

**DISCOVERY OF *LOBESIA BOTRANA* ([DENIS & SCHIFFERMÜLLER])
IN CALIFORNIA: AN INVASIVE SPECIES NEW TO
NORTH AMERICA (LEPIDOPTERA: TORTRICIDAE)**

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Abstract.—The European grape vine moth, *Lobesia botrana* ([Denis and Schiffermüller]), is one of the most destructive pests of grape in the Palearctic Region. Larvae feed on fruit, causing direct damage and promoting secondary infection by *Botrytis cinerea* Persoon (botrytis bunch rot or gray mold). On September 30, 2009, tortricid larvae damaging grapes in the Napa Valley of California were identified as *L. botrana*, representing the first records of this species in North America. The presence of *L. botrana* could have a significant impact on California agriculture—wine, table, and raisin grapes are grown on more than 800,000 acres throughout the state. We provide descriptions and illustrations to aid in the identification of this newly arrived pest, along with a brief history of its discovery.

Key Words: *Botrytis*, grape, European grapevine moth, EGVM, introduction, Olethreutini, Palearctic, *Paralobesia*, *viteana*, *Vitis*

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Lobesia botrana ([Denis and Schiffermüller]) is an economically important pest of vineyards throughout the Palearctic Region (e.g., Bovey 1966, Voigt 1972, Thiéry and Moreau 2005) but is

particularly destructive in southern Europe and several Mediterranean countries (Roehrich and Boller 1991). The larvae cause damage to grapes by feeding directly on fruit, although the most serious economic losses are due to secondary infection of feeding sites by *Botrytis cinerea* Persoon (botrytis bunch rot

or gray mold) (e.g., Roehrich and Boller 1991, Fermaud and Le Menn 1992). The threat that this moth poses to American agriculture has not gone unnoticed (Pierce 1918), and there have been sporadic efforts focused on its exclusion and/or detection in North America over the last few decades. These included a series of pest alerts, risk assessments, and surveys in both the United States (Whittle 1985, Fowler and Lakin 2002, Venette et al. 2003) and Canada. On September 30, 2009, tortricid larvae found in grape (*Vitis vinifera* L.: Vitaceae) from the Napa Valley of California were identified as *L. botrana*, representing the first North American records of this species. Because more than 800,000 acres of grapes are cultivated throughout the state, *L. botrana* could have a significant impact on California agriculture.

The purpose of this contribution is to summarize the literature on the geographic distribution, hosts, life cycle, and morphology of *L. botrana* and to make this information available to those involved in exclusion, detection, and identification of this species. We also document its discovery in California.

MATERIALS AND METHODS

Specimens of *L. botrana* from Europe, Chile, and California were examined and dissected using a Wild M5A stereomicroscope (Wild Heerbrugg AG, Switzerland). Dissection methodology follows Brown and Powell (1991) except that some preparations were not transferred to xylene and instead were mounted in Euparal (Bioquip Products, Rancho Dominguez, CA). Adults were photographed with a Canon EOS 40D digital SLR camera (Canon U.S.A., Lake Success, NY) mounted on a Visionary Digital BK Lab System (Visionary Digital, Palmyra, VA). Photographs of genitalia and larval cuticles were taken using a Nikon DXM 1200 digital camera mounted on a Nikon Labophot2 compound microscope

(Nikon Instruments, Melville, NY). The photograph of the pupal abdominal segments and cremaster was taken with a Nikon DXM 1200 camera mounted on an upright Zeiss Axiomat microscope (Carl Zeiss Inc., Thornwood, NY). Scanning electron micrographs (SEMs) were prepared using a JEOL JSM-6500 microscope. Some photographs are a combination of several layers produced with Helicon Focus 4.80 software (Helicon Soft Ltd., Kharkov, Ukraine). All photographs were edited using Adobe Photoshop CS3 Extended (Adobe Systems Inc., San Jose, CA). Morphological terminology and wing pattern descriptions follow Gilligan et al. (2008). Natural history and host information is compiled from Ben-Yehuda et al. (1993), Bradley et al. (1979), CPC (2007), Thiéry and Moreau (2005), and Venette et al. (2003).

RESULTS AND DISCUSSION

Nomenclature

Tortrix botrana Denis and Schiffermüller was described from Vienna, Austria. Ragonot (1894) proposed the genus *Polychrosis* with *T. botrana* as the type species. Over half a century later, Obraztsov (1953) relegated *Polychrosis* to a subgenus of *Lobesia* Guenée, with *L. botrana* as its only member. Synonyms of *L. botrana* include *Phalaena vitisana* Jacquin and *Olinidia rosmarinana* Millière (Brown 2005). Dufrane (1960) described “flavosquamella” as a form of *L. botrana* from France. Older literature often used the combination *Eudemis botrana* (González 2008). Authorship of the species name *botrana* is unequivocally attributed to Denis & Schiffermüller even though their names do not appear on the original work. Hence, per Recommendation 51D of the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999), the authors’

names . . . “should be enclosed in square brackets to show the original anonymity.” Unfortunately, this convention is too frequently ignored.

Lobesia botrana has a wide variety of common names in several languages (see list in González 2008). English common names for *L. botrana* include: European grapevine moth (EGVM), European grape berry moth, grape berry moth, grapevine moth, vine moth, European vine moth, grape leaf roller, and grape fruit moth (Meijerman and Ulenberg 2000, CPC 2007); several of these names are shared with *Eupoecilia ambiguella* (Hübner), another European tortricid grape pest. When common names are necessary, we suggest using European grape vine moth for *L. botrana* and European grape berry moth for *E. ambiguella*, or avoiding the issue completely by using scientific nomenclature.

Geographic Distribution

Lobesia botrana is native to the Palearctic Region and is widely distributed in Western Europe, Central Asia, and northern Africa (Razowski 2003, CPC 2007). Records from Japan (Bae and Komai 1991) and eastern Africa (Kenya, Ethiopia, and Eritrea) are likely due to inadvertent human introductions (CPC 2007). North American records of *L. botrana* from the mid- to late-1800s are misidentifications of *Paralobesia viteana* (Clemens) (Kearfott 1904), a native North American grape-feeding tortricid that is extremely similar morphologically to *L. botrana*.

