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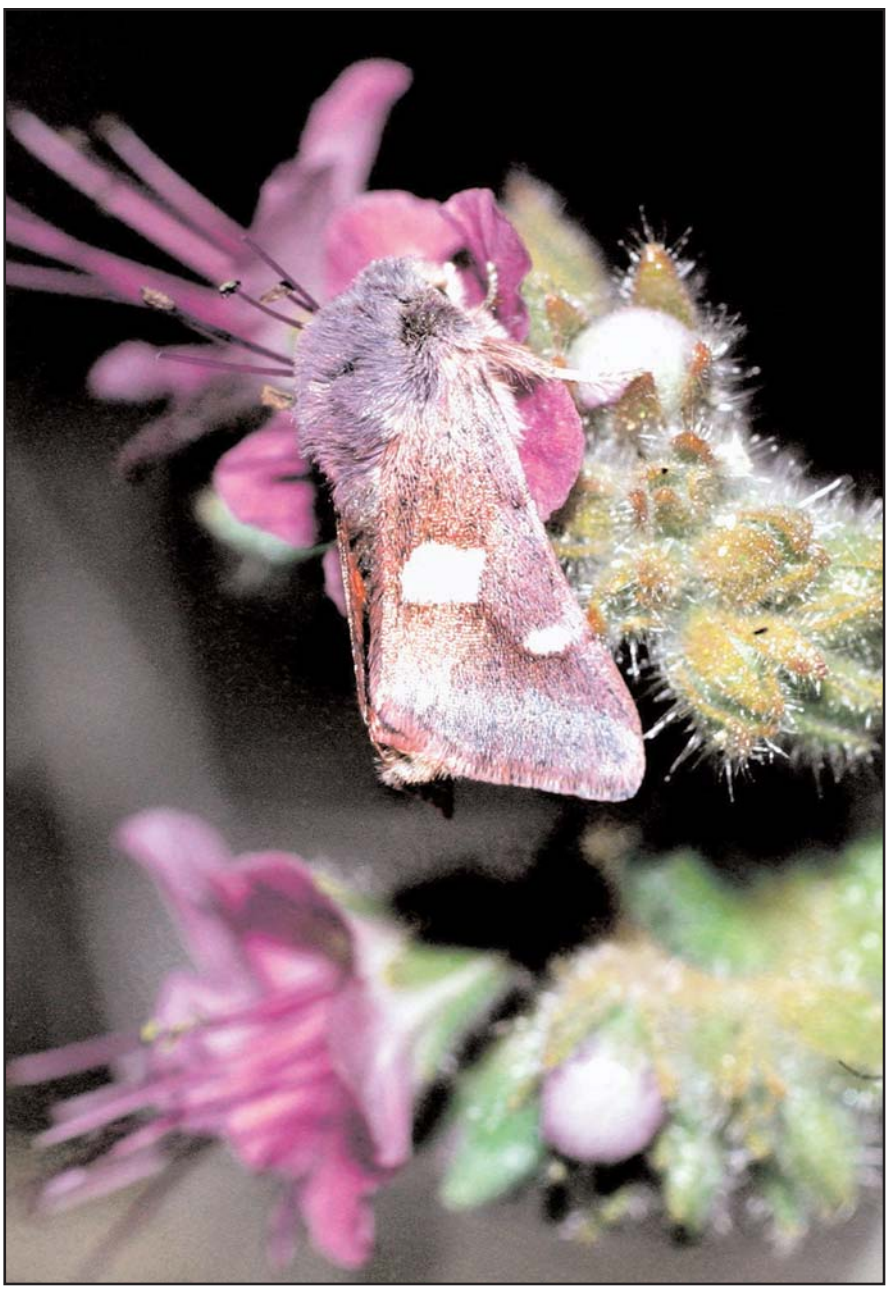

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Cover Illustration: Nocturnal repose of *Baptarma felicita*, a Heliothine Noctuid, on its Scorpionweed (*Phacelia crenulata*) host, Palm Springs, Riverside County, California, March 16, 2005. Photograph: Kendall H. Osborne.

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REVIEW OF SYMMOCINAE (LEPIDOPTERA: AUTOSTICHIDAE) IN NORTH AMERICA WITH THE DESCRIPTION OF A NEW GENUS AND SPECIES

SANGMI LEE AND RICHARD L. BROWN

Mississippi Entomological Museum, Box 9775, Mississippi State, MS 39762-9775; email: microlepi@hotmail.com

Abstract. The three species of Symmocinae (Autostichidae) known to occur in North America are reviewed, and imagos and male and female genitalia are illustrated. A new genus and new species of Symmocinae are described and novel morphological characters are illustrated.

Additional key words: Gelechioidea, morphology, confocal microscopy, spore-like structure

The Symmocinae (Lepidoptera: Autostichidae) includes 170 species of moths in 42 genera, with highest diversity in xeric areas of the Palearctic Region (Gozmány 1957, 1959, 1963, 1964; Hodges 1983). Larvae are known to feed on decaying plant materials (Gozmány 1963; Griffith 1890; Powell 1960). Three species have been reported from North America: *Sceptea aequepulvella* (Chambers) (Figs. 1, 5) *Oegoconia quadripuncta* (Haworth) (Figs. 2, 6), and *Symmoca signatella* Herrich-Schäffer (Figs. 3, 7), with the latter two species introduced from the Palearctic Region (Hodges 1983; Powell 1960). Specimens of an unknown symmocine, initially collected in Mississippi and later from other states, have been identified here as a new species as well as a new genus.

The classification and phylogenetic position of *Symmoca* and related genera have been unstable. In recent years, the Symmocinae has been treated as a family (Gozmány 1963), a subfamily of Blastobasidae (Hodges 1983), and a subfamily of Autostichidae (Hodges 1999; Kaila 2004).

Hodges (1999) defined the Autostichidae by homoplasous characters of an articulated gnathos (Fig. 8) and presence of spiniform setae on abdominal terga (Fig. 12). He further defined the Symmocinae by homoplasous characters of a forewing with CuP absent (Fig. 10A), female with retinaculum composed of a series of anteriorly directed scales between CuA and R (Fig. 16), abdominal terga crossed by bands of slender, spiniform setae, sometimes deciduous, and the gnathos forming a mesial hook (Fig. 8).

The purpose of this study is to review and illustrate North American species of Symmocinae and describe novel morphological characters of a new genus and species that may be valuable for resolving the phylogenetic relationships of gelechioid taxa in future studies.

METHODS

Published figures of 139 species representing 42 genera, including male genitalia of 38 type species, were examined. Figures of male genitalia are lacking for type species of five genera, including *Tenieta* Gozmány, *Hamartema* Gozmány, *Symmoletria* Gozmány, *Sceptea* Walsingham, and *Gigantoletria* Gozmány, the latter four described to include species represented only by females.

One to two male and female specimens of the following species were borrowed from the National Museum of Natural History (USNM): *Amselina oxybiella* (Millière), *Aprominta designatella* (Herrich-Schäffer), *Nestorellus meyricki* Gerasimov, and the three species in North America, *Sceptea aequepulvella* (Chambers), *Oegoconia quadripuncta* (Haworth), and *Symmoca signatella* Herrich-Schäffer.

Dissection and slide mounting methods for genitalia followed Clarke (1941), except the preparations were stained in eosin and mounted in euparol. Wing

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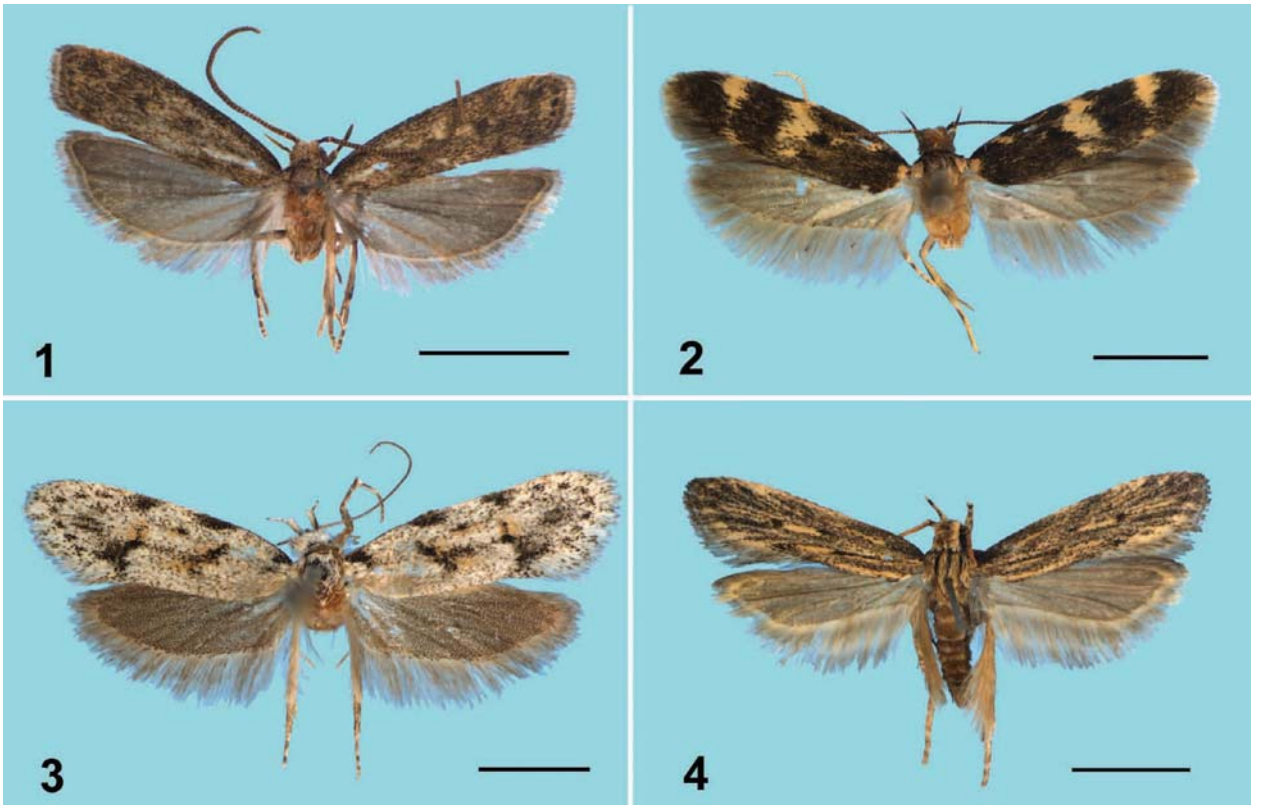

FIGS. 1–4. Adults of Symmocinae in North America. **1**, *Sceptea aequepulvella* (Cham.). **2,** *Oegoconia quadripuncta* (Haw.). **3,** *Symmoca signatella* (H.-S.). **4,** *Spinitibia hodgesi*. Scale bar: 1.0 mm.

venation slides were made with the same method used for genitalia, except the denuded wing was stained in eosin overnight. A hind leg from each species of the known Symmocinae in North America was cleaned of scales, stained, and slide mounted separately. Whole body mounts of the new species were made following methodology of Lee & Brown (2006), and these were compared with whole body mounts of the following taxa: *Agonopterix thelmae* Clarke, *Antaeotricha humilis* (Zeller), *Antaeotricha leucillana* (Zeller), *Autosticha kyotensis* (Matsumura), *Blastobasis glandulella* (Riley), *Callima argenticinctella* Clemens, *Calosima lepidophaga* (Clarke), *Coleophora cratipennella* Clemens, *Dichomeris ligulella* Hübner, *Durrantia piperatella* (Zeller), *Ethmia longimaculella* (Chambers), *Ethmia trifurcella* (Chambers), *Eupragia hospita* Hodges, *Gelechia albisparsella* (Chambers), *Gerdana caritella* Busck, *Glyphidocera democratica* (Meyrick), *Glyphidocera lactiflosella* (Chambers), *Inga sparsiciliella* Clemens, *Homaledra heptathalma* Busck, *Machimia tentoriferella* Clemens, and *Pseuderotis obiterella* (Busck).

A Leica MZ 125 Stereo-Microscope and Olympus Compound Microscope were used for examining specimens and slide mounts. Images were made with a Leica TCS NT confocal laser scanning microscope, LEO S360 scanning electron microscope, and a Leica stereoscope with Image Pro Plus 5.1 program for autoformatting. For scanning electron microscopy, specimens were air dried and mounted on aluminum stubs with silver paste, coated with gold-palladium, and examined at an accelerating voltage of 5kV. Distributional data are based on publications and on specimens in collections of the Mississippi Entomological Museum (MEM) and USNM.

DNA samples were extracted from two pairs of hindlegs from two pinned specimens of the new species following the protocol for Qiagen's DNeasy Tissue Kit. Five of ten clones could be sequenced and checked in GenBank using the BLAST function to determine the identity of spore-like structures associated with the hindlegs.

Symmocinae

Symmocinae Gozmány, 1957, Annales. Historico-Naturales Musei. Nationalis Hungarici, 8 (n. s.), 326; Bradley *et al*., 1972, A Check List of British Insects; Hodges, 1978, Moths America North of Mexico, 7; Hodges, 1999, Lepidoptera, Moths and Butterflies

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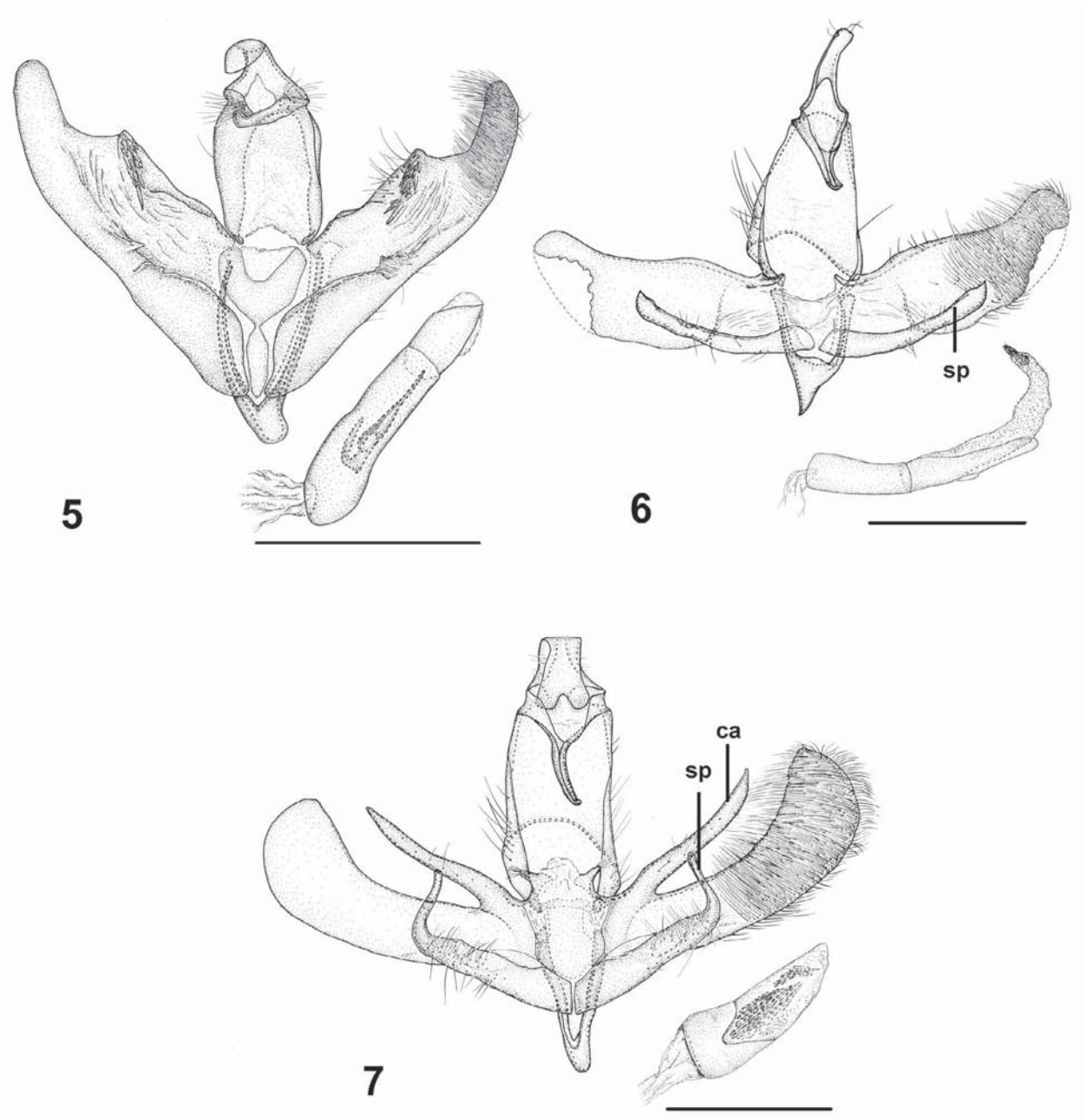

FIGS. 5–7. Male genitalia of Symmocinae in North America. **5,** *Sceptea aequepulvella* (Cham.). **6,** *Oegoconia quadripuncta* (Haw.). **7,** *Symmoca signatella* (H.-S.). Scale bar: 0.5 mm.

Vol. 1: Evolution, Systematics, and Biogeography, 146.

Type-genus: *Symmoca* Hübner, 1825

Symmocidae Gozmány, 1963, Acta Zoologica Academiae Scientiarum Hungaricae, 9: 67.

Diagnosis of subfamily. Defined by forewing with CuP absent (parallelism with other Gelechioidea), female with retinaculum consisting of a series of anteriorly directed scales between CuA and R (parallelism with other Gelechioidea), second abdominal sternum with venula, venula + apodeme, or apodeme (polymorphy), forewing with R_5 terminating on outer margin or on costa (polymorphy). Gnathos a slender band fused to tegumen, forming non-articulated mesial hook, abdominal terga II–VII crossed by bands

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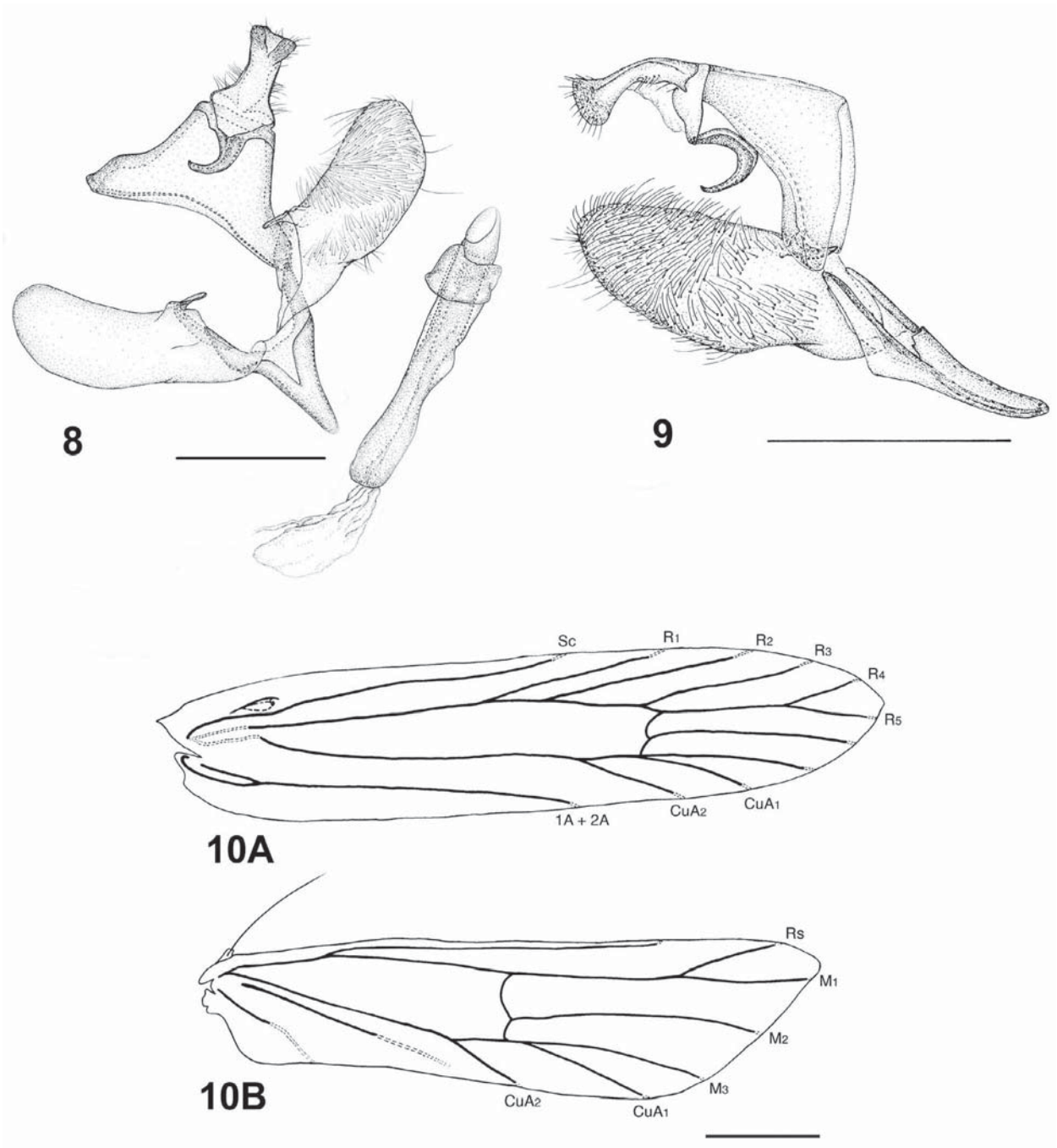

FIGS. 8–10. Genitalia and wing venation of *Spinitibia hodgesi*. **8-9,** Male. Scale bar: 0.5mm. **10.** A, forewing. B, hindwing. Scale bar: 1.0 mm.

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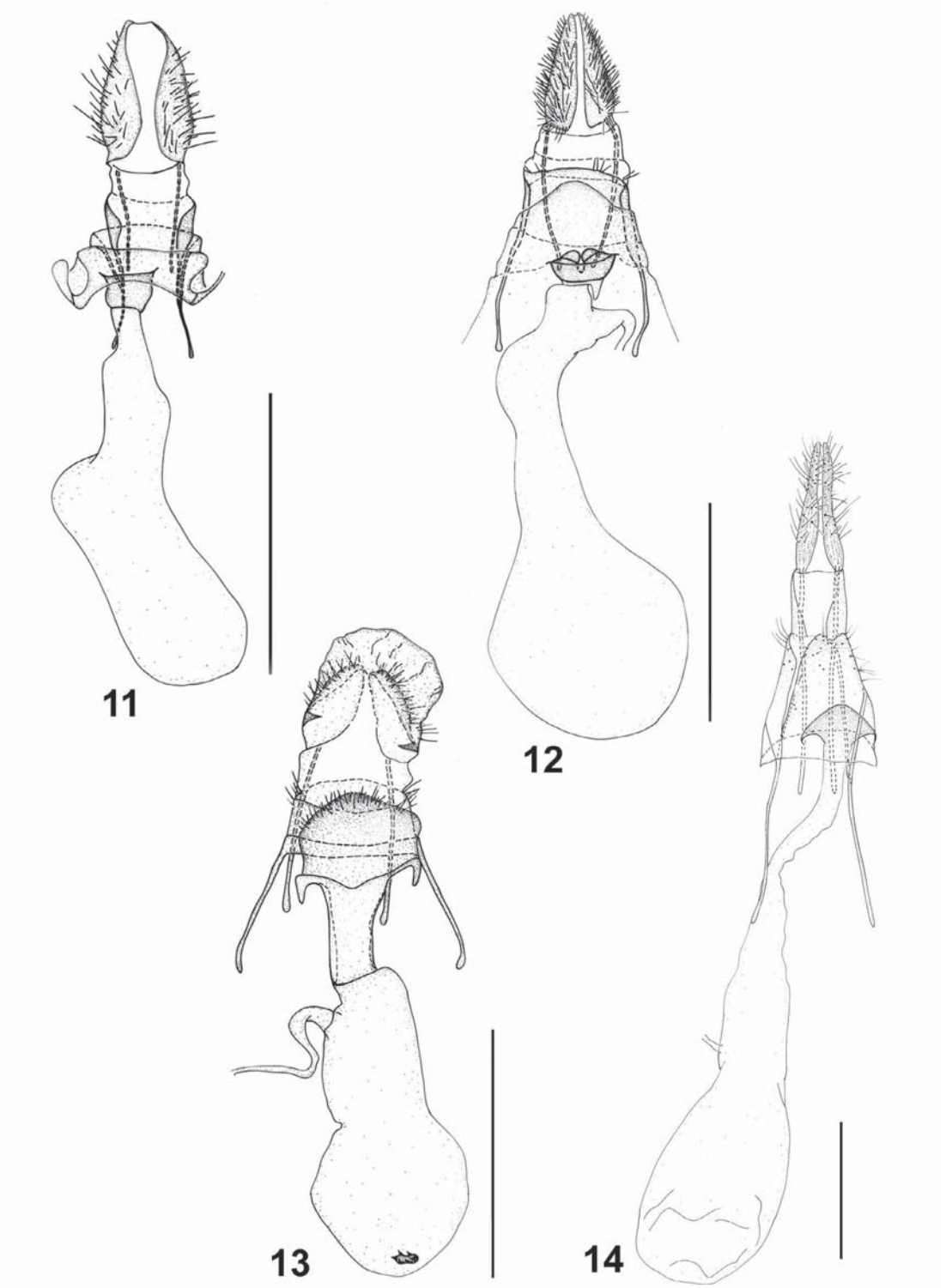

FIGS. 11–14. Female genitalia. **11,** *Sceptea aequepulvella* (Cham.). **12,** *Oegoconia quadripuncta* (Haw.). **13,** *Symmoca signatella* (H.-S.). **14.** *Spinitibia hodgesi*. Scale bar: 1.0 mm.

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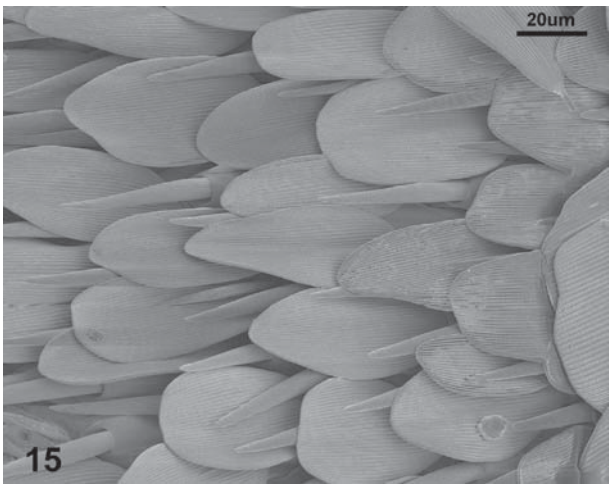


FIG. 15. *Spinitibia hodgesi*, abdominal spiniform setae.

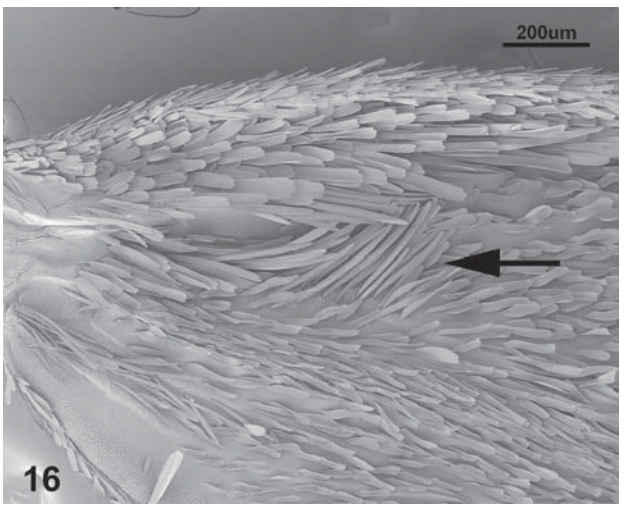


FIG. 16. *Spinitibia hodgesi*, forewing retinaculum (arrow).

or entirely covered by spiniform setae, sometimes deciduous (Hodges 1999).

Sceptea aequepulvella (Chambers) (Figs. 1, 5, 11, 20)

Gelechia aequepulvella Chambers, 1872, The Canadian Entomologist 4: 192.

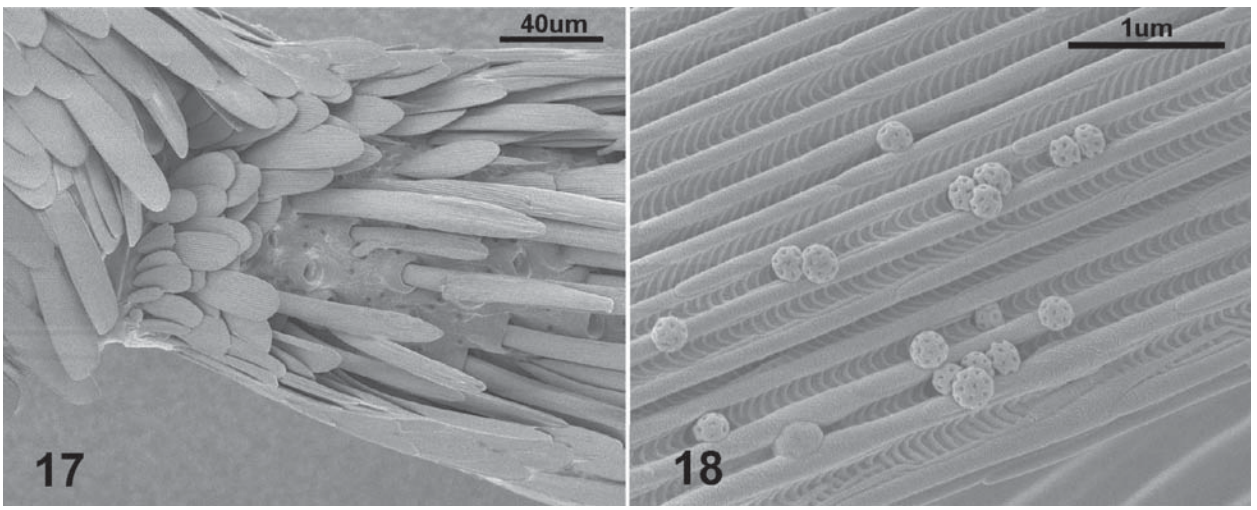
Glyphidocera aberratella Busck, 1907, Journal of the New York Entomological Society 15: 138.

Sceptea aequepulvella: Hodges, 1983, Check List of the Lepidoptera of America North of Mexico, p. 14.

The description of this species was based on an unknown number of specimens collected from Kentucky. Catalogs of type specimens in the Museum of Comparative Zoology (Miller & Hodges 1990) and the National Museum of Natural History, Smithsonian Institution (Brown *et al*. 2004) do not mention this species, and the location of the type specimen is unknown. The following description is based on specimens that were identified by early workers in the USNM and more recently collected specimens that were compared to older material.

Description. *Imago.* Head and thorax dark gray scaled; labial palpus ascendant, reaching top of head. Forewing length 5.0–6.0 mm, brown intermixed with almost equal numbers of yellowish scales throughout wing, but with variable concentrations of brown scales in some specimens with brown concentrated on basal half of costa, as one or two spots in discal cell, as spot between R_4 and R_5 near apex, as spot near tornus, and as spots between veins at termen. Hindwing pale grayish brown. Second abdominal sternum with venula + apodeme.

Male genitalia (Fig. 5). Uncus with rounded apex; gnathos with apex weakly curved dorsally; juxta forming a wide U-shaped plate dorsally; tegumen below juxta forming sclerotized lateral arms, weakly sclerotized medially; valva with short, costal projection at 2/3 length, with a series of spiniform setae extending ventromedially from costal projection, valva narrowing from costal projection to a rounded apex; sacculus without projection, with medial fold terminating at 1/2 length



FIGS. 17–18. *Spinitibia hodgesi*, metatibial spiniform setae. **17,** enlarged sockets (arrow) in cluster of spiniform setae. **18,** spiniform seta with spore-like structure.

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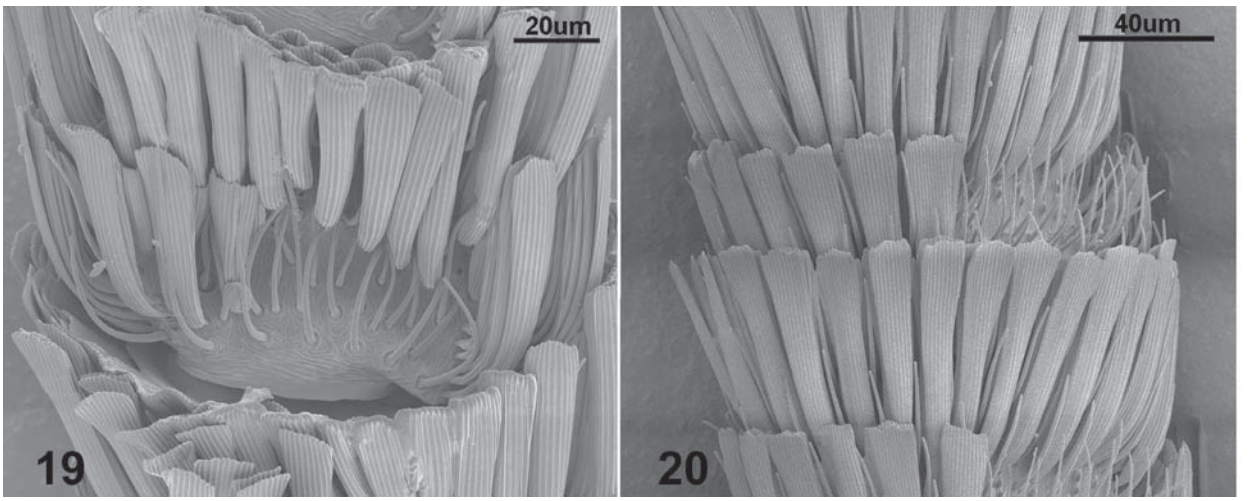

FIGS. 19–20. Scales and setae on ventral surface of antenna. **19,** *Spinitibia hodgesi*. **20,** *Sceptea aequepulvella*.

of valva; phallus tubular, cornutus spiniform, basally hook shaped.

Female genitalia (Fig. 11). Papillae anales sparsely setose. Posterior apophyses slightly shorter than papillae anales. Anterior apophyses slightly shorter than posterior apophyses, divided near middle to form dorsal branch extending to eighth tergum and ventral branch extending to eighth sternum. Ostium bursae encircled by sclerotized ring of ductus bursae, ductus bursae with membranous portion subequal in length with papillae anales, gradually widening anteriorly to an elongate, elliptical corpus bursae. Signum absent.

Distribution. USA (District of Columbia, Illinois, Kentucky, Mississippi, New Jersey, Ohio, Pennsylvania).

Oegoconia quadripuncta (Haworth) (Figs. 2, 6, 12)

Recurvaria quadripuncta Haworth, 1828, Lepidoptera Britannica Part IV, p. 557.

Oegoconia quadripuncta: Stainton, 1854, Insecta Britannica. Lepidoptera: Tineina 3, p. 162.

Symmoca novimundi Busck, 1915, Proceedings of the Entomological Society of Washington 17: 84.

This Palearctic species occurs throughout Europe (Gozmány & Riedl 1996) and was introduced into the northeastern United States sometime before 1915 with subsequent dispersal to other states including California (Powell 1992).

Description. *Imago.* Head brown; labial palpus ascendant, reaching top of head; thorax dark gray with tegulae brown basally, pale yellow apically. Forewing length 5.5–7.0 mm, dark brown with pale yellow spots at base and below costa at 1/4 length, and transverse bands extending from costa to dorsum beyond 1/2 length and at 3/4 length, the latter broken near CuA_1. Hindwