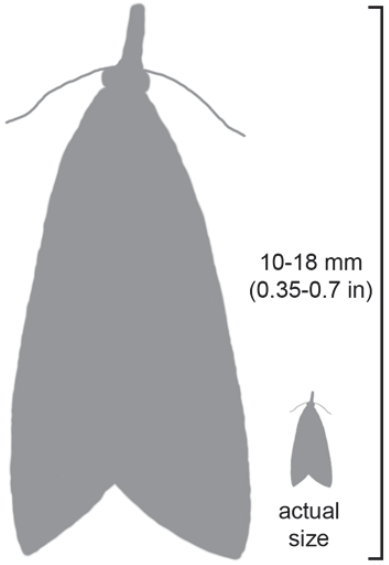

Fig. 3: Outline and size of a resting *C suppressalis* male. Many crambid moths have a similar resting posture. This general shape can be used to separate crambids from other similar sized moths.

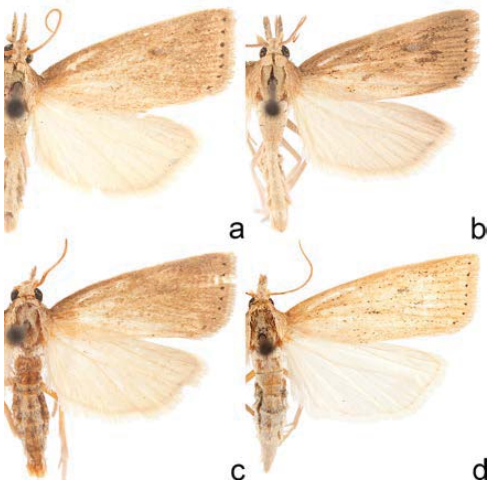

Fig. 4: Variation in wing pattern and coloration of *C suppressalis* adults (a-c = males; d = female). Note the row of black dots along the termen of the forewing (although this character is not always present).

Fig. 5: Adult of *Chilo partellus* (Photo by Georg Goergen, IITA Insect Museum, Benin).

Fig. 6: Lateral view of *Chilo partellus* adults, top male, bottom female (Photos by James Hayden, FSCA, Gainesville, Florida).

Level 1 & 2 Screening

Stem Borers
Chilo spp.

Moths that meet the sorting requirements should be screened for suspect *Chilo*. Level 1 & 2 Screening utilizes the same characters. Screeners should proceed through the characters listed here as far as their expertise allows and forward remaining suspect pyraloids for identification. Screening can be moderately difficult and may need to be performed by a trained Lepidopterist.

Level 1 Screening

Suspect pyraloids have the following combination of characters:

1) Maxillary palpi conspicuous. The maxillary palpi are located above the labial palpi on the head (Figs. 7-8). The maxillary palpi are approximately 1/3 to 1/2 as long as the labial palpi in *Chilo*. Maxillary palpi are reduced and not visible in many other families like Tortricidae.

2) Labial palpi long, densely scaled, and projecting forwards (Figs. 7-8). Some families (especially in the Gelechioidea) have long labial palpi that curve upwards over the head. Other pyraloids have much shorter palpi.

3) Proboscis (tongue) scaled at the base. Members of the Gelechioidea and Pyraloidea have a scaled proboscis; the proboscis in many other families is unscaled.

Suspect pyraloids meeting the above conditions should be moved to level 2 screening. If traps are to be forwarded to another facility for further screening, follow the steps at the bottom of this page to ensure they are packed correctly. Only proceed to level 2 screening if expertise if available.

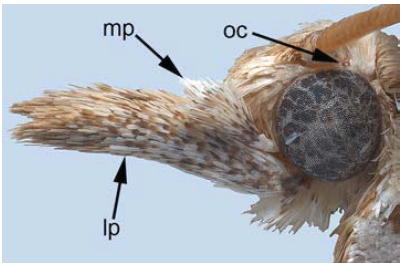

Fig. 7: *Chilo suppressalis* head; lp = labial palpi; mp = maxillary palpi; oc = ocellus (Photo by Christi Jaeger, Miss. State Univ.).

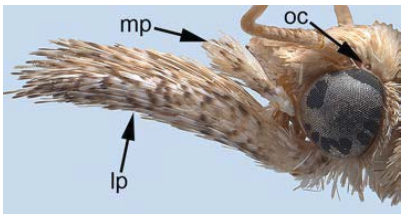

Fig. 8: *Chilo e otellus* head; lp = labial palpi; mp = maxillary palpi; oc = ocellus (Photo by Christi Jaeger, Miss. State Univ.).

Level 2 Screening

Suspect pyraloids should be cleaned to identify suspect *Chilo* individuals. Instructions on cleaning specimens caught in sticky traps can be found here: http://idtools.org/id/leps/tortai/dissections.html. Cleaned specimens should be properly pinned and labeled. Suspect *Chilo* have the following combination of characters:

4) Tympanum present at the base of the abdomen. Noctuoidea have a tympanum on the thorax near the junction with the abdomen. Other families (like Tortricidae) lack a tympanum. Although this is a family level character, the tympanum is difficult to see without cleaning and manipulating the specimen.

5) Ocelli present (Figs. 7-8). Ocelli are present on the head behind the antenna in *Chilo* and many other Crambidae. Ocelli are absent in some closely related genera like *iatraea*.

Traps that are to be shipped should be carefully packed following the steps outlined in Fig. 9. Traps should be folded, with glue on the inside, making sure the two halves are not touching, secured loosely with a rubber band or a few small pieces of tape. Plastic bags can be used unless the traps have been in the field a long time or contain large numbers of possibly rotten insects. Insert 2-3 styrofoam packing peanuts on trap surfaces without moths to cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. DO NOT simply fold traps flat or cover traps with transparent plastic wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

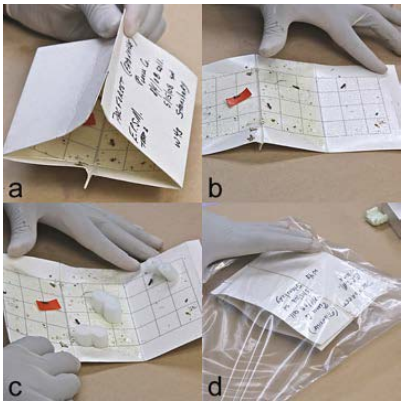

Fig. 9: Recommended packing method for shipment of sticky traps: a & b) open and unfold trap; c) place 2-3 packing peanuts in areas of trap with no moths; d) fold trap, secure with rubber band, and place in plastic bag (Photos by E. LaGasa, WSDA).

Fig. 10: *Chilo ple a ellus*.

Fig. 11: *Chilo erianthalis*.

Fig. 12: *Chilo e otellus*.

Fig. 13: *Chilo e otellus*.

Fig. 14: *iatraea saccharalis*.

Fig. 15: *iatraea saccharalis*.

Fig. 16: *iatraea e anescens*.

Fig. 17: *iatraea gran iosella*.

Fig. 18: *iatraea lisetta*.

Fig. 19: *oreu a ensella*.

Fig. 20: *u i a panalope*.

A sampling of *Chilo* spp. and non-targets in related genera that are present in North America. It is expected that other crambids will be attracted to *Chilo* pheromone traps; a sampling of non-target crambids is shown on this page. Note that these species have not been verified to be attracted to *Chilo* pheromone traps and that non-targets encountered during CAPS surveys will vary by region.

