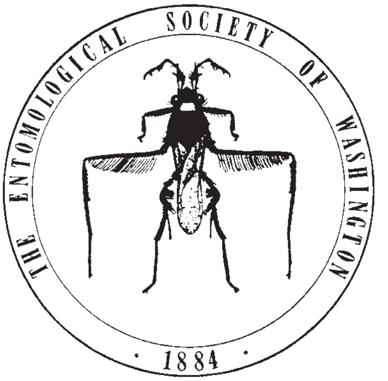
PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY
of WASHINGTON



A NEW SPECIES OF *HISTURA* RAZOWSKI (LEPIDOPTERA: TORTRICIDAE: POLYORTHINI) FROM GUATEMALA ATTACKING AVOCADOS (*PERSEA AMERICANA*) (LAURACEAE)

John W. Brown and Mark S. Hoddle

PROC. ENTOMOL. SOC. WASH.
112(1), 2010, pp. 10–21

A NEW SPECIES OF *HISTURA* RAZOWSKI (LEPIDOPTERA: TORTRICIDAE: POLYORTHINI) FROM GUATEMALA ATTACKING AVOCADOS (*PERSEA AMERICANA*) (LAURACEAE)

JOHN W. BROWN AND MARK S. HODDLE

(JWB) Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, Washington, DC 20013 U.S.A. (e-mail: john.brown@ars.usda.gov); (MSH) Department of Entomology, University of California, Riverside, CA 92521 U.S.A., and Center for Invasive Species Research, University of California, Riverside, CA 92521 U.S.A. (e-mail: mark.hoddle@ucr.edu)

Abstract.—***Histura perseavora*** **Brown, new species,** from Guatemala, is described and illustrated. It is compared with *Histura curvata* (Meyrick) from Brazil and *Histurodes costaricana* Razowski from Costa Rica. All specimens of *H. perseavora* were reared from either fruit, fruit pedicels, or young green branches of avocados (*Persea americana* Mill.; Lauraceae) during efforts to identify lepidopteran pests of this commodity in Guatemala. Coincidentally, we discovered museum specimens of *H. costaricana* reared from avocados in Costa Rica. We present a brief review of the fragmentary knowledge of the larval stages of Polyorthini, the tribe to which *H. perseavora* is assigned.

Key Words: *Histurodes*, Central America, Chlidanotinae, pest species

DOI: 10.4289.0013-8797.112.1.253.10

Avocado (*Persea americana* Mill.; Lauraceae) is a semi-deciduous tree reaching a maximum height of about 20 m. It is native to Mexico and Central America, ranging from the eastern and central highlands of Mexico south through Guatemala to the Pacific Coast of Honduras, Nicaragua, and Costa Rica. There is evidence that avocado fruit has been used by indigenous peoples in Mexico for nearly 10,000 years. The tree was introduced into Indonesia around 1750, Israel in 1908, and South Africa, New Zealand, and Australia in the late 19th century (Index Fresh Avocado 2007). In the U.S., avocados were introduced into Florida before 1850 and into California before 1856. Commercial varieties of avocados were introduced to Chile from California in 1928. Other countries in South America with commercial avocado industries include Brazil, Peru, and Venezuela. Currently, U.S. avocado fruit production is concentrated primarily in California and to a much lesser extent in Florida and Hawaii. In California the Hass cultivar is a high-value agricultural commodity and an iconic crop readily identifiable with this U.S. state (Hoddle et al. 2003).

Fresh avocado fruit imports from Mexico and Central America into the

* Accepted by Michael W. Gates

U.S. became illegal under a federal ban imposed in 1918 to protect U.S. avocado growers from the unwanted introduction of specialist fruit-feeding insects (e.g., tephritids, curculionids, and lepidopterans) that had evolved with avocados in the home range of this plant (Hoddle 2007a). However, after the North American Free Trade Agreement (NAFTA) became law in 1994, barriers to fresh avocado fruit exports were lowered, allowing Mexico to legally export avocados (mainly Hass variety) to the U.S. Because of concerns about the potential introduction and establishment of unwanted invasive species, primarily fruit flies (Diptera: Tephritidae), Mexican avocados initially were imported only into the northeastern U.S. during winter. The rationale for this time-limited and highly geographic importation window was that semi-tropical fruit-feeding pests accidentally imported with fruit that escaped into the environment would be unable to withstand extreme winter cold, thereby preventing the establishment of perennial populations. However, by the end of 2005, Mexican avocados were granted entry into every U.S. state except California, Florida, and Hawaii which have commercial avocado industries. On 1 February 2007, fresh avocados were allowed to be exported from Mexico to California, the largest avocado producing and consuming state in the U.S. High volumes of fruit (>130,000 tons) now are shipped annually to all 50 U.S. states (Herald Tribune 2007).

Given the enormous flow of avocado fruit into the U.S. from Mexico, there is now the expectation that unwanted fruit-feeding pests eventually will establish in California. While the invasion risk posed by known fruit pests is identifiable and possibly can be mitigated to a certain extent, the threat of previously unknown species entering and damaging California-grown avocados is perhaps more worrisome. Three of the last five folivorous pests to become established on avocados in California were all species new to science at the time of first detection in the U.S. This is remarkable given the long history of avocado domestication and commercialization in Mexico and Central America (Hoddle 2004).