Lobesia botrana was first discovered in the Americas from Chile in April 2008, where it was reported feeding on grape by the Chilean Department of Agriculture (González 2008). Subsequently, it spread to all grape growing regions of that country (SAG 2010), and in March 2010, the Argentinean National

Service for Agrifood Health and Quality reported *L. botrana* in Argentina at two locations in the Maipú Department, Mendoza Province, close to the Chilean border (SENASA 2010).

Larval Hosts and Damage

Lobesia botrana is one of the most important pests of grape (*Vitis vinifera*) in the Palearctic (Bovey 1966, Roehrich and Boller 1991). Larvae are polyphagous and have been recorded from over 40 species of plants in the following families: Actinidiaceae, Araliaceae, Asteraceae, Berberidaceae, Caprifoliaceae, Caryophyllaceae, Cornaceae, Ebenaceae, Ericaceae, Grossulariaceae, Lamiaceae, Liliaceae, Menispermaceae, Oleaceae, Punicaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Thymeleaceae, and Vitaceae. A partial host list is presented in Table 1.

Preference for *V. vinifera* may have evolved only recently as damage to grape by *L. botrana* was not reported until the early part of the 20th century (Marchal 1912, Thiéry and Moreau 2005). Female *L. botrana* are attracted to volatiles of both *Vitis* and *Daphne* (Tasin 2005) but prefer to oviposit on *Daphne* rather than *Vitis* when given a choice (Maher and Thiéry 2006). As a result, several authors (e.g., Bovey 1966, Tasin 2005, Thiéry and Moreau 2005, Maher and Thiéry 2006) have hypothesized that *Daphne gnidium* L. (Thymelaeaceae) is the native host plant for *L. botrana*. Polyphagy may persist because hosts other than *Vitis* provide better nutritional value. Thiéry and Moreau (2005) demonstrated that individuals feeding on alternate hosts had lower larval mortality, shorter development times, higher pupal weight, and increased female fecundity and mating success.

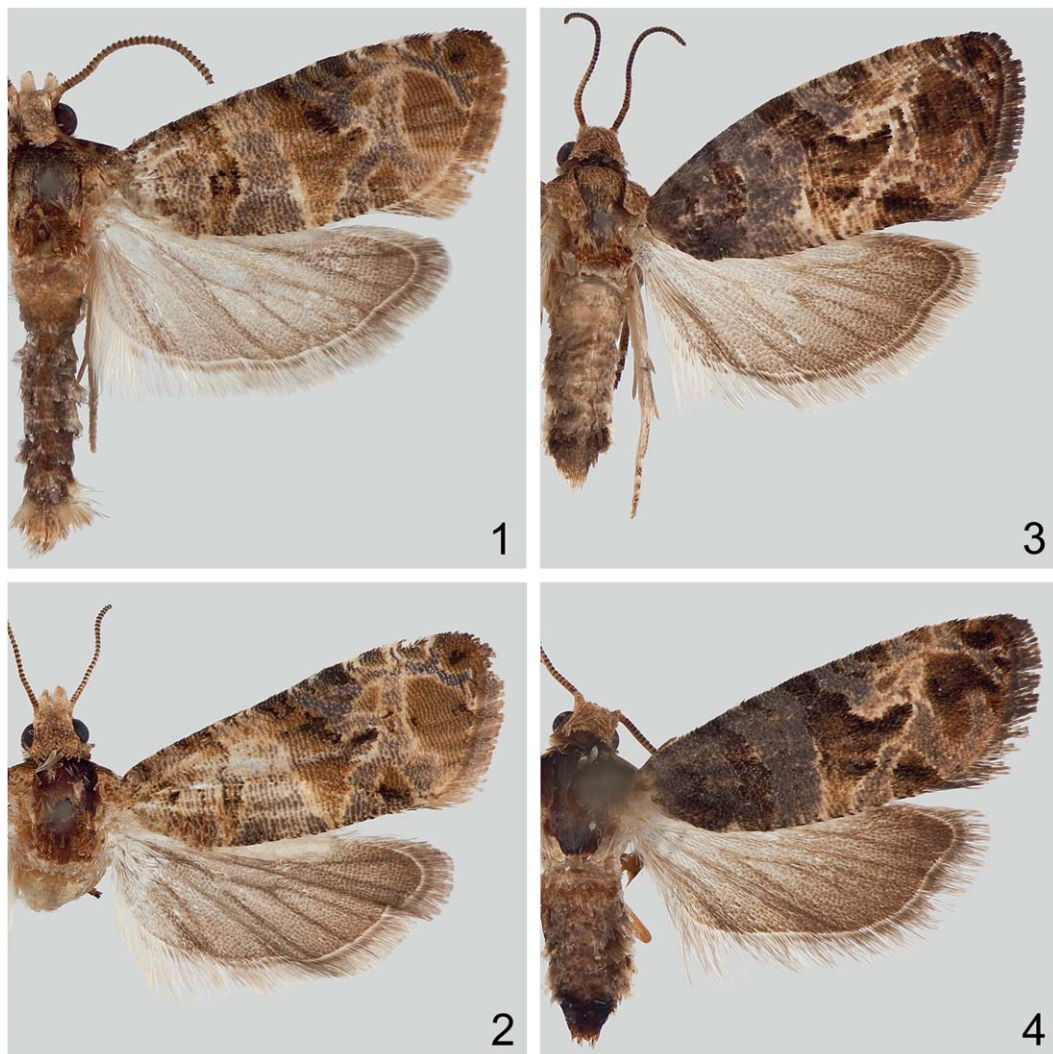
Larvae of *L. botrana* damage grape by feeding on flowers, buds, and fruit. First generation larvae feed on flower buds, resulting in reduced yields, whereas second

Table 1. Documented host plants for *L. botrana*.