Key and References

Key to Sort and Screen *i o* Suspects in the United States

1. Moths approximately 10-18 mm long; overall shape typical pyraloid (Fig. 3); forewings pale brown to pale yellow with relatively few markings as in Figs. 4-6 and 10-13 2
1'. Moths larger or smaller than 10-18 mm long; overall shape not typically pyraloid; forewing color not pale brown to pale yellow; or forewings strongly marked .....Not *Chilo*

2. Maxillary palpi conspicuous and 1/3 to 1/2 as long as labial palpi; labial palpi long and projecting forwards; and proboscis scaled at the base as in Figs. 7-8..... 3
2'. Maxillary palpi absent or very short; labial palpi short or upcurved; or proboscis not scaled at the base .....Not *Chilo*

3. Ocelli present..... ***i o suspect***
3'. Ocelli absent.....Not *Chilo*

Citation

Royals, H. R., T. M. Gilligan and S. Passoa. 2017. Screening aid: Stem borers, *Chilo* spp. Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 5 pp.

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Screening Aid

Cabbage Moth

Mamestra brassicae (Linnaeus)

Hanna R. Royals[1], Todd M. Gilligan[1] and Steven C. Passoa[2]

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2) USDA-APHIS-PPQ, USDA-FS Northern Forest Research Station and Ohio State University, 1315 Kinnear Road, Columbus, Ohio 43212 U.S.A. (Email: Steven.C.Passoa@aphis.usda.gov)

Version 1
21 October 2016

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The cabbage moth, *Mamestra brassicae* (Linnaeus), is a highly polyphagous pest in Europe and Asia. Larvae are reported to feed on more than 77 plant species in 22 families. Most larval hosts are *rassica* spp. but other known hosts include apple, beetroot, onion, potato, rhubarb, tomato, and tobacco. Large infestations can cause significant product loss, although this is usually due to secondary fungal and bacterial infections, and aesthetic damage resulting from large amounts of frass production.

Mamestra brassicae is a member of the Noctuidae (subfamily Hadeninae), the family of moths (Lepidoptera) with the largest number of total species and also including many well-known pest species. In North America there are approximately 2,500 species of noctuids, which are often referred to as “owlet moths,” “cutworms,” or “miller moths.” Most noctuids are medium-sized with relatively drab brown or gray coloration, although they can range in size from very small to very large and some species are brightly colored. *Mamestra brassicae* is a common species throughout Northern Africa, Asia, and most of Europe and Britain, becoming less common further north. There are a few records of the cabbage moth from Hawaii, but none from the Americas, although the predicted range for *M. brassicae* based on habitat suitability includes eight USDA plant hardiness zones (3-10).

Fig. 1. *Mamestra brassicae* adult resting (photo by Heidrun Melzer, www.lepiforum.de).

The cabbage moth has a forewing length of 14-22 mm and a wing pattern similar to many other noctuid species in several genera, particularly those in the subfamily Hadeninae. Typical of the Hadeninae moths, they are recognized by the “hair” on the surface of the eyes. Forewings are brown and mottled and have a reniform stigma with a prominent white outline, and a deep but faint “W” in the subterminal line. There is relatively low variability in forewing coloration between individuals. Other important general features include the prominent brown or black slightly curved tibial spur on the forelegs and thoracic dorsal scale tufts. Examination of dissected male genitalia is needed to positively distinguish *M. brassicae* from *M. configurata* and *M. curialis* which are both native to North America.

Fig. 2. *Mamestra brassicae* adult resting (photo by S. van der Moor, www.ipm.msu.edu).

This aid is designed to assist in the sorting and screening *M. brassicae* suspect adults collected from CAPS bucket traps in the continental United States. It covers basic sorting of traps and first level screening, all based on morphological characters. Basic knowledge of adult Lepidoptera morphology is necessary to screen for *M. brassicae* suspects.

Mamestra brassicae pheromone traps should be sorted initially for the presence of moths of the appropriate size, color, and shape. Traps that contain moths meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Moths have a forewing length of 14-22mm (0.5-0.9 inches) (Fig. 3).

2) Moths have an overall shape that is similar to the outline depicted in Fig. 3, but be aware that moths sometimes do not die in a natural position when captured in traps.

3) Moth forewings are a mottled brownish-gray (Fig. 4).

4) Moth antennae are filiform (threadlike - Figs. 3-4) and not feathery or plumose.

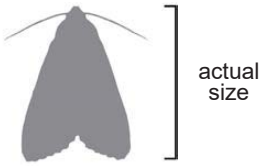

Fig. 3. Resting position of *Mamestra brassicae* adult.

Fig. 4. Wing pattern and coloration of typical *M. brassicae* adults.

Level 1 Screening

Cabbage Moth
Mamestra brassicae (Linnaeus)

Suspect adults should be pinned and properly labeled. A combination of wing, eye, and tibial characters are used to identify suspect specimens for Level 1 screening.

Hairy Eyes

Moths in the subfamily Hadeninae have “hairs” on the compound eyes (Fig. 5). These hairs are easily observed under low magnification.

Fig. 5. “Hairy” eyes characteristic of Hadeninae moths.

Forewing Coloration and Pattern

Most individuals of *M. brassicae* have mottled gray-brown forewings with markings consisting of two primary elements: a basal “orbicular spot” and a discal “reniform spot.” In *M. brassicae* the orbicular spot is round with a blackish margin while the conspicuous reniform spot is kidney shaped and encircled by white scales. Similar markings are found in many other species of noctuids. Also present is a thin white subterminal line that forms a wide faint “W”, and a series of black spots along the lateral margin (Fig. 6.)

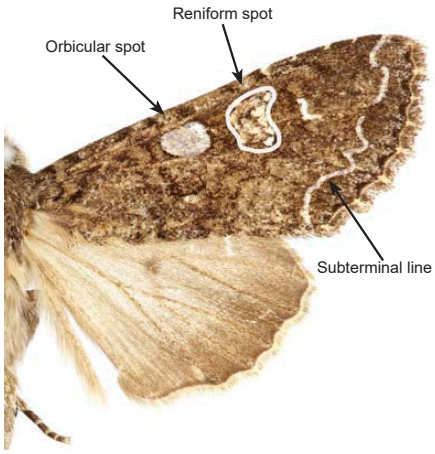

Fig. 6. Typical forewing pattern.

Foretibial Spur

Typical of *Mamestra* spp. is a large, dark, curved spine on the foretibia that is easily seen under low magnification (Fig. 7).

The following is a summary of suspect *M. brassicae* adult characters:

1) **Medium sized noctuid moth**
2) **“Hairy” eyes**
3) **Grayish-brown forewings**
4) **Conspicuous reniform spot ringed in white scales**
5) **Large foretibial spur**

Suspect *M. brassicae* specimens should be sent forward for identification. Specimens must be pinned, properly labeled, and carefully packed to avoid damage during shipping.

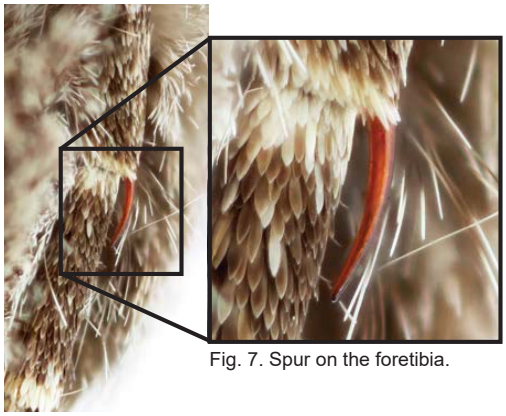

Fig. 7. Spur on the foretibia.


Fig. 8: *Amphipoea americana**


Fig. 9: *Amphipoea velata**


Fig. 10: *Feltia jaculifera**


Fig. 11: *Orthodes crenulata**


Fig. 12: *Abrostola urentis* *


Fig. 13: *Anarta trifolii**


Fig. 14: *Anarta trifolii**


Fig. 15: *Mythimna oxygala**


Fig. 16: *Mamestra configurata*


Fig. 17: *Mamestra curialis*


Fig. 18: *Melanchra adjuncta*


Fig. 19: *Melanchra adjuncta*


Fig. 20: *Orthodes detracta**


Fig. 21: *Papestra brenda*


Fig. 22: *Polia imbrifera**


Fig. 23: *Polia nimbosa**


Fig. 24: *Spiramater lutra*

A sampling of North American non-targets (Figs. 8-24). Names with an * denote species that were collected in cabbage moth sticky traps between 1987 and 1992. In general, non-targets expected to be encountered in *M. brassicae* pheromone traps include other Hadeninae along with other noctuids. Note that some of the above species have not been verified to be attracted to *M. brassicae* traps and that non-targets encountered during CAPS surveys will vary by region. Non-target data were obtained from five sources: the Exotic Pest Detection (EPD) Manual; J. Knodel's (1987) letter to OTIS; West Virginia's 1987 results (J. Messineo, T. Sutton); Marc Epstein's 1987 report; and the results of the 1992 survey performed in the Reynoldsburg Lab (see Passoa 1993).

Key to Sort and Screen *amestra rassicae* Suspects in the United States

1. Forewings 14-22mm; overall shape is typical for a noctuid (Fig. 3); antennae filiform; and forewings are a mix of brown, gray, white and black (Fig. 4) 2
1'. Forewing length less than or larger than 14-22 mm; overall shape not typically noctuid; antennae feathery or plumose; or forewing color not brown, gray, white and black ..... Not *M. brassicae*

2. Eyes "hairy" (Fig. 5) 3
2'. Eyes not "hairy" (naked) ..... Not *M. brassicae*

3. Foreleg tibia with spur (Fig. 7) 4
3'. Foreleg tibia lacking spur ..... Not *M. brassicae*

4. Forewings grayish brown with a prominent reniform spot highlighted in white; black spots along the lateral margin and a broken white subterminal line with a faint deep "W" (Fig. 6) ..... ***. rassicae suspect***
4'. Forewings not grayish-brown or lacking prominent reniform spots, black spots along lateral margin and broken white subterminal line with faint deep "W" ..... Not *M. brassicae*

Citation

Royals, H. R., T. M. Gilligan and S. Passoa. 2016. Screening aid: Cabbage moth, *Mamestra brassicae* (Linnaeus). Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 5 pp.

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Acknowledgments

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Screening Aid

Large White
Pieris brassicae (Linnaeus)

Hanna R. Royals[1], Todd M. Gilligan[1] and Steven C. Passoa[2]

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The large white or large cabbage white, *Pieris brassicae* (Linnaeus), is an invasive pest that is present throughout mainland Europe, Asia, and North Africa. Due to its migratory nature and broad host range, populations can be widespread. Larval hosts are primarily plants in the family Brassicaceae. Larvae feed on all leaf parts and can be highly destructive, leading to significant crop loss due to skeletonization of the host. Larvae also cause aesthetic damage to crops through feeding and excess frass production. This species completes up to 4 generations in central Europe and up to 7 in more southern regions. Several non-target species with similar feeding habits and morphology are present in North America including: *Pieris rapae*, *P. virginiensis*, *P. marginalis P. oleraceae*, *Pontia protodice*, *Ascia monuste* and *Appias drusilla*. The presence of these similar species and the broad host range indicate a potential for establishment of *P. brassicae* in North America if introduced.

Fig. 1. *Pieris brassicae* female with wings spread (photo by S. Sepp, commons.wikipedia.org).

Pieris brassicae is a member of the Pieridae, a family with over 1,000 species and a wide variety of ranges, larval hosts, and coloring. Forewings of both sexes of *P. brassicae* are a creamy white or very pale yellow with distinct black markings that curve slightly down the termen at the wing apices and two black spots on the ventral sides of the forewings. Forewing length measures 25-35mm and antennae are black with white tips. The female can be distinguished from the male by having two black spots on the dorsal forewing. This species also displays seasonal variability with both males and females of spring broods appearing slightly lighter with greyer markings, while the summer generations have very dark markings. Morphology of *P. brassicae* is quite similar to that of *Pieris rapae*, the cabbage white, which is one of the most common butterflies in North America. *Pieris rapae* can be distinguished from *P. brassicae* by its smaller size and the dark marks at the wing apices, which do not extend down the termen (see Level 1 screening for size and color comparisons). Larvae of *P. brassicae* and *P. rapae* are easily distinguished by coloration differences.

Fig. 2. *Pieris brassicae* resting on *ud dleja davidii* (photo by Thomas Bresson, commons.wikimedia.org).

Large White

Pieris brassicae (Linnaeus)

Pieris brassicae visual surveys should note the presence of butterflies of the appropriate size, color, and shape. The large cabbage white is most easily confused with *P. rapae*, one of the most common butterflies in the U.S. (Figs. 4-9), but *P. rapae* can be distinguished from *P. brassicae* by its smaller size (mean FWL = 31mm vs. 22mm), lighter wing markings, and dark marks at the apex of the forewing, which do not extend down the termen. Other common non-targets in the Pieridae are shown in Figs. 13-23. Most are smaller than *P. brassicae* and have different wing patterns. The only species similar in size to *P. brassicae* are some southern migrants such as *Appias drusilla* and *Ascia monuste*. These can be distinguished from *P. brassicae* by wing pattern: *A. drusilla* lacks dark wing markings, while markings in *A. monuste* are more brown and extensive than in *P. brassicae*, and both of these species lack forewing spots (Figs. 21-23).

1) Butterflies have a forewing length of 25-35mm (0.5-0.9 inches).

2) Butterflies have an overall shape and coloration similar to those in Figs. 3a-d:

* dark wing tips that extend down the termen in contrast to those of *P. rapae* that are confined to the wing apex

** females will have two spots and a dash on the dorsal forewing

*** both sexes have two dark spots present on the ventral side of the forewing.

3) Butterfly antennae are clubbed as in Figs. 3a-d.

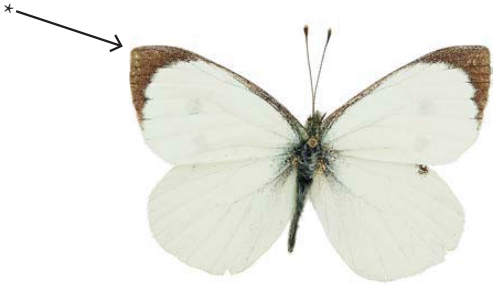

Fig. 3a. *Pieris brassicae* male

Fig. 3b *Pieris brassicae* male

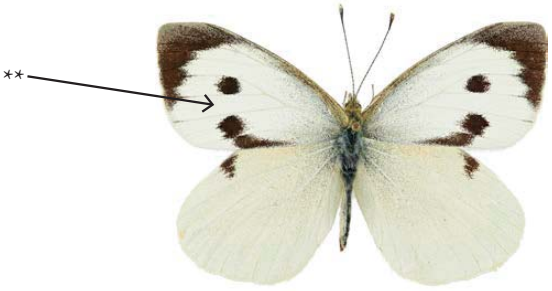

Fig. 3c *Pieris brassicae* female

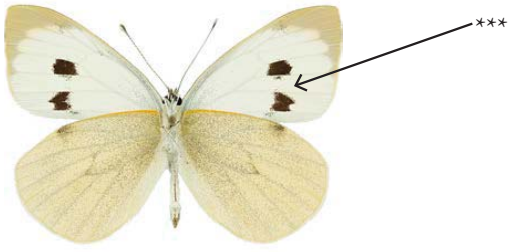

Fig. 3d *Pieris brassicae* male (ventral)

(Figs. 3a-d are actual size.)

Figures 4-23 portray wing patterns and relative sizes (at 75% scale) of target and non-target species.

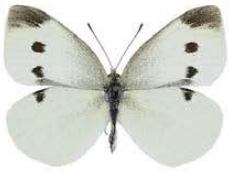

Fig. 4. *Pieris rapae*

Fig. 5. *Pieris rapae* ventral

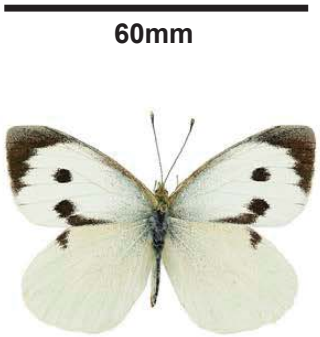

Fig. 10. *Pieris brassicae* female

Fig. 6. *Pieris rapae*

Fig. 7. *Pieris rapae*

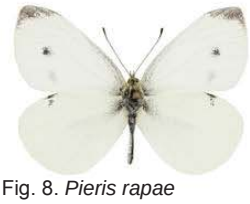

Fig. 8. *Pieris rapae*

Fig. 9. *Pieris rapae*

Fig. 11. *Pieris brassicae* male

Fig. 13. *Pontia protodice*

Fig. 14. *Pontia protodice*

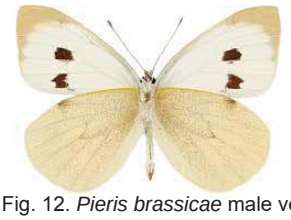

Fig. 12. *Pieris brassicae* male ventral

Fig. 15. *Pieris virginiensis*

Fig. 16. *Pieris marginalis*

Fig. 17. *Pieris marginalis* ventral

Fig. 18. *Colias eurytheme*

Fig. 19. *Euchloe olympia*

Fig. 20. *Euchloe* sp.

Fig. 21. *Appias drusilla* male

Fig. 22. *Ascia monuste* female

Fig. 23. *Ascia monuste* male

References

Key to Screen *ieris* *rassicae* Suspects in the United States

1. Forewings 25-35mm; overall shape is as observed in Figs. 3a-d; antennae are clubbed; forewings are creamy pale white to light yellow with dark wing tips that extend down the termen ..... **. *rassicae* suspect**

1'. Forewing length less than or larger than 25-35 mm; overall shape is not as observed Figs. 3a-d; antennae are not clubbed; forewing color not creamy pale white to yellow; or dark wing tips, if present, do not extend down the termen ..... not *P. brassicae*

Citation

Royals, H. R., T. M. Gilligan and S. Passoa. 2016. Screening aid: Large white, *Pieris brassicae* (Linnaeus). Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 4 pp.

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Screening Aid

Sugar Cane Weevil

Rhabdoscelus obscurus (Boisduval)

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The sugar cane weevil, *ha oscelus o scurus* (Boisduval), a native of New Guinea, is a relatively large weevil that has spread to many areas of the world, especially sugar cane growing regions of the Pacific. The preferred host is sugar cane but this weevil has been known to attack a large variety of plants, including banana and a variety of palms, and infrequently corn. Larvae feed on stalks and stems creating large tunnels, leading to plant death or loss of value due to aesthetic damage in ornamental plants. This species has been a pest in Hawaii since the 1860's but has not been established in the continental United States.

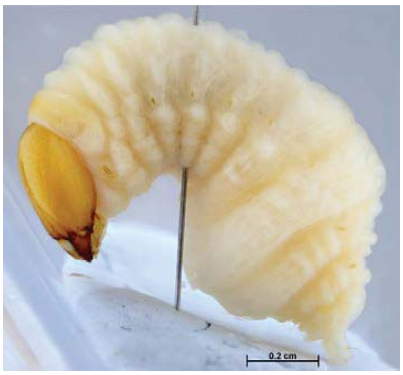

Fig. 1: *ha oscelus o scurus* larva. (Photo by Caroline Harding).

While there are several genera that are similar in appearance to *ha oscelus*, only a few are established in the U.S. Generic separation is possible but difficult, and identification to species will be difficult without representatives of each species to compare. Adults are highly variable, ranging in size from 12-14 mm, colored reddish to reddish-brown, and the pronotum often has a dark streak from apex to base. Some species of *h nchophorus* have similar markings and hosts, but can be differentiated by size. They typically measure 2-2.5 times longer and 3 times wider than *o scurus* Separation from other genera in the Dryophthoridae, the palm weevils, will be difficult without a microscope but can be done by comparison of several key characteristics. These genera include *Cos opolites*, *eta asius*, and *phenophorus* which share monocotyledonous hosts and whose characters can be difficult to compare, and *c phophorus* which also appears similar, but can be separated by their black color, larger size and succulent host plants *ga e* and *ucca*

Fig. 2: Adult female sugar cane weevil. (Photo by Sarah McCaffrey).

Visual inspection for the presence of larvae or larval damage is effective, but traps using a combination of lures is recommended for adults. This weevil has been transported by plant material into several continents and little literature is available to separate species; any specimen resembling *o scurus* should be reported. Basic knowledge of adult Coleoptera morphology is necessary to screen for *o scurus* suspects.

Fig. 3: Adult female sugar cane weevil. (Photo by Sarah McCaffrey).

Sorting

Sugar Cane Weevil
ha oscelus o scurus (Boisduval)

ha oscelus o scurus pheromone traps should be sorted initially for the presence of weevils of the appropriate size, color, and shape. Traps that contain weevils meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Weevils are approximately 12-14 mm (one-half inch) long (Fig. 4).

2) Weevils have an overall shape that is similar to the outline depicted in Fig. 4.

3) Weevils are reddish to red-brown, sometimes with a dark streak down midline of pronotum (Fig. 5).

4) Weevils have an elongated rostrum (Fig. 6).

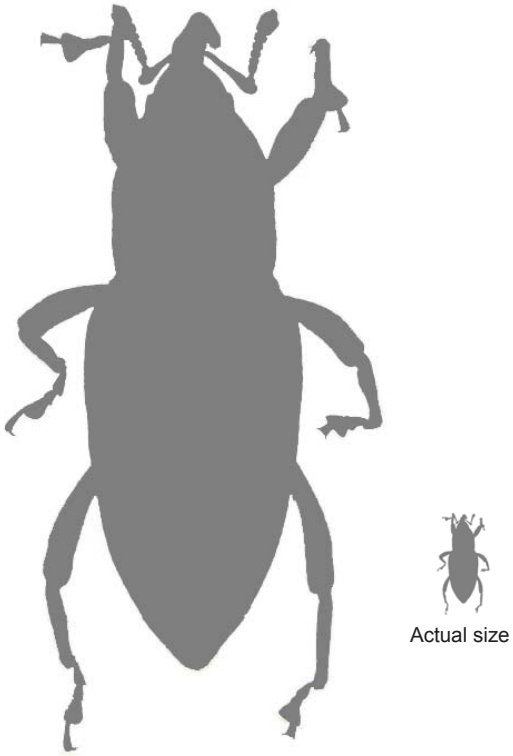

Fig. 4: Outline and size of *o scurus*.