One of the most important pests attacking avocado fruit in Central and South America is the avocado seed moth, *Stenoma catenifer* Walsingham (Lepidoptera: Elachistidae), a species that is a specialist on members of the plant family Lauraceae. Larvae feeding internally can cause premature fruit drop and disfigurement of harvestable fruit, and production losses of 45–95% can result (e.g., Nava et al. 2005). Consequently within the home range of this pest, intensive management with broad spectrum insecticides is practiced to minimize economic losses despite substantial natural enemy activity against eggs by trichogrammatid parasitoids and larvae by braconids and ichneumonids (Wysoki et al. 2002; Nava et al. 2005; Hoddle 2007a, b; Hoddle and Hoddle 2008a, b).

During survey work for *S. catenifer* and other lepidopteran pests of avocados in Guatemala, a variety of microlepidoptera were reared from field-collected fruit. Among these was a large number of specimens of a tortricid moth, which inflicted considerable damage on avocado fruit but, only in orchards above about 1,450 m elevation. After studying the material, it became clear that these specimens represented a new species in the tribe Polyorthini. The generic assignment was not immediately clear, and a review of morphological features of *Histura* Razowski and *Histurodes* Razowski suggested that the two genera may not be clearly defined and/or differentiated. A comparison of larval features of the new species with those previously described for other Polyorthini revealed a high degree of variation in the chaetotaxy, suggesting that no features of the larvae alone can be used to unambiguously assign them to this tribe.

The purpose of this paper is to describe and illustrate this new species that feeds on avocado, which may have the potential to become a significant avocado pest in areas outside of its natural range. In addition, information is presented on its biology, and the fragmentary information on the larval stages of Polyorthini is reviewed.

Materials and Methods

Study sites.—Avocado fruit used in this study was collected from commercial Hass avocado orchards and from non-Hass trees that were growing along roadsides, in backyards, or as shade trees in coffee plantations. Fruit collections were part of a much larger survey being conducted for fruit-feeding Lepidoptera in Guatemala (Hoddle and Hoddle 2008a). The new species described herein was reared from fruit collected from two commercial Hass orchards. The first orchard was located in San Miguel Dueñas, Sacatepéquez, Guatemala (14°31.461′N; 90°46.579′W, 1,494 m elevation). This orchard was ~5 Ha consisting of ~800 trees; trees were ~5 years old and ~4–5 m in height, and canopies were separated by ~5–7 m of clear ground allowing full sun exposure. Trees were subjected to monthly rotating applications of malathion and endosulfan. Over the study period (24 January–23 February 2007), 2080 fruit showing damage (e.g., frass accumulations, perseitol exudates, and tunnel openings) from Lepidoptera feeding were picked from trees and returned to the laboratory for rearing of pests. The second Hass orchard was under organic management in Santa Lucia Miplas Altas, Sacatepéquez, Guatemala (14°35.647′N; 90°40.027′W, 2275 m elevation). This orchard was ~3 Ha consisting of ~300 10–12-year-old trees that were ~6–8 m in height with interlacing canopies. On 25 and 30 November 2007, 11 and 27 fruit, respectively, showing lepidopteran feeding damage were harvested at this site and returned to the laboratory for rearing.

The new species of *Histura* also was reared from unmanaged non-Hass fruit. On 11 December 2006, 354 fruit were purchased from a roadside vendor in Santiago Atitlan, Sololá, Guatemala (14°37.581′N; 91°13.557′W, 1,592 m elevation). These fruit had been harvested from backyard trees by the vendor in the immediate vicinity of the purchase site. The second site with non-Hass avocados that yielded the new species was in Sumpango, Sacatepéquez, Guatemala (14°40.292′N; 90°43.195′W, 1,825 m elevation). Over the period 14–23 November 2007, 81 fruit were harvested from one tree at this site.

Rearing methods.—Hass and non-Hass avocados were returned to the laboratory and kept for 10–14 days in collapsible ventilated insect rearing cages (Bug-Dorm-2120 [60 cm × 60 cm × 60 cm], MegaView, Taiwan) that were labeled by collecting date and location. Rearing of larvae was conducted in a well-lit room under natural daylight and lengths (~12 h) at 22.14°C ± 0.13 (temperature measured with a Hobo data logger [Onsett Corp., MA] at 30 min intervals). Fruit were inspected daily, and mature Lepidoptera larvae searching for pupation sites were isolated and kept in clear labeled plastic cups with ventilated lids that were lined with paper towel to provide a pupation substrate. Moths were kept along with pupal cases from which they emerged;

in most cases the exuvium is mounted on a small card beneath the pinned specimen. Some last instars were preserved in 95% ethanol for subsequent morphological examination and possible DNA study.

Systematic methods.—Dissection methods for examining genitalia follow those presented in Brown and Powell (1991, 2000). Dissected genitalia were illustrated with the aid of a microprojector. Terminology for genitalia structures follows Horak (1984); terminology for forewing pattern elements follows Razowski (2003); and terminology for larval features follows Brown (1987).