Family	Genus/species	Common name
Actinidiaceae	<i>Actinidia chinensis</i> Planch.	kiwi
Araliaceae	<i>Hedera helix</i> L.	English ivy
Asteraceae	<i>Tanacetum vulgare</i> L.	common tansy
Berberidaceae	<i>Berberis vulgaris</i> L.	common barberry
Caprifoliaceae	<i>Lonicera tatarica</i> L.	Tatarian honeysuckle
Caprifoliaceae	<i>Viburnum lantana</i> L.	wayfaringtree
Caryophyllaceae	<i>Dianthus</i> L.	carnation
Cornaceae	<i>Cornus mas</i> L.	Cornelian cherry
Cornaceae	<i>Cornus sanguinea</i> L.	bloodtwig dogwood
Cornaceae	<i>Cornus</i> L.	dogwood
Ebenaceae	<i>Diospyros kaki</i> L. f.	Japanese persimmon
Ebenaceae	<i>Diospyros virginiana</i> L.	common persimmon
Ericaceae	<i>Arbutus unedo</i> L.	strawberry tree
Grossulariaceae	<i>Ribes nigrum</i> L.	European black currant
Grossulariaceae	<i>Ribes rubrum</i> L.	cultivated currant
Grossulariaceae	<i>Ribes uva-crispa</i> L.	European gooseberry
Lamiaceae	<i>Rosmarinus officinalis</i> L.	rosemary
Liliaceae	<i>Urginea maritima</i> (L.) Baker	red squill
Menispermaceae	<i>Menispermum canadense</i> L.	common moonseed
Oleaceae	<i>Ligustrum vulgare</i> L.	European privet
Oleaceae	<i>Ligustrum japonicum</i> L.	Japanese privet
Oleaceae	<i>Olea europaea</i> L.	olive
Oleaceae	<i>Syringa vulgaris</i> L.	common lilac
Punicaceae	<i>Punica granatum</i> L.	pomegranate
Ranunculaceae	<i>Clematis vitalba</i> L.	evergreen clematis
Rhamnaceae	<i>Ziziphus jujuba</i> (L.) Karst.	common jujube
Rosaceae	<i>Malus pumila</i> Mill.	apple
Rosaceae	<i>Prunus avium</i> (L.) L.	sweet cherry
Rosaceae	<i>Prunus domestica</i> L.	European plum
Rosaceae	<i>Prunus dulcis</i> (Mill.) D.A. Webb	sweet almond
Rosaceae	<i>Prunus persica</i> (L.) Batsch var. <i>nucipersica</i> (Suckow) C.K. Schneid.	nectarine
Rosaceae	<i>Prunus salicina</i> Lindl.	Japanese plum
Rosaceae	<i>Prunus spinosa</i> L.	blackthorn
Rosaceae	<i>Pyrus communis</i> L.	common pear
Rosaceae	<i>Rubus caesius</i> L.	European dewberry
Rosaceae	<i>Rubus fruticosus</i> L. [excluded]	shrubby blackberry
Rosaceae	<i>Rubus</i> L.	raspberry
Thymeleaceae	<i>Daphne gnidium</i> L.	flax-leaved daphne
Thymeleaceae	<i>Thymelaea hirsuta</i> (L.) Endl.	thymelaea
Vitaceae	<i>Parthenocissus quinquefolia</i> (L.) Planch.	Virginia creeper
Vitaceae	<i>Vitis vinifera</i> L.	wine grape

and third generation larvae feed on ripening and mature grapes, respectively (Roehrich and Boller 1991). The most significant economic losses are due not to direct damage to berries but to secondary infection of feeding sites by *B.*

cinerea (e.g., Roehrich and Boller 1991, Fermaud and Le Menn 1992). Economic thresholds for *L. botrana* in grape vary with climatic conditions, type of grape (wine or table), and cultivar (Roehrich and Boller 1991). The species also is



Figs. 1–4. Adult wing patterns. 1–2, *Lobesia botrana*; 3–4, *Paralobesia viteana*

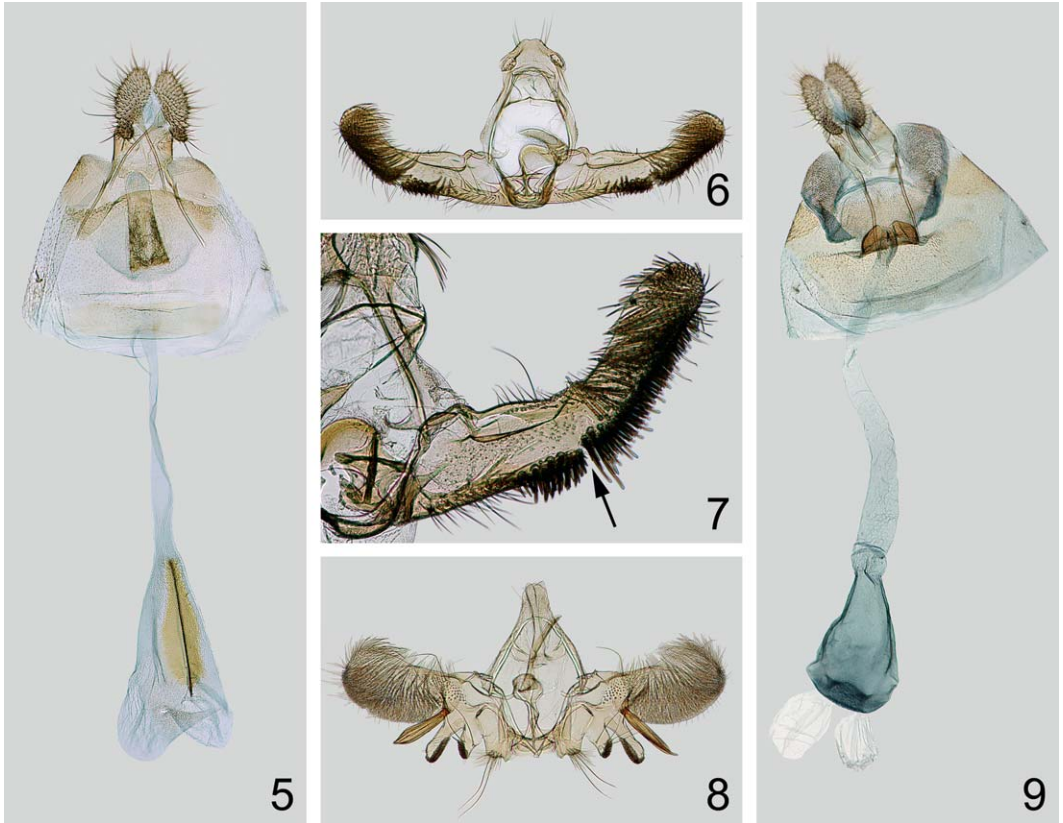
considered a minor pest of some ornamental and greenhouse plants and has been reported infesting pear (*Pyrus communis* L.; Rosaceae) orchards in Israel (Ben-Yehuda et al. 1993).