Fig. 5: Dorsal aspect of *o scurus* (Photo by Caroline Harding)

Fig. 6: Elongated rostrum of *o scurus* (Photo by Caroline Harding)

While most species similar in appearance to the sugar cane weevil are not native to the United States, they might be detected in commodity surveys as many have the same host plants, including sugar cane, palms, and corn. Separation to family can be accomplished based on tarsal and antennal characteristics:

Tarsus: Dryophthoridae have flaps between tarsal claws (Fig. 7a) and Curculionidae do not (Fig. 7b):

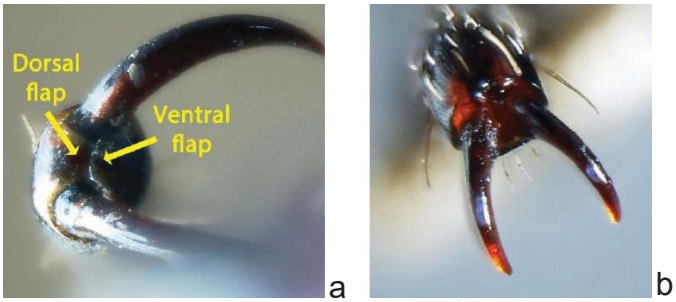

Fig. 7: a) flaps between tarsal claws present in the Dryophthoridae and b) absence of flaps in the Curculionidae

Antenna: Dryophthoridae have a glabrous (lacking setae) first antennal club segment (Fig. 8a) and a scape that surpasses the posterior margin of the eye (Fig. 8b). Curculionidae have a first antennal club segment that is not glabrous (Fig. 8c) and a scape that does not surpass the posterior margin of the eye (Fig. 8d):

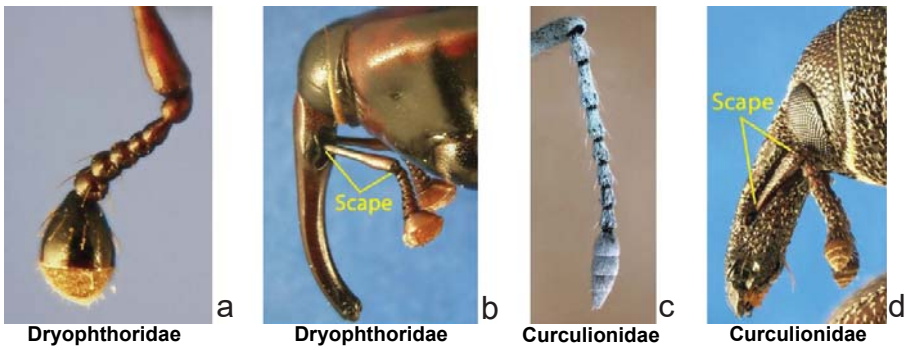

Fig. 8: Differences in antennae of Dryophthoridae and Curculionidae (Photos by Charles Brodel USDA-APHIS-PPQ)

Related genera in the Dryophthoridae can be separated based on the shape of the scutellum. *ha oscelus* possesses a scutellum that is longer than it is wide, with the width equal to or less than that of the sutural interval, and with sides that are almost parallel (Fig. 9a). *Cos opolites* has a scutellum that is sub-circular (Fig. 9b) while *eta asius*, *phenophorus* and *c phophorus* have a triangular scutellum (Fig 9c):

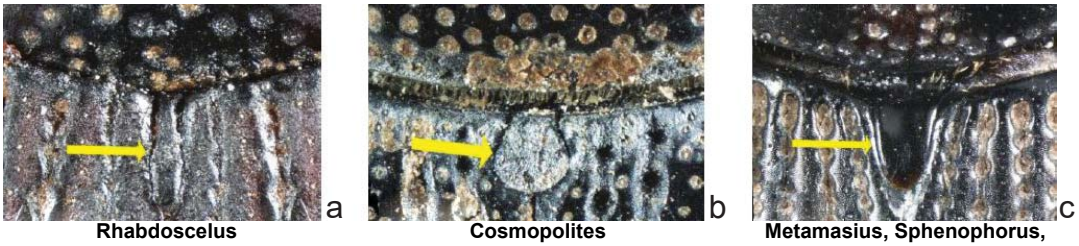

Fig. 9: Scutellum shapes differentiating some genera of the Dryophthoridae (Photos by Charles Brodel USDA-APHIS-PPQ)

Key and References

Sugar Cane Weevil
ha oscelus o scurus (Boisduval)

Key to Sort and Screen *a osce us* and Related Genera

1. Scutellum sub-circular, with length about equal to width; associated with bananas ..... *Cos opolites*
1'. Scutellum almost parallel-sided, with length greater than width, width equal to or less than that of sutural interval ..... ***a osce us* suspect**
1''. Scutellum widest at base, triangular or tapering apically 2

2. Tarsal segment 3 with ventral pilosity restricted to anterolateral areas, area in middle mostly glabrous; segment 3 not dilated in most species, about equal in width to segment 2, dilated in a few species and wider than 2; associated with grasses and corn ..... *phenophorus*
2'. Tarsal segment 3 with ventral pilosity covering almost all of ventral surface except near base at middle; segment 3 greatly dilated in most species compared to segment 2 but, if only slightly dilated, then longer than segment 2; associated with palms, sugar cane, bananas, and bromeliads ..... *eta asius*
2''. Tarsal segment 3 with ventral pilosity long, confined to apical margin as a continuous fringe, ventral surface otherwise glabrous; segment 3 greatly dilated in both species compared to segment 2; associated with *ga e eaucarnea* and *ucca* ..... *c phophorus*

Citation

Royals, H. R., T. M. Gilligan and C. F. Brodel. 2017. Screening aid: Sugar Cane Weevil, *ha oscelus o scurus* (Boisduval). Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 4 pp.

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Screening Aid

Palm Weevils
Rhynchophorus spp.

Hanna R. Royals and Todd M. Gilligan

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The Red Palm Weevil, *h nchophorus ferrugineus* (Olivier), and South American Palm Weevil, *pal aru* (L.), are the two of the most destructive of six species in *h nchophorus* that are known to attack palms. These weevils are well-known pests of date palms but can attack a number of other hosts. *h nchophorus ferrugineus* has been reported to also attack agave and sugar cane and *pal aru* has a wider range of reported hosts including twelve plant families, but primarily attacks Arecaceae. The adult palm weevils feed on a number of tropical fruits but do not cause the economic damage to the same extent as the larvae. However, larval signs can be difficult to detect, whereas the presence of adults is often obvious due to their large size.

Fig. 1: *h nchophorus ferrugineus* (Photo by Hanna Royals).

Early signs of larval attack are visible as frass-filled holes and the presence of cocoons at the base of palm leaves, and symptoms resembling drought stress (wilting and yellowing). Severely attacked palm trees show loss of the palms and rotting of the trunk, leading to tree death. *h nchophorus pal aru* is a known vector of the nematode *ursaphelenchus cocophilus* that causes red ring disease of palms. Two other weevils, *na is orassi* and *eta asius he ipterus* have been reported as vectors of red ring disease nematodes. A subspecies of *he ipterus* is present in Florida (*he ipterus sericeus*), but *orassi* is not recorded from the United States.