Abbreviations of depositories are as follows: BMNH, The Natural History Museum, London, U.K.; INBio, Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica; UCR, University of California, Riverside, California, U.S.A.; and USNM, National Museum of Natural History, Smithsonian Institution, Washington, DC, U.S.A.

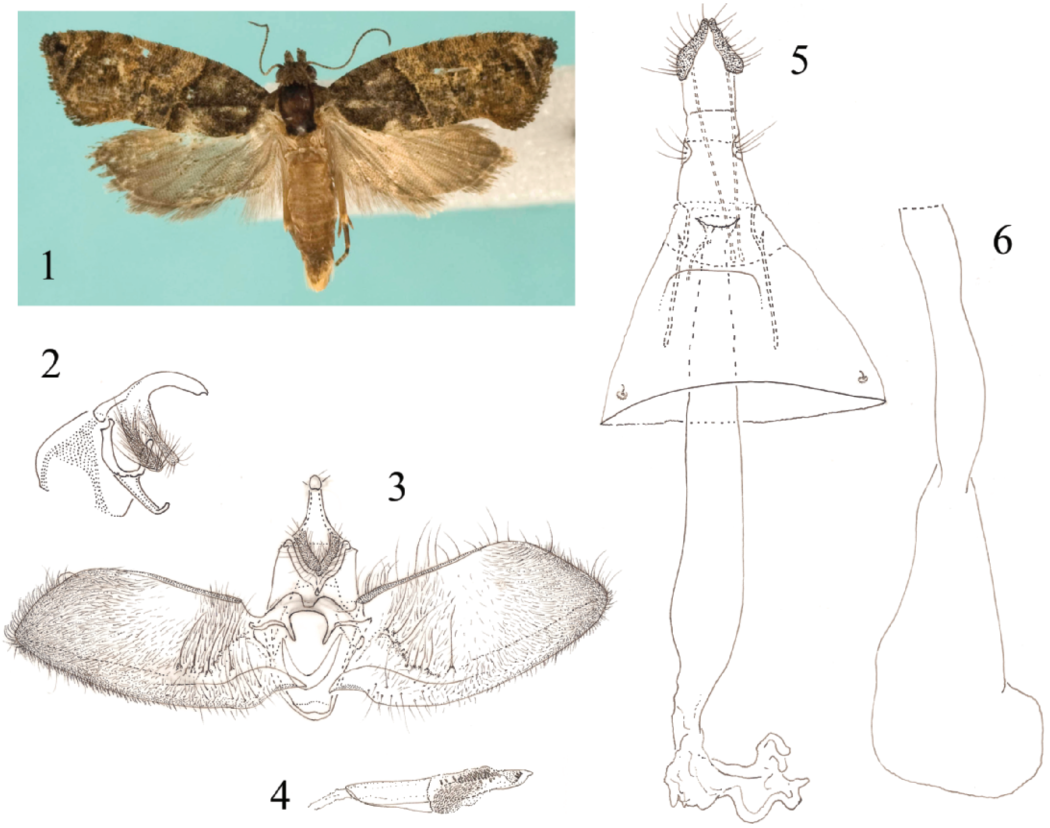
RESULTS

Polyorthini, comprised of about 150 species in 20 genera, was proposed by Obraztsov (1966); its classification was developed by Diakonoff (1974) and revised by Razowski (1979a, b, 1981). The monophyly of the group is well supported (Razowski 1979a, 1981), and it is generally accepted that Polyorthini is the sister-group to Hilarographini + Chlidanotini (Tuck 1981, Horak and Brown 1991, Poinar and Brown 1993, Horak 1999). These three tribes comprise the tortricid subfamily Chlidanotinae. Polyorthini are mostly pan-tropical in distribution, but two genera, *Olindia* Guenée and *Isotrias* Meyrick, are restricted to temperate Europe (Razowski 1979b).

Males of all Polyorthini have a unique "split" (i.e., longitudinally divided) valva in which the abdominal hairpencils from segment seven reside, raised scales on the forewing of both sexes, and a finely spined anellus in the male genitalia. Details of the musculature of the male genitalia are presented by Razowski (1979b), and what is known of the larval stages, which are poorly studied, are summarized by Horak and Brown (1991).

Seven genera of Polyorthini occur in the New World tropics. Among these, *Histura* Razowski (eight species) and *Histurodes* Razowski (two species) are extremely similar in facies and genitalia. In overall appearance (e.g., forewing shape, forewing pattern, length of labial palpi), they are more similar to the Old World *Lopharcha* Diakonoff and *Polylopha* Lower than to the Neotropical *Polyortha* Dognin, *Ardeutica* Meyrick, *Lypothora* Razowski, or *Pseudatteria* Walsingham. Adults of the aforementioned Neotropical genera have a distinctive forewing shape, marked polymorphism, and extremely long, porrect labial palpi, three or more times the diameter of the compound eye. *Histura* and *Histurodes* possess none of these features.

In his description of *Histurodes*, Razowski (1984) indicated that the transtilla is absent. However, we interpret the transtilla as present, represented by a pair of blunt appendages weakly united mesally by the spiny anellus. A similar character state also is present in *Histura bicornigera* Razowski. Hence, the distinction between *Histura* and *Histurodes* may not be particularly well defined. However, the synonymy of these two genera can be determined most convincingly through a phylogenetic anaylsis that includes all described species, which is well beyond the scope of the current work. The new species described below is assigned provisionally to *Histura* on the basis of the complete transtilla.



Figs. 1–6. *Histura perseavora*. 1, Adult moth. 2, Male genitalia—uncus, socii, and gnathos (lateral view). 3, Male genitalia (valvae spread, aedeagus removed). 4, Aedeagus. 5, Female genitalia (unmated female). 6, Ductus bursae and corpus bursae of mated female.

***Histura perseavora* Brown, new species**

Figs. 1–13, 17–19

Diagnosis.—*Histura perseavora* is superficially most similar to *Histurodes costaricana* Razowski and *Histura cuprata* (Meyrick), with short labial palpi and a well-defined, two-toned forewing pattern with a dark proximal one-third and a paler distal two-thirds (Fig. 1). The male genitalia of *H. perseavora* (Figs. 2–4) differ from those of *H. cuprata* by the medially narrowed transtilla and the presence of a linear patch of long spines in the distal half of the aedeagus. They differ from those of *H. costaricana* by their shorter, rounder valva, slenderer socii, and the patch of spines of the aedeagus. The last character appears to represent an autapomorphy for the new species.

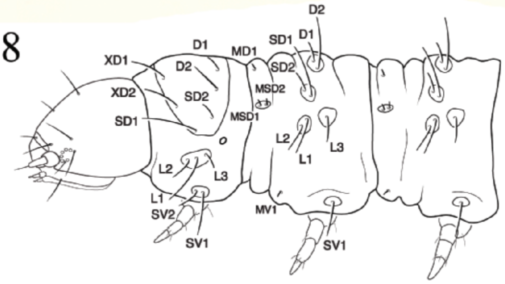
Description.—Adult (Figs. 1, 19). *Head:* Vertex and frons dark gray brown, paler on lower frons; labial palpus with length approximately 1.2× diameter of compound eye, mostly dark gray brown dorsally, lighter on inner surface and ventrally, third segment extending beyond scaling of second; ocellus large; antenna extending to ca. middle of forewing costa, with two rows of scales per flagellomere. *Thorax:* Dorsum dark gray brown, tegula concolorous with dorsum; scales at posterior end of dorsum conspicuously flattened.

Legs unmodified. Forewing length 5.0–5.5 mm (n = 15); pattern essentially two-toned with darker proximal one-third distinguished from lighter distal two-thirds by nearly straight oblique line from costa ca. 0.3 distance from base, to dorsum ca. 0.45 distance from base (Fig. 1); basal area nearly uniform dark gray brown; distal area pale copper with irregular darker scales and ill-defined pale red-brown blotch in subterminal area; a dark spot at end of discal cell; three oblique linear patches of raised scales, one immediately basad of oblique line forming outer edge of basal patch (interrupted near middle), one at two-thirds distance from base to termen, and one about midway between two aforementioned; fringe pale copper to gray brown. Hind wing dingy grayish white; fringe concolorous with hind wing. *Abdomen:* Male with long paired hairpencils from invaginated pouches of segment seven. Male genitalia (Figs. 2–4) with tegumen rectangular; vinculum large, with rounded dilation at junction with tegumen (i.e., near point of attachment of costa of valva); saccus well developed, short, rounded; uncus moderately long, strongly sclerotized, slightly curved ventro-posteriorly, truncate-rounded apically; socii slender, digitate, ca. as long as uncus, with short, fine, hairlike scales; gnathos arms unmodified, united distally into narrow, terminal process ca. as long as basal portion of gnathos arms, with upturned tip; transtilla moderately broad with deep rounded excavation at middle (transtilla frequently broken at middle in slide mounted preparations owing to extremely narrow junction of basal halves); juxta large, U-shaped; valva broad, rounded, split longitudinally, sparsely hairy throughout, with hairs most dense in subbasal area; sacculus broad, well defined basally, ill defined distally, without free projection. Aedeagus (Fig. 4) slightly curved near middle, sclerotized and irregular angled apically; with linear patch of spines from ca. 0.60–0.75 distance from base, spines increasing in size apically. Female genitalia (Figs. 5–6) with ovipositor narrow, somewhat telescopic; papillae anales narrow; sterigma weakly sclerotized, poorly developed; ostium anteriad and dorsad of posterior edge of segment seven (i.e., situated in slightly invaginated intersegmental membrane); ductus bursae uniform in width (in unmated females) (Fig. 5) or gradually expanded anteriorly (Fig. 6); corpus bursae not differentiated from ductus busae, without signa; ductus seminalis from ductus bursae near ostium.