Life Cycle and Biology

Lobesia botrana completes 2–3 generations annually in southern Europe, although the number of generations varies from one in northern Europe to as many

as five in Central Asia (Filip 1986, CPC 2007). There are at least three and possibly four generations in Chile (González 2008). The lower temperature threshold for egg, larval, and pupal development is approximately 8 °C (Gabel and Mocko 1984).

The following summary of the life cycle on grape is derived from Bovey (1966), Bradley et al. (1979), CPC (2007), Masante-Roca et al. (2007), and Meijerman and Ulenberg (2000). Females



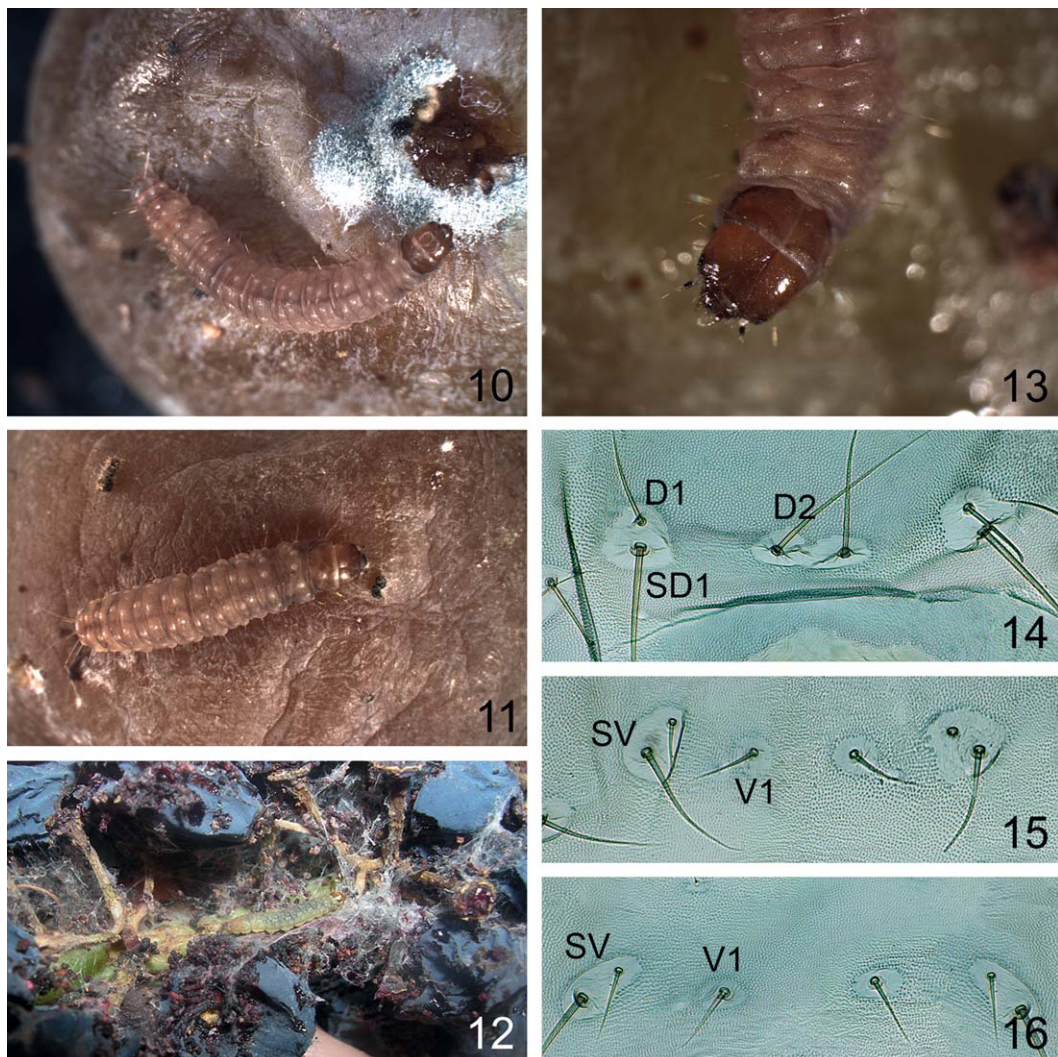
Figs. 5–9. Male and female genitalia. 5, *L. botrana* female; 6, *L. botrana* male; 7, *L. botrana* male, arrow denotes gap in spines on valva; 8, *P. viteana* male; 9, *P. viteana* female.

of the first generation deposit eggs singly or in groups of two or three on buds, pedicels, and flowers; those of the second and third generations deposit single eggs on individual grape berries. Eggs hatch in approximately 5–10 days or 75 degree-days above a 10 °C threshold. Larvae complete five instars, with the first generation feeding on flowers and buds, the second generation feeding within a single unripened grape berry, and the third and subsequent generations feeding on ripened berries. Larval development is completed in approximately 20–28 days or 170 degree-days for larvae feeding on flowers and 225 degree-days for larvae feeding on berries. Non-diapausing individuals of

the first and second generations pupate in rolled leaves or inflorescences tied with silk. Pupae complete development in approximately 12–14 days, or 130 degree-days, for non-diapausing individuals. Diapausing individuals of the third or subsequent generations pupate under bark, in the soil, or under leaf litter; adults emerge the following spring.

Morphology

Egg (Figs. 20–22).—The egg of *L. botrana*, originally illustrated by Silvestri (1912), is elliptical, flattened, and slightly convex. Each egg is approximately 0.65–0.90 mm long by 0.45–0.75 mm wide (CPC 2007). The chorion is