Fig. 2: *h nchophorus ferrugineus* larval damage (Photo by Amy Roda USDA-APHIS).

h nchophorus ferrugineus adults range from 25-42 mm long with an elongate oval body that is red to black in color. Black and red markings on the pronotum can be extremely variable. Males have a patch of short stout setae subapically at the rostrum (Fig. 4). *h nchophorus pal aru* adults on average, are slightly larger in size than *ferrugineus* with adults ranging from 26-45 mm long.

The only North American species that might be confused with these species during surveys is *h nchophorus cruentatus* (Fabricius) a native to the southeastern U.S., including Florida. However, any suspect weevils resembling *h nchophorus* should be submitted for professional identification following the protocol for South American palm weevil specimen forwarding (Page 6) to monitor for weevils vectoring nematodes. Basic knowledge of Coleoptera morphology is necessary to screen for *h nchophorus* suspects.

h nchophorus pheromone traps should be sorted initially for the presence of weevils of the appropriate size, color, and shape. Traps that contain weevils meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Weevils are longer than 25 mm (Fig. 3).

2) Weevils have an overall shape that is similar to the outline depicted in Fig. 3.

3) Weevils have an elongated rostrum (Fig. 4).

4) Weevils are dark red to black with variable red coloration. (Figs. 5-7).

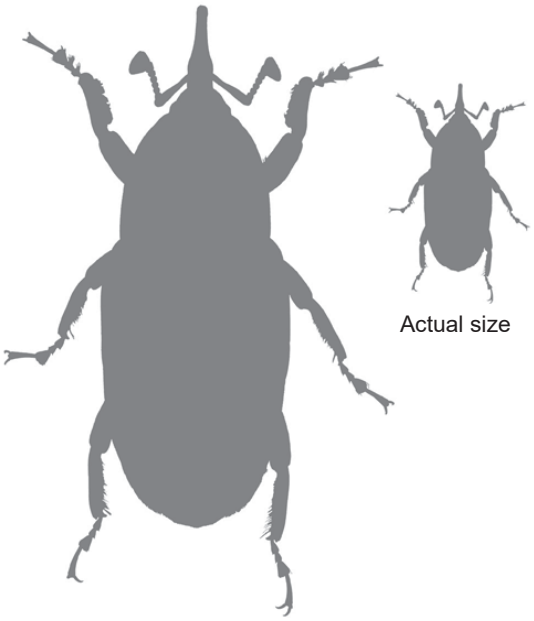

Fig. 3: Outline of an adult *h nchophorus ferrugineus*.

Fig. 4: Elongated rostrum. Males of *h nchophorus pal aru* have stout setae on the rostrum (Photo by Hanna Royals).

Fig. 5: Variable red and black coloration of *h nchophorus ferrugineus* (female) (Photo by Hanna Royals).

Fig. 6: Variable red and black coloration of *h nchophorus ferrugineus* (male) (Photo by Hanna Royals).

Fig. 7: Black coloration of *h nchophorus pal aru* (Photo by Hanna Royals).

Separation to family can be accomplished based on tarsal and antennal characteristics.

Tarsus: Dryophthoridae have flaps between tarsal claws (Fig. 8a) and Curculionidae do not (Fig. 8b):

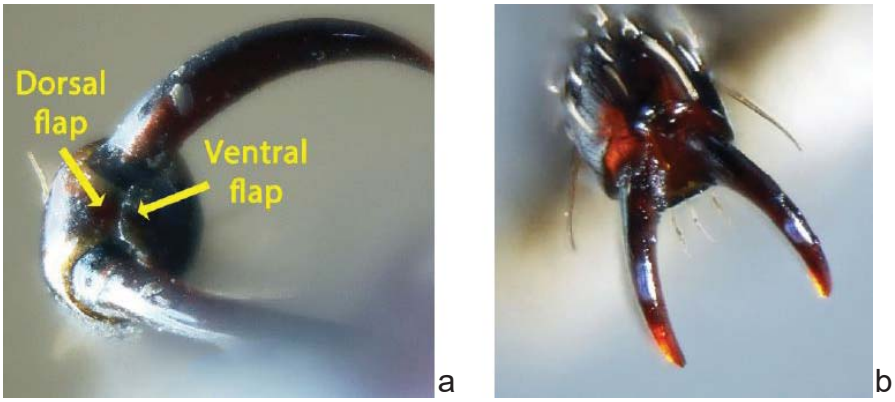

Fig. 8: a) flaps between tarsal claws present in the Dryophthoridae and b) absence of flaps in the Curculionidae

Antenna: Dryophthoridae have a glabrous (lacking setae) first antennal club segment (Fig. 9a) and a scape that surpasses the posterior margin of the eye (Fig. 9b). Curculionidae have a first antennal club segment that is not glabrous (Fig. 9c) and a scape that does not surpass the posterior margin of the eye (Fig. 9d):

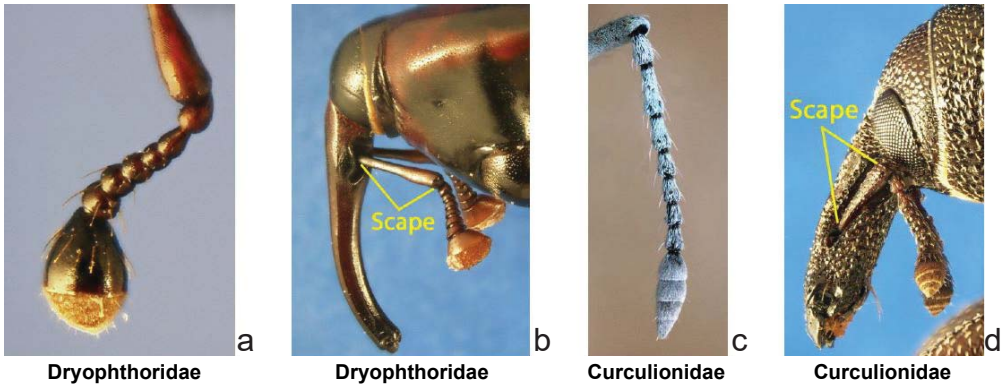

Fig. 9: Differences in antennae of Dryophthoridae and Curculionidae (Photos by Charles Brodel USDA-APHIS-PPQ)

Other *h nchophorus* are present in the U.S., and all are difficult to identify to species without expert knowledge. Therefore, all specimens passing Level 1 and Level 2 Screening should be submitted for identification following the protocol for nematode detection on palm weevils described on page 6.

There are a number of Nearctic genera in the Rhynchophorini that might be similar in appearance to the *h nchophorus* palm weevils, though none are comparable in terms of size. In addition to their large size, *h nchophorus* can be differentiated by their relatively broad metepisternum (Fig. 10) and distinct antennae with a transverse sub-triangular club that is wider than it is long (Fig. 11).

Fig. 10: Highlighted in magenta, a) the broad metepisternum of *h nchophorus* and b) the elongate metepisternum of *c phophorus* (Photos by Hanna Royals)

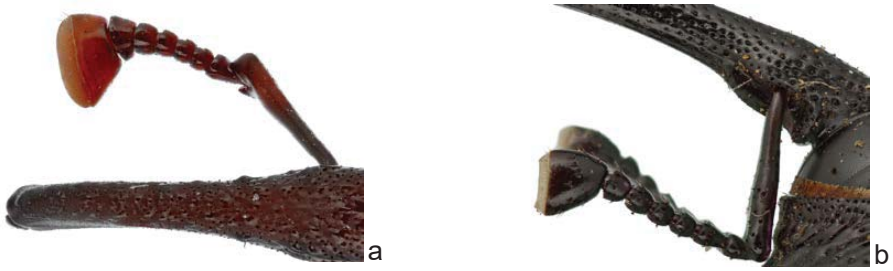

Fig. 11: Antennae, a) the wide antennal club of *h nchophorus* and b) the longer antennal club of *c phophorus* (Photos by Hanna Royals)

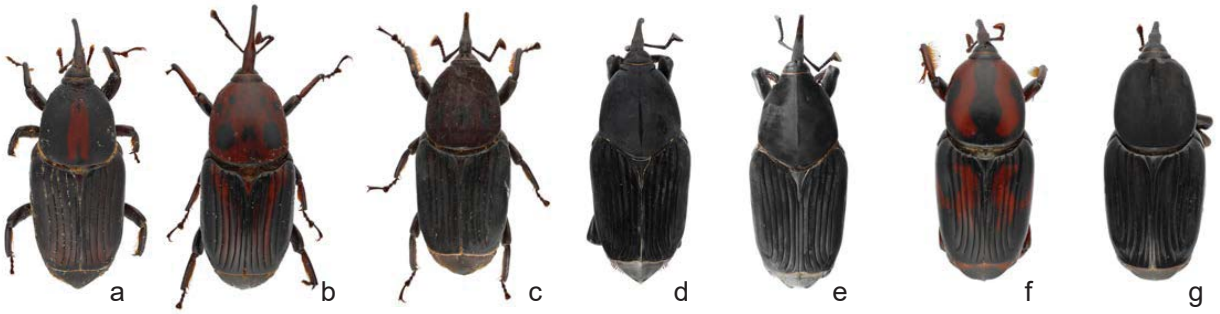

Fig. 12: Adult palm weevils, variation in coloration of *ferrugineus* (a-c) *pal aru* (d-e) and *cruentatus* (f-g).

The Florida native *h nchophorus cruentatus* can be distinguished from *ferrugineus* and *pal aru* by the shape of the pronotum. However, the differences are very subtle and species-level identification should only be done by an expert. Therefore, any specimen meeting the criteria for Level 1 and 2 Screening should be submitted for identification following the protocol for nematode detection on palm weevils described on page 6.

Key and References

Key to Sort and Screen *nc op orus* spp. Suspects in the United States

1. Metepisternum broad, length more or less 2 times width (Fig. 10); antenna with club transverse, wider than long, shape sub-triangular (Fig. 11); total body length greater than 25 mm..... ***nc op orus* suspect**

1'. Metepisternum narrow, length 3 or more times width; antenna with club elongate, longer than wide, shape sub-quadrate or sub-oval; total body length less than 25 mm.....Not *h nchophorus*

Citation

Royals, H. R. and T. M. Gilligan. 2017. Screening aid: Palm Weevils, *h nchophorus* spp. Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 6 pp.

References for more information on *nc op orus* species and non-targets

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Acknowledgments

We would like to thank USDA-APHIS-PPQ National Identification Services and the USDA-APHIS-PPQ-S&T Identification Technology Program for support of this work, and Jim E. Zablotny (Identifier, USDA APHIS PPQ) for their review of this screening aid. Funding for this project was provided to H. Royals through section 10007 of the 2014 Farm Bill.

Specimen Preparation

Palm Weevils
h nchophorus spp.

Protocol for Preparing and Forwarding Suspect South American Palm Weevil from Survey Traps for Confirmation and to Maximize Red Ring Nematode Detection

JFloyd, 6/21/2012

Instructions for Personnel Servicing Traps:

1. When suspect palm weevils are recovered from palm weevil bucket traps, carefully remove the weevil and place it in a screw-top vial containing water. Do not rinse the surface of the weevil or put the weevil in alcohol. If the weevil is still alive, freeze it for several hours to kill it before immersing in water.

2. If possible, wrap Parafilm® around the vial screw cap to prevent leakage. Label the vial with a local collection number using a Sharpie® permanent pen.

3. From the liquid in the trap with a weevil, extract approximately 50 cc's from the:
    a. top surface of the liquid in the trap if it is mostly propylene glycol;
    b. bottom of the trap if it's mostly water.

Place the liquid sample in a separate container that will not leak. A pipette or glass (not plastic) turkey baster can be used for this. Be sure to rinse it thoroughly between samples if reused to prevent cross-contamination. Write the same collection number on this container.

4. Until the specimen and other container of water can be shipped for identification, place the vial in cool conditions such as an ice-chest with cool packs, but do not freeze the specimen.

5. As soon as possible, send the vial with the specimen in water cushioned in a crush-proof box by overnight carrier to a PPQ Identifier or State taxonomist in your state. Include a completed PPQ form 391 indicating it is in water, with the local collection number, and notify the taxonomist /identifier by e-mail that the specimen is being forwarded, supplying the overnight carrier tracking number. Also notify local PPQ and state program managers that the specimen is being forwarded. (Do not ship on a Friday, rather keep the specimen in a refrigerator until Monday when it can be shipped overnight without weekend delays).

ATTENTION: Dr. Lynn Carta
Mycology and Nematology Genetic Diversity and Biology Laboratory
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10300 Baltimore Avenue, Beltsville, MD 20705
office phone: 301-504-8787 lab phone: 301-504-7039 fax: 301-504-5062

Screening Aid

Black Maize Beetle

Heteronychus arator (Fabricius)

Hanna R. Royals[1], Todd M. Gilligan[1] and Charles F. Brodel[2]

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Version 1.0
21 February 2017

This CAPS (Cooperative Agricultural Pest Survey) screening aid produced for and distributed by:
USDA-APHIS-PPQ National Identification Services (NIS)
This and other identification resources are available at: http://caps.ceris.purdue.edu/taxonomic_services

The black maize beetle, *Heteronychus arator* (F.), is a scarab beetle native to Africa and introduced into Australia, New Zealand, and Central and South America. This scarab is a member of the subfamily Dynastinae, the rhinoceros beetles. Adults are characterized by robust body shapes, exposed pygidia, dark coloration, and mandibles that are generally visible from the dorsal aspect.

Fig. 1: Lateral view of *Heteronychus arator* (Photo by Hanna Royals).

Damage to agricultural crops occurs mostly due to adults feeding on stems and plant bases, particularly those of seedlings, resulting in plant death. African black beetles have been recorded feeding on *Ananas comosus* (pineapple), *Eucalyptus, Solanum tuberosum* (potato), *Vitis vinifera* (grapevine), and seem to have a preference for a large number of plants in the Poaceae such as: *Bromus catharticus* (prairie grass), *Lolium perenne* (perennial ryegrass), *Pennisetum clandestinum* (kikuyu grass), *Saccharum officinarum* (sugar cane), and *Zea mays* (maize). Larvae and adults both feed at the base of grasses and can cause significant damage to lawns and pastures.

Fig. 2: General scarab larval form (Photo by Charles F. Brodel).

Adults of the African black beetle are 12-15 mm long and are generally a shiny black with a reddish underside. Separation of *H. arator* from other scarab genera can be challenging because many other species resemble this typical scarab in size, color, and morphology. Accurate identification to genus is possible by comparison of key morphological characters, often requiring a microscope. The North American genera that would most likely be confused with *H. arator* are *Euetheola, Tomarus,* and some *Stenocrates* that may stray north from Mexico. Any suspect scarab should be submitted for professional identification.