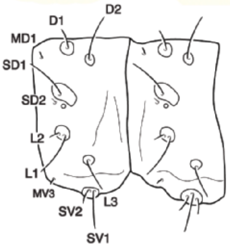
Larva.—Based on three presumed last instars. *General* (Figs. 7–11, 17): Length 6–7 mm; body color cream pink with moderately large, conspicuous, dark brown pinacula; most of integument covered with short dark spinules, absent only from pinacula. *Head:* Amber with small dark stemmatal patch. *Thorax* (Fig. 8): Prothoracic shield dark brown with slender, pale dividing line at mid-dorsum; L-group on T1 trisetose, setae arranged nearly parallel to longitudinal axis of larva; spiracle round, relatively small, with strongly sclerotized perimeter; SV-group on T1, T2, and T3 2:1:1; T2 and T3 with extra setae: MD1, MSD1, MSD2. *Abdomen* (Figs. 9–11): Spiracles small, round, slightly larger on A8; L1 and L2 on shared pinaculum below spiracle; tiny SD2 without pinaculum, separate from large SD1 pinaculum on A1–8; SD1 on A8 dorsoanterad of spiracle; SV-group on A1,2,7,8,9 2(3):3:3:2:2; D2s on shared dorsal pinaculum on A9; D1 and SD1 on shared pinaculum on A9; L-group trisetose on A9; crochets biordinal in complete circle; Vs about same distance apart on A7, A8, and A9; anal shield rounded; abdominal prolegs with 29–32 crochets, A10 proleg with

7

8

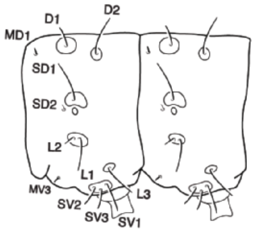


9

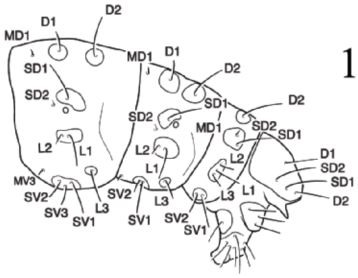


DIANAMARQUES

10



11

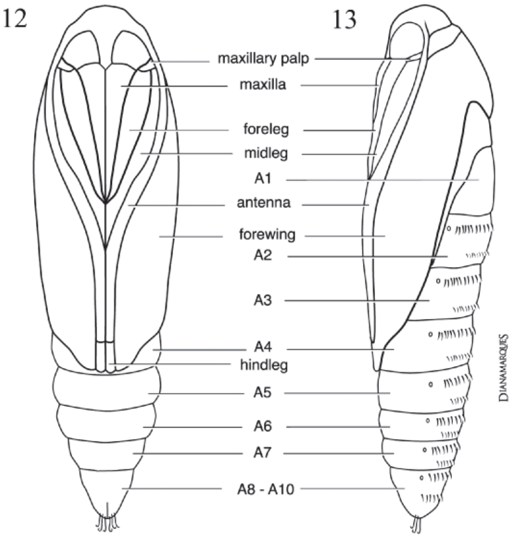


Figs. 7–11. Early stages of *Histura perseavora*. 7, Last instar. 8, Larval chaetotaxy, head, and thoracic segments T1, T2, T3. 9, Larval chaetotaxy, abdominal segments A1 and A2. 10, Larval chaetotaxy, abdominal segments A3 and A4. 11, Larval chaetotaxy, abdominal segments A7–A10.

20–22 crochets; anal fork broad, fan-shaped, with 7–8 slender, pointed tines.

Pupa.—Based on 10 exuviae and 2 preserved pupae. Typically tortricoid, fusiform, 5–6 mm in length, 1.0–1.5 mm in width (Fig. 12–13, 18). Head and thorax typical for family as described elsewhere (e.g., Horak 1999), lacking cephalic projection and conspicuous sculpturing. Abdomen with A1 lacking dorsal spines; A2–A7 with two rows of strong spines; A8 with single row of spines in most females and two rows in most males; A9 with single row in both sexes; posterior end of pupa with three pairs of long, distally-hooked setae; cremaster not developed.

Biology.—The larvae of *H. perseavora* attack fruit and fruit pedicels of avocados, and when fruit is scarce, larvae mine succulent young branches with flush growth. Typical damage is illustrated in Figs. 14–16. The larval stages are superficially similar to those of *Stenoma catenifer* in both appearance and damage. These two pests are sympatric at elevations between ~1,500 and 1,600 m, but only *H. perseavora* has been recorded above 1,800 m where *S.*



Figs. 12–13. Pupa of *Histura perseavora*. 12, Ventral view. 13, Lateral view.

catenifera is uncommon or absent. All larvae ($\sim$16) reared from avocados collected at $\sim$1,800 were *H. perseavora*. At elevations below 1,600 m, $<5\%$ of the reared larvae were *H. perseavora*, the remainder were almost all *S. catenifer*.

A single species of parasitoid was reared from larvae of *H. perseavora*, a *Chelonus* sp. (Hymenoptera: Braconidae: Cheloninae) (UCRC ENT 169534).