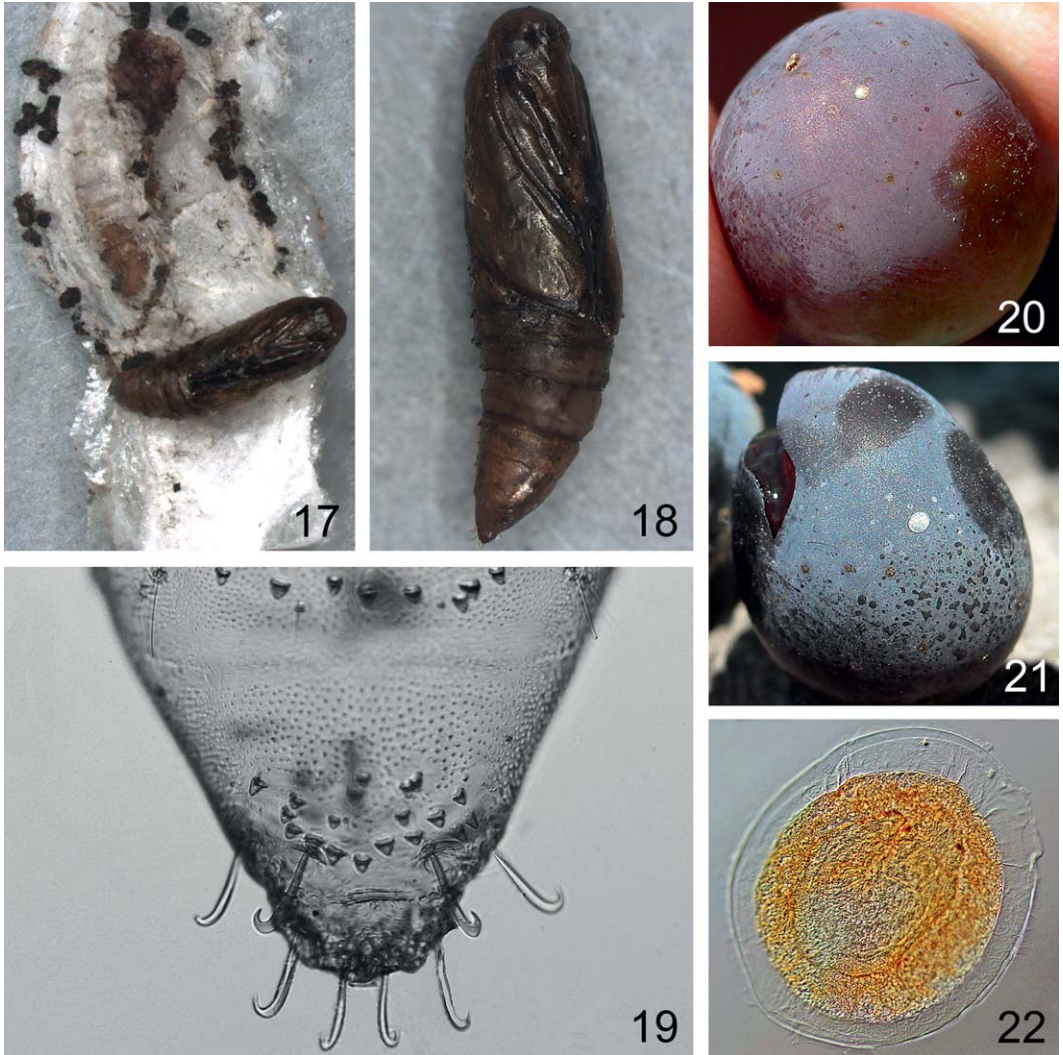


Figs. 10–16. *Lobesia botrana* larvae. 10, Larva feeding on *Botrytis cinerea*; 11, Larva on grape; 12, Typical damage to grapes (courtesy Roberto H. González, Universidad de Chile); 13, Details of head and prothoracic shield; 14, Dorsal aspect of segment A9 showing D2s on “saddle” pinaculum, and D1 and SD1 on same pinaculum; 15, Ventral aspect of segment A8 showing relative spacing of V1 setae; 16, Ventral aspect of segment A9 showing relative spacing of V1 setae.

either smooth or there is a slight polygonal reticulation on the border and around the micropile (CPC 2007). When newly laid, eggs are translucent pale yellow, eventually turning “opalescent” gray (Meijerman and Ulenberg 2000), with the embryo becoming visible during incubation. Because the egg is semi-transparent, dark

substrates may affect the coloration (H. Nadel pers. comm.).

No morphological characters are available to separate eggs of *L. botrana* from related species in the Olethreutinae. However, many species of Tortricinae (i.e., Archipini and Sparganothini) oviposit in large overlapping clusters (Powell and



Figs. 17–22. *Lobesia botrana* eggs and pupae. 17, Pupa and cocoon; 18, Pupa; 19, Pupa, dorsal aspect of A10 with patch of spines; 20, Egg on grape; 21, Egg on grape; 22, Embryo inside of translucent egg.

Common 1985, Horak 1991). This oviposition pattern characterizes several common Californian tortricid pests such as *Platynota stultana* Walsingham, *Argyrotaenia franciscana* (Walsingham), and *Epiphyas postvittana* (Walker). Eggs of *L. botrana* are laid singly or in small clumps, never in a mass.

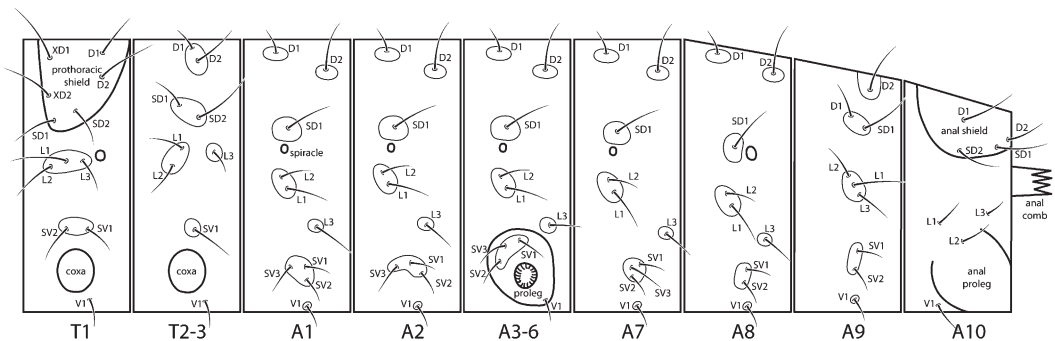
Larva (Figs. 10–16, 23–29).—The first instar larva is yellowish green and

approximately 1.0 mm in length. The head is black to dark brown, and the paler prothoracic shield is concolorous with the rest of the body. The mature larva (Figs. 10–12) is 10–15 mm long and varies in color from light yellowish green to pale brown. The head is brown to light yellowish brown to honey colored, the antennae and thoracic legs are brown to black, and the prothoracic shield is