Sorting

Black Maize Beetle
Heteronychus arator (Fabricius)

Heteronychus arator traps should be sorted initially for the presence of beetles of the appropriate size, color, and shape. Beetles should verified as belonging to the Scarabaeidae. Traps that contain scarabs meeting all of the following requirements should be moved to Level 1 Screening (Page 3):

1) Beetles are 12-15 mm (0.47-0.60 inches) long

2) Beetles have an overall shape that is similar to the outline depicted in Fig. 3

3) Beetles have a black or dark reddish coloration (Fig. 4)

4) Beetles have protibia that are scalloped or toothed (Fig. 5)

5) Beetles have lamellate antennae (Fig. 6)

Note that beetles caught in traps can appear very similar in appearance as there is an abundance of scarab species. For this reason, any scarab-like beetle meeting the above criteria should be sent forward for screening.

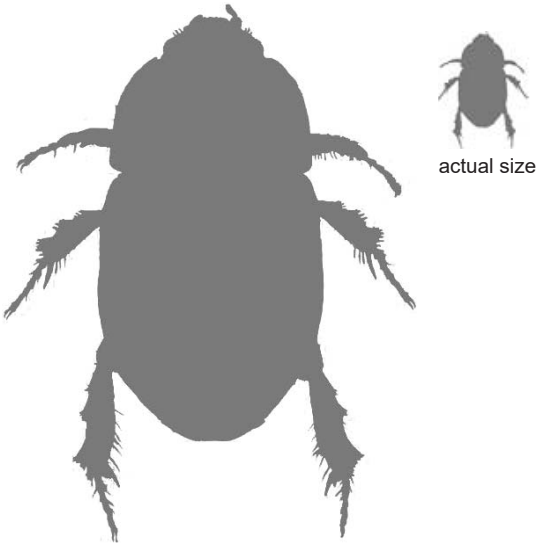

Fig. 3: Outline of *Heteronychus arator* male.

Fig. 4: Variation in color of *Heteronychus arator* adults (left = female; right = male). Males can be distinguished by their swollen front tarsal segments.

Fig. 5: Toothed protibia of *Heteronychus arator*

Fig. 6: Lamellate antenna of *Heteronychus arator*

Level 1 & 2 Screening

Black Maize Beetle
Heteronychus arator (Fabricius)

Scarabs that meet the sorting requirements should be screened for suspects in the Dynastinae. Level 1 Screening by a trained coleopterist is based on only a few characteristics. When in doubt distinguishing or evaluating first-level screening characters, forward specimens that have passed the sorting requirements to a trained taxonomist.

Dynastinae scarabs can be identified by the following combination of characters:

1) Bodies robust (Fig. 4).

2) Two spurs present on mesotibia (Fig. 7).

3) Pygidium exposed past apex of elytra (Fig 8).

4) Mandibles often visible dorsally (Fig. 9).

5) Claws of meso- and metatarsi simple and similar in length and shape (Fig. 10).

Beetles meeting the above criteria should be moved to Level 2 Screening. Specimens should be pinned and clearly labeled before being sent to a trained coleopterist.

Fig. 7: Two spurs present on mesotibia of *Tomarus gibbosus.* (Photo by Hanna Royals).

Fig. 8: Exposed pygidium of *Heteronychus arator.* (Photo by Simon Hinley & Ken Walker: Museum Victoria).

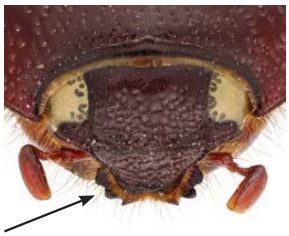

Fig. 9. Mandibles of *Tomarus fossor* visible from dorsal view of head. (Photo by Hanna Royals).

Fig. 10. Tarsal claws. (Photo by Charles F. Brodel).

Level 2 Screening

Heteronychus arator is most often confused with beetles in three other genera: *Euetheola, Tomarus,* and some *Stenocrates.* There are morphological characters to separate *H. arator* from each genus. Species identification is nearly impossible without dissection of male genitalia, a task which should be performed by a trained coleopterist. Any suspect *Heteronychus* specimens should be submitted for review.

1) *Heteronychus* beetles can be separated from all three genera by the presence of paired ridged stridulatory bands on the propygidium. However, this character is often difficult or impossible to observe without careful removal of an elytron.

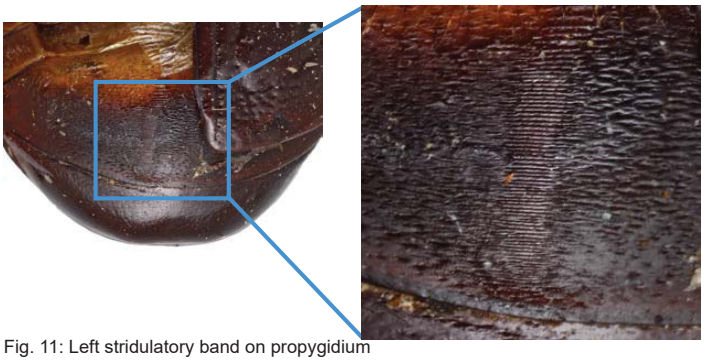

Fig. 11: Left stridulatory band on propygidium

2) *Heteronychus* can be distinguished from *Euetheola* by the pronotum. *Heteronychus* lack punctures on the pronotum (left). Three out of four species of *Euetheola* have moderate to large punctures on the pronotum (right). One species has micropunctures on the pronotum that must be detected with high magnification under directed light. (*Stenocrates* and *Tomarus* have some species with and some without punctures on the pronotum.)

Fig. 12: *Heteronychus*

Fig. 13: *Euetheola*

3) *Heteronychus* can be distinguished from *Stenocrates* by the mandibles. *Heteronychus* has 2 or 3 teeth on the outer margin of each mandible (left). *Stenocrates* has no teeth on the outer margin of each mandible (right). [*Euetheola* has 1 or 2 teeth and *Tomarus* has 2 or 3 teeth - not shown.]

Fig. 14: *Heteronychus*

Fig. 15: *Stenocrates*

4) *Heteronychus* can be distinguished from *Tomarus* by features on the head. *Heteronychus* has no tubercle or carina on the head (left). *Tomarus* has 2 tubercles OR one transverse carina (not shown) on the head. [*Euetheola* has no tubercles and no carina on the head. *Stenocrates* has no tubercles and no carina on the head.]

Fig. 16: *Heteronychus*

Fig. 17: *Tomarus*

Final species-level identification must be performed by a specialist using genitalic characters.

Key and References

Key to Sort and Screen *Heteronychus arator* Suspects in the United States

1.	Beetles 12-15 mm long with an overall shape scarab-like (Fig. 3), dark in color, with lamellate antennae and pygidium exposed (Fig. 8)	2
1'.	Beetles shorter or longer than 12-15 mm long with an overall shape that is not scarab-like; not dark in color; not with lamellate antennae; or pygidium hidden beneath elytra	Not *H. arator*
2.	Pronotum lacking punctures (Fig. 12)	3
2'.	Pronotum with punctures	Not *H. arator*
3.	Mandibles with 2 or 3 teeth on the outer margin (Fig. 14)	4
3'.	Mandibles with 1 or without teeth on the outer margin	Not *H. arator*
4.	Head lacking tubercles or carina (Fig. 16)	5
4'	Head with tubercles or carina	Not *H. arator*
5	Propygidium with a pair of stridulatory bands (Fig. 11)	***H. arator* suspect**
5'	Propygidium without stridulatory bands	Not *H. arator*

Citation

Royals, H. R., T. M. Gilligan and C. F. Brodel. 2017. Screening aid: Black maize beetle, *Heteronychus arator* (Fabricius). Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 5 pp.

References for more information on *H. arator* and non-targets

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