We examined four specimens of *Histurodes costaricana*, including the type series ($n = 2$), and all were reared from avocados in Costa Rica (USNM, INBio). Native hosts for species of Polyorthini are exceedingly poorly documented and totally unknown for all other species of *Histura* and *Histurodes*. However, based on these limited data, there appears to be a tendency for species of these two genera to move onto cultivated Lauraceae when the opportunity presents itself. Given the intensity of sampling for Lepidoptera in Costa Rica, it is remarkable that additional examples of *H. costaricana* are not present in the collection of INBio, suggesting that adults may not

Figs. 14–19. *Histura perseavora*. 14, Damage to avocado fruit. 15, Damage to avocado fruit. 16, Entrance hole of larva into avocado fruit. 17, Larva. 18. Pupa. 19, Adult.

be attracted to light traps, the primary method of sampling.

Other tortricids reared from avocado during the Guatemala surveys include *Cryptaspasma* sp. (Olethreutinae: Microcorsini), which likely represents the same species reported by Brown and Brown (2004) from avocados in Michoacan, Mexico; *Amorbia santamaria* Phillips and Powell (Tortricinae: Sparganothini), a polyphagous leafroller recently described from Guatemala (Phillips-Rodriguez and Powell 2007); *Netechma pyrodelta* (Meyrick) (Tortricinae: Euliini), representing the first host record for this Neotropical genus (Hoddle and Hoddle 2008a); and *Apotomops* n. sp. (Tortricidae: Euliini), a genus which has been recorded previously only from Pinaceae, i.e., *A. wellingtoniana* (Kearfott) on *Abies* and *Tsuga* (Prentice 1966, Brown and Passoa 1998).

Distribution.—*Histura perseavora* is known only from Hass avocado orchards and non-Hass avocados growing at elevations of ~1,500 to 1,800 m in Guatemala.

Holotype ♂. Guatemala, Sololá Province, San Lucas Toliman, near Santiago Atitlan, 1,585 m, 14°37′31″N, 91°8′43″W, ex non-Hass avocado fruit, XII.2006-III.2007, M. & C. Hoddle (USNM).

Paratypes (8♂, 8♀). Guatemala, Sololá Province, San Lucas Toliman, near Santiago Atitlan, 1,585 m, 14°37′31″N, 91°8′43″W, ex avocado fruit, XII.2006-III.2007 (5♂, 6♀), M. & C. Hoddle. Sacatepéquez: Finca Miguel Urias, San Miguel Dueñas, 1,495 m, 14°31′27″N, 90°46′34″W, ex avocado fruit, XII.2006-III.2007 (3♂, 2♀), M. & C. Hoddle. Paratypes distributed among USNM, UCR, and BMNH.

Etymology.—The specific epithet is derived from the host genus, *Persea*, and "voro," which is Latin for "eat greedily." It is considered an adjective.

Discussion

Information on the early stages of Polyorthini is either lacking or at best fragmentary and dispersed in the literature. Fletcher (1921) provided superficial descriptions and illustrations of the Asian *Polylopha epidesma* Lower. Swatschek (1958) provided a description of the larva of the European *Olindia schumacherana* (Fabricius). Dugdale (1966) presented a description and illustration of the larva and a few details of the pupa of *Lopharcha insolita* (Dugdale) from New Zealand. Becker (1970) provided descriptions and illustrations of the larva and pupa of *Polylopha viridescens* Meyrick from Brazil. We have examined preserved larvae of *P. viridescens* and *H. perseavora*, preserved pupae of *P. viridescens*, and pupae exuviae of *H. perseavora* and *P. epidesma*. Our observations, in combination with descriptions and illustrations from the literature, present a bewildering array of character states that allow few generalizations about the immature stages of Polyorthini.

The SV-group on the thorax of the larva of nearly all tortricids is 2:1:1 (T1, T2, T3, respectively). However, Becker (1970) reported the SV-group as 2:2:2 in *P. viridescens*, possibly representing the ancestral condition for the family based on the hypothesis that derived conditions in larval chaetotaxy are manifested as losses (Horak and Brown 1991). An examination of larvae in the USNM confirms this character state for *P. viridescens*. All other Polyorthini either examined by us or reported in the literature have a thoracic SV-group of 2:1:1.

The SV-group on abdominal segments 1,2,7,8,9 is 3:3:3:2:2 in most species of Archipini and Sparganothini and reduced in species of most other groups: usually 3:3:2:2:2 in Cnephasiini and Tortricini (Swatschek 1958, MacKay

1962), variably reduced in nearly all Olethreutinae (Swatschek 1958, MacKay 1962), and unusually multisetose in Chlidanotini (Diakonoff and Arita 1981). The SV-group is 3:3:3:3:2 in *P. viridescens* (Becker 1970, confirmed by examination of material), which is aberrant, as is the thoracic SV-group described above. It is 2(3):3:3:2:2 in *H. perseavora* (reported here) and *O. schumacherana* (Swastchek 1958); 2:3:3:2:2 in *L. insolita* (Dugdale 1966); and 2:3:3:2:1 in *Polylopha cassiicola* Liu and Kawabe (Liu and Kawabe 1993).