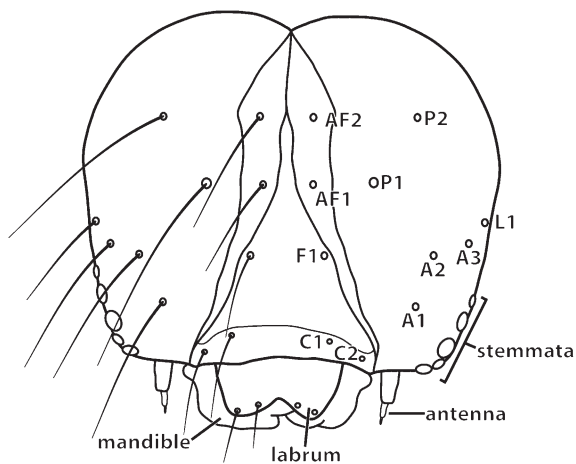
variably shaded with dark brown to black on the posterior and lateral margins. All instars have a dark stemmatal area and genal dash. Prepupae are colored a “dull dark purple” (H. Nadel pers. comm.). Irigaray et al. (2006) measured head capsule widths for each instar.

Important structural features of the *L. botrana* larva include: mandibles without inner teeth (sensu Passoa 1985) or a retinaculum (Fig. 25); distance between P1 and AF2 on head equal to distance between P1 and P2 (Fig. 24); a horizontal line connecting the P2 setae

on head passes through AF2 (Fig. 24); L pinaculum on T1 horizontal, not extending beneath spiracle (Fig. 23); SV groups on A1, 2, 7, 8, 9 with 3:3:3:2:2 setae (Fig. 23); SD2 on A1–8 absent (Fig. 23); distance between V setae on A9 approximately 1.5–2.0× the distance between V setae on A8 (Fig. 29); distance between D1 setae on anal shield equal to the distance between D1 and SD1 (Fig. 23); anal comb with 5–6 teeth in California individuals (Fig. 29), other authors (e.g., Swatschek 1958) report 6–8 teeth; and body spicules relatively



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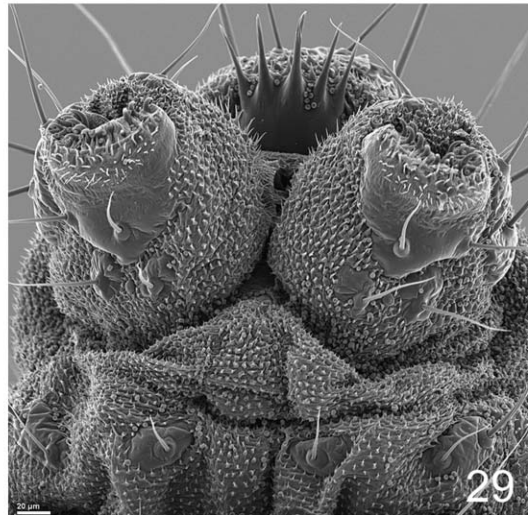
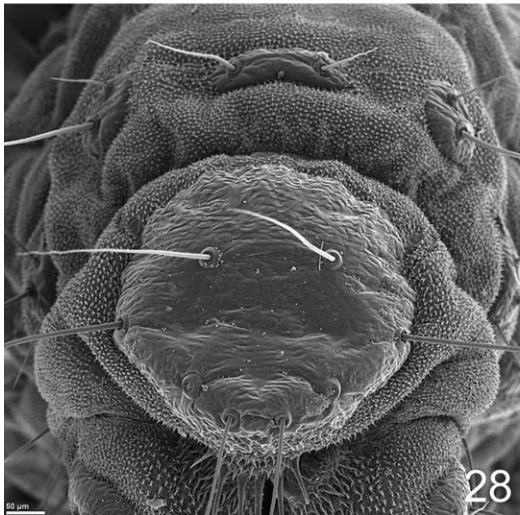
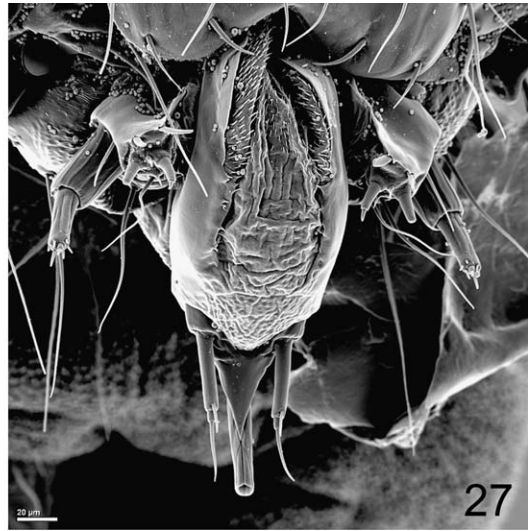
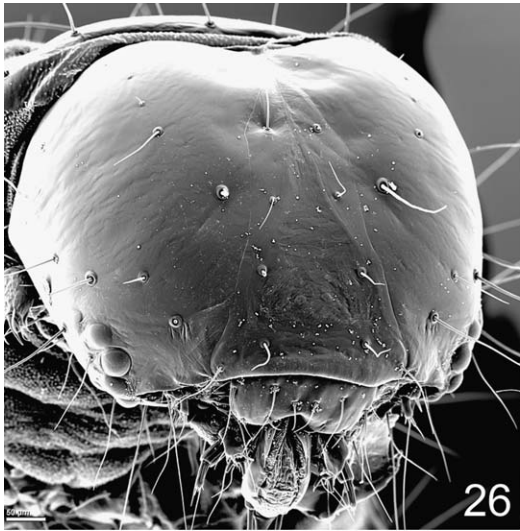
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Figs. 23–25. *Lobesia botrana* larval details. 23, Complete setal map; 24, Head with setal map; 25, Mandible.

dense (at 200× or more) (Figs. 28–29). See Figs. 23–24 for a complete setal map.

In addition to the above, Swatschek (1958) stated the abdominal prolegs have 35 biordinal crochets in a complete circle and the anal proleg has 25 crochets, also biordinal. Four setae are present on the ventral portion of the anal proleg (called the “caudal disc” in the translation by Ericson 1960).