In general, the tiny SD2 seta is on the same pinaculum as the much larger SD1 in all species of Archipini and Sparganothini, but the two setae are on separate pinacula (or the SD2 pinaculum greatly reduced and often inconspicuous) in all species of Cnephasiini and Tortricini, and most species of Olethreutinae (Swatschek 1958, MacKay 1962). In all species of Polyorthini but *O. schumacherana*, the setae are on separate pinacula (similar to that found in species of Cnephasiini, Tortricini, and Olethreutinae). Liu and Kawabe (1993) reported that the SD2 seta is absent in *P. cassiicola*, but we suspect that the seta may be present but inconspicuous owing to the absence of a distinct pinaculum and the tiny size of the seta.

In general, most tortricines have setae D1 and SD1 on separate pinacula on A9, whereas most olethreutines (and species of Hilarographini) have them on a shared pinaculum. However, there is substantial variation in this character in both subfamilies. In *L. insolita* (Dugdale 1966), *P. cassiicola* (Liu and Kawabe 1993), and *H. perseavora*, D1 and SD1 are on a shared pinaculum (as in most olethreutines), whereas in *P. viridescens* and *Olindia* the setae are on separate pinacula on A9 (as in most tortricines).

Three larval character states that appear to be consistent among Polyorthini larvae we investigated are a trisetose L-group on A9 (common to nearly all tortricids), a conspicuously spiny integument (common to many tortricids), and the presence of an anal comb (ancestral for tortricids, but secondarily lost in many internal feeders). However, the anal comb is highly modified in *Lopharcha* (Dugdale 1966), and its presence/absence was not reported in *P. cassiicola* (Liu and Kawabe 1993). In summary, none of the larval features we examined provide evidence for the relationship of Polyorthini to any other major tortricid group, and most are highly variable within the tribe.

ACKNOWLEDGMENTS

Illustrations of genitalia were rendered by David Adamski, USDA, ARS, Systematic Entomology Laboratory, and those of the larva and pupa by Diana Marquez; illustrations were arranged into plates by Mike Lewis, Department of Entomology, University of California, Riverside; and the parasitoid was identified by Roger Burks, Department of Entomology, University of California, Riverside. We thank the following for providing helpful reviews of the manuscript: Robert Kula and Thomas Henry, USDA, Systematic Entomology Laboratory, National Museum of Natural History, Washington, DC, U.S.A.; Joaquin Baixeras, Institut Cavanilles de Biodiversitat i Biologia Evolutiva, Universitat de Valencia, Spain; and Richard Brown, Mississippi State University, Starkville, Mississippi, U.S.A. Funding for field work in Guatemala was provided in part by the California Avocado Commission.

LITERATURE CITED

Becker, V. 1970. Sobre duas especies Brazileiras do genero *Polyortha* (Lepidoptera, Tortricidae). Bulletin Universidad Federal de Paraná, Conselho de Pesquisa, Zoologia 4: 1–11.

Brown, J. W. and R. L. Brown. 2004. A new species of *Cryptaspasma* (Lepidoptera: Tortricidae: Olethreutinae) from Central America, the Caribbean, and southeastern United States, with a catalog of the world fauna of Microcorsini. Proceedings of the Entomological Society of Washington 106: 288–297.

Brown, J. W. and S. Passoa. 1998. Larval foodplants of Euliini (Lepidoptera: Tortricidae): From *Abies* to *Vitis*. Pan-Pacific Entomologist 74: 1–11.

Brown, J. W. and J. A. Powell. 1991. Systematics of the *Chrysoxena* group of genera (Lepidoptera: Tortricidae: Euliini). University of California Publications in Entomology 111. 87 pp. + figs.

———. 2000. Systematics of *Anopina* Obraztsov (Lepidoptera: Tortricidae: Euliini). University of California Publications in Entomology 120. 128 pp. + figs.

Brown, R. L. 1987. Tortricidae (Tortricoidea), pp. 419–433. *In* F. W. Stehr, ed. Immature Insects, volume 1. Kendall/Hunt, Dubuque, Iowa.

Diakonoff, A. 1974. The South Asiatic Polyorthini with notes on species of *Polyortha* Dognin (Lepidoptera: Tortricidae). Zoologische Verhangelingen 131: 1–86.

Diakonoff, A. and Y. Arita. 1981. The early stages of *Thaumatographa eremnotorna* Diakonoff & Arita, with remarks on the status of the Hilarographini (Lepidoptera: Tortricoidea). Entomologische Berichten 41: 56–60.

Dugdale, J. D. 1966. A revision of the New Zealand Schoenotenini and Cnephasiini (Lepidoptera: Tortricidae: Tortricinae). New Zealand Journal of Science 9: 731–775.

Fletcher, T. B. 1921. Life histories of Indian insects, Microlepidoptera. Memoirs of the Department of Agriculture of India, Entomological Series, volume 6(1920): 1–217.

Herald Tribune. 2007. Mexico praises lifting of last U.S. avocado import barriers. Website: http://www.iht.com/articles/ap/2007/02/03/business/LA-FIN-ECO-Mexico-US-Avocados.php. Published 2 February 2007.

Hoddle, M. S. 2004. Invasions of leaf feeding arthropods: why are so many new pests attacking California-grown avocados? California Avocado Society Yearbook 87: 65–81.

———. 2007a. Lurkers on the threshold: potential new avocado fruit pests for California avocados. California Avocado Society Yearbook 89: 69–92.

———. 2007b. The avocado seed moth, *Stenoma catenifer* Walsingham (Lepidoptera: Elachistidae). Website: http://www.biolcontrol.ucr.edu/Stenoma/Stenoma.html (accessed 1 April 2008).

Hoddle, M. S. and C. D. Hoddle. 2008a. Survey results for Lepidoptera and associated parasitoids attacking Hass and non-Hass avocados in Guatemala. Journal of Economic Entomology 101: 1310–1316.

———. 2008b. Bioecology of *Stenoma catenifer* Walsingham (Lepidoptera: Elachistidae) and associated larval parasitoids reared from Haas avocados in Guatemala. Journal of Economic Entomology 101: 692–698.

Hoddle, M. S., K. M. Jetter, and J. G. Morse. 2003. The economic impact of *Scirtothrips perseae* Nakahara (Thysanoptera: Thripidae) on California avocado production. Crop Protection 22: 485–493.

Horak, M. 1984. Assessment of taxonomically significant structures in Tortricinae (Lep., Tortricidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 57: 3–64.

———. 1999. Tortricoidea, pp. 199–215. *In* N. Kristensen, ed. Lepidoptera, moths and butterflies. Volume 1: Evolution, systematics, and biogeography. Handbook of Zoology 4 (35), Arthropoda: Insecta. Walter de Gruyter, Berlin & New York.

Horak, M. and R. L. Brown. 1991. 1.2 Taxonomy and phylogeny, pp. 23–48. *In* L. P. S. van der Geest and H. H. Evenhuis, eds. Tortricid pests, their biology, natural enemies and control. Elsevier Science Publishers B. V., Amsterdam.

Index Fresh Avocado. 2007. Website: http://www.indexfresh.com/avocado_history.htm. (accessed 19 March 2008).

Liu, Y.-Q. and A. Kawabe. 1993. A new species of the genus *Polylopha* injurious to cinnamon in China (Tortricidae, Chlidanotinae, Polyorthini). Japan Heterocerists' Journal 173: 404–406.

MacKay, M. R. 1962. Larvae of the North American Tortricinae (Lepidoptera: Tortricinae). Canadian Entomologist Supplement 28. 182 pp.

Nava, D. E., J. R. P. Parra, V. A. Costa, T. M. Guerra, and F. L. Consoli. 2005. Population dynamics of *Stenoma catenifer* Walsingham (Lepidoptera: Elachistidae) and related larval parasitoids in Minas Gerais, Brazil. Florida Entomologist 88: 441–446.

Obraztsov, N. S. 1966. Neotropical microlepidoptera, IX. Revision of genus *Pseudatteria* (Lepidoptera: Tortricidae). Proceedings of the U.S. National Museum 118: 577–622.

Phillips-Rodriguez, E. and J. A. Powell. 2007. Phylogenetic relationships, systematics, and biology of the species of *Amorbia* Clemens (Lepidoptera: Tortricidae: Sparganothini). Zootaxa 1670. 109 pp.

Poinar, G. O. and J. W. Brown. 1993. A new fossil tortricid (Lepidoptera: Tortricidae) from Dominican amber. Entomologica Scandinavica 23: 25–29.

Prentice, R. M. 1966. Vol. 4. Microlepidoptera. *In:* Forest Lepidoptera of Canada recorded by the Forest Insect Survey. Department of Forestry Canada, Publication 1142(1965): 543–840.

Razowski, J. 1979a. On the morphology and system of Polyorthini (Lepiodoptera, Tortricidae). Bulletin de l'Academie Polonaise des Sciences, Series des Sciences Biologiques, 26(1978): 857–862.

———. 1979b. The systematic position of *Olindia* and *Isotrias* (Lepiodoptera, Tortricidae). Zoologisches Mededelingen 54: 241–243.

———. 1981. Notes on the system of Polyorthini (Lepiodoptera, Tortricidae). Acta Zoologica Cracoviensia 25: 309–318.

———. 2003. Reassessment of forewing pattern elements in Tortricidae (Lepidoptera). Acta Zoologica Cracoviensia 46: 269–275.

Swatschek, B. 1958. Die larval systematik der wickler (Tortricidae and Carposinidae) aus dem zoologischen Institut der Universitat Erlangen. Akademie-Verlag, Berlin. 269 pp. [Abhandlungen zur larvalsystematik Insekten 3.]

Tuck, K. R. 1981. A new genus of Chlidanotini (Lepidoptera: Tortricidae) from New Caledonia, with a key to the genera and checklist of species. Systematic Entomology 6: 337–346.

Wysoki, M., M. A. Van den Berg, G. Ish-Am, S. Gazit, J. E. Peña, and G. K. Waite. 2002. Pests and pollinators of avocado, pp. 223–293. *In* J. Peña, J. L. Sharp, and M. Wysoki, eds. Tropical Fruit Pests and Pollinators, Biology, Economic Importance, Natural Enemies and Control. CABI Publishing, Wallingford, Oxfordshire, U.K.