Lobesia botrana belongs to the subfamily Olethreutinae, whose larvae can usually be recognized by a combination of three characters: L group on the prothorax trisetose, D2 setae of A9 closely spaced or joined on “saddle” pinaculum, and A9 with the D1 and SD1 setae fused on a single pinaculum (Figs. 14, 28). Other common tortricid pests in California (*P. stultana*, *A. franciscana*, and



Figs. 26–29. SEMs of *L. botrana* larva. 26, Head; 27, Spinneret; 28, Dorsal aspect of segments A9–10 with anal shield; 29, Ventral aspect of segments A9–10 showing spacing of VI setae, 4 setae on the anal proleg, and anal comb with 5 teeth.

E. postvittana) belong to the subfamily Tortricinae, whose larvae have D1 and SD2 of A9 on separate pinacula (see Gilligan and Epstein 2009).

The key in MacKay (1959), or the simplified version in Passoa (2008), can be used to separate *L. botrana* larvae from many other Olethreutinae in the United States. Because the A and L setae of the head are not in a straight line, all thoracic legs are concolorous, and the SV group on A7 is trisetose, *L. botrana* will group with Nearctic species of *Endothenia*, *Lobesia*, and *Paralobesia* using either of these keys. The larva of *L. botrana* also lacks a dark contrasting patch on the prothoracic shield (although a thin marginal line may be present) and extra setae on the abdominal segments.

Paralobesia viteana (Clemens) is a native North American pest of grapes with an almost identical larval morphology to *L. botrana*. The two species presently have separate distributions: *P. viteana* occurs in the eastern U.S., ranging as far west as Colorado, while *L. botrana* is currently restricted to California. Although it appears that the brown to greenish yellow antenna of *P. viteana* (Ensminger 1958) differs from the black or dark brown antenna of *L. botrana*, this difference needs to be tested with a large series of specimens. Ensminger (1958) and MacKay (1959) illustrate the larvae of *P. viteana*.

Should *L. botrana* spread to areas outside of California, or become common on hosts other than grape, larval identification will be difficult. Characters in the published (MacKay 1959) and unpublished literature (USDA/APHIS/PPQ training aids) such as attenuated adfrontal areas, or the spiracle size compared to the SD1 pinaculum, seem too variable or difficult to interpret to be useful for identification of these closely related taxa. Minute differences in crochet

patterns might be more useful. We recommend rearing the immature stages to an adult or using molecular methods if accurate larval identifications are needed for quarantine decisions in areas outside of California and/or on hosts other than grape. Color photographs of the immature stages without vouchers specimens cannot be identified.

Pupa (Figs. 17–19).—The most accurate pupal description of *L. botrana* was given by Patočka and Turčáni. (2005). Like many tortricids, the pupa is initially greenish brown and later turns dark brown; however, cast pupal skins are somewhat unusual in retaining a greenish tint on the anterior abdominal segments. The average length of male and female pupae is 5.5 mm and 7.0 mm, respectively (CPC 2007). Important structural features of *L. botrana* include: head unmodified, without projections (Fig. 18); clypeus with two pairs of setae; A4 and A5 with 22–24 spines between the D2 setae; dorsum of A10 with a patch of spines (Fig. 19) and no setae present on the anal rise (Fig. 19) (Patočka and Turčáni 2005). The cremaster is fan-shaped with a weakly emarginate caudal margin (Fig. 19) (Meijerman and Ulenberg 2000).

On agriculturally important plants in North America, most pupae with two rows of abdominal spines are those of Tortricidae. Mosher's (1916) key to families is still the standard, although recent workers have modified this diagnosis slightly (Horak 1991, Passoa 2008), and her classification is outdated. Mosher (1916) examined the pupa of *L. botrana* and recognized it as distinct from *P. viteana*. The broad cremaster lacking thick curved hooks at the lateral margin, the presence of spines on A9, the lack of setae on the anal rise and presence of a spine patch on A10 was used to define *Lobesia* (= *Polychrosis*).

As with the larvae, *L. botrana* pupae are morphologically similar to those of

P. viteana. Both species have a patch (or weakly defined row) of spines on the dorsum of A10 (Fig. 19), but they can be separated by the number of spines on the anterior row of segments A4 and A5: 22–24 spines between the D2 setae in *L. botrana* (Patočka and Turčáni 2005), never more than 15 in *P. viteana*.

Larvae of *L. botrana* spin an opaque, white cocoon approximately 8–10 mm in length that is usually at least partially covered in frass. The presence of a cocoon can be used to separate *L. botrana* pupae from other common California tortricid grape pests that do not spin a cocoon, such as *P. stultana* and *A. franciscana*.

Adult (Figs. 1–2, 5–7).—Forewing length ranges from 4.5–8.5 mm (Bradley et al. 1979). Forewing pattern (Figs. 1–2) exhibits little variation and no sexual dimorphism. Forewing pattern is as follows: ground color cream; interfascial areas overlaid with leaden gray; costal strigulae cream, well defined; fasciae brown to dark brown; subbasal fascia well defined, with black scaling medially; median fascia well defined, with triangular medial projection often suffused with black scaling; postmedian fascia broken, forming pretornal patch along dorsum with cluster of black scales; postmedian band forming large brown patch along termen; apex often with conspicuous black dot; termen outlined in cream; fringe brown. The males lack a forewing costal fold. The male hind wing is whitish with a brown periphery, while the female hind wing is completely brown.

Male genitalia (Figs. 6–7) can be distinguished by a combination of the following characters: socii short, lateral, apex with numerous setae; uncus reduced to small bilobed hump on tegumen; gnathos weakly sclerotized; valvae long and narrow with dense row of

strong spines on ventral margin; cucullus densely setose, separated from sacculus by distinct gap in row of ventral spines (Fig. 7); sacculus weakly concave post-medially; phallus small; cornuti absent. Female genitalia (Fig. 5) are characterized by a long, slender ductus bursae that is undifferentiated from the corpus bursae, gradually expanded anteriorly, and an unusual, elongate, somewhat feather-shaped signum.

Lobesia botrana is similar in size and wing pattern to several species of *Paralobesia*, specifically *Paralobesia viteana* (Figs. 3–4), which is a native pest of grapes in eastern North America. The two species can be separated by genitalic structures: *P. viteana* has a sclerotized lobe projecting from the ventral base of the male cucullus that is absent in all other Nearctic olethreutines (Fig. 8), and the female corpus bursae lacks a signum and has two small lobelike anterior accessory bursae (Fig. 9) (Gilligan et al. 2008). Only three species of *Paralobesia* have been recorded from the West Coast. *Paralobesia palliolana* (McDunnough) was collected in the late 1990's near Olympia, Washington (E. LaGasa pers. comm.). An apparently undescribed species of *Paralobesia* was reared from *Calocedrus* sp. (Cupressaceae) in California (J. Powell unpubl.). Another undescribed species of *Paralobesia* was discovered in Oregon as a non-target species in an *E. postvittana* pheromone trap on August 6, 2009 (R. Worth pers. comm.); it is unknown if this species is native to or established in Oregon or present in California. All of the species of *Paralobesia* mentioned here can be separated from *L. botrana* by features of the male and female genitalia; it is unknown if any of them are attracted to *L. botrana* pheromone. Other species of *Paralobesia* in the eastern U.S. are treated in detail by Gilligan et al. (2008).

In California, common tortricid pests recorded feeding on grape include *P. stultana*, *A. franciscana*, and *E. postvittana*. Gilligan and Epstein (2009) provided diagnostic characters for these three species, the adults of which are easily distinguished from *L. botrana* by wing pattern and genitalic structure (e.g., see Brown et al. 2010, Gilligan et al. 2010).

Two other species of *Lobesia*, *Lobesia carduana* (Busck) and *Lobesia bicinctana spiraeae* (McDunnough), are present in North America. The former is a leaf-roller on thistle (Asteraceae) in the eastern United States. The latter was described as *Polychrosis spiraeae* by McDunnough (1938) from individuals feeding in flower heads of *Spiraea* (Rosaceae) in Nova Scotia and was relegated to a subspecies of *Lobesia bicinctana* (Duponchel) by Obraztsov (1953). Both *Lobesia* species can be distinguished from *L. botrana* by genitalia characters. The Palearctic *L. bicinctana* is illustrated by Razowski (2003), and *L. carduana* is illustrated by Gilligan et al. (2008).

Discovery of *Lobesia botrana* in California

The introduction of *L. botrana* into the United States was predicted as early as 1904 by W. D. Kearfott who wrote: "It is not at all unlikely that the European *botrana* will be at some time introduced in this country with imported grape vines..." Kearfott's prediction came true on September 15, 2009 when several Lepidoptera larvae were collected from a vineyard 18 km northwest of Napa, Napa County, California. Napa County officials at the site noted that every grape cluster in the vineyard was damaged and that many clusters were infected with *Botrytis*. Larvae were forwarded to M. Epstein at the California Department of Agriculture's (CDFA) Plant Pest

Diagnostics Branch for identification. DNA was extracted from several larvae, amplified and sequenced. On 30 September, barcode sequences (650 base-pair region of the mitochondrial gene cytochrome oxidase I) from the unknown larvae were compared with sequence data of a known *L. botrana* specimen obtained from Spain in 2009 by T. Gilligan and sequenced by USDA-CPHST Mission Laboratory. The two sequences were identical. One adult and several larvae were received by J. Brown at the USDA Systematic Entomology Laboratory on 8 October where the adult was confirmed as *L. botrana* and the six larvae identified as *Lobesia* sp. CDFA immediately initiated pheromone trapping in grape-growing regions of Napa and Sonoma counties. The discovery of *L. botrana* in California was informally reported in several newspaper articles and press releases on 12 and 13 October. Adult *L. botrana* were collected in pheromone traps in Napa County through late October 2009.

Larvae of *L. botrana* were unknowingly collected in California the previous year. On September 11, 2008, several larvae were found in grape clusters in Napa Valley. A second series of larvae were collected on 17 September. The larvae, originally thought to be those of orange tortrix, *Argyrotaenia franciscana* (Walsingham), were sent to M. Epstein for identification. The larvae were confirmed as Tortricidae but could not be identified to genus or species. Attempts to rear the larvae to adults were unsuccessful as they died as pupae in cocoons during the winter, sealed in a growth chamber. Immediate molecular diagnosis of the larvae was not possible because public barcode reference sequences of *L. botrana* were not available in 2008, and attempts to obtain reference larvae for *P. viteana* from the eastern

United States and *L. botrana* from Europe were unsuccessful. In October 2009, DNA sequence data from larvae captured in 2008 were found to match (e.g., 100%) sequence data of larvae captured from the original collecting site in 2009.

A statewide survey of California for *L. botrana* was initiated in early 2010. As of October 2010, individuals of *L. botrana* have been collected from the following California counties (dates represent the first collection date): Fresno, April 27, 2010; Mendocino, April 26, 2010; Merced, May 10, 2010; Monterey, May 10, 2010; Napa, September 17, 2008; San Joaquin, August 2, 2010; Santa Clara, September 15, 2010; Santa Cruz, September 1, 2010; Solano, April 19, 2010; and Sonoma, March 29, 2010. A total of 100,945 individual *L. botrana* have been captured in California through October 2, 2010 (K. Hoffman pers. comm.). Interception records from neither APHIS nor CDFA provide evidence of the origin, pathway, or date of arrival of *P. botrana* into California.

CONCLUSIONS

Increased globalization has led to a concomitant increase in the potential transport, introduction, and establishment of plant and animal species around the world. Invasive species cost the U.S. billions of dollars per year in agricultural and forest ecosystem losses (Pimentel et al. 2000). The introduction of pests such as *L. botrana* into North America represents not only potential economic impacts to agroecosystems but also may result in costly quarantine actions with trading partners. The European grape vine moth may negatively affect grape production in California and elsewhere if it proves able to spread from the Napa Valley to other grape growing regions. The association with stone and pome fruits, although rare, is equally disturbing.

Eupoecilia ambiguella sometimes co-exists with *L. botrana* in Europe although the distribution and abundance of each species is greatly influenced by climate (Roehrich and Boller 1991). Morphological differences between the two were provided by Silvestri (1912). Regulatory officials should be diligent in their efforts to exclude *E. ambiguella* which could follow *L. botrana* into North American vineyards, especially in cooler areas.

Control and management of invasive species begin with their early detection and accurate identification. The need to support local moth surveys in analyzing exotic pest establishments has already been demonstrated (Brown et al. 2010). Hence, entomologists at the local, state, and federal levels are encouraged to cooperate in the continued monitoring and management of this and other potentially invasive pests.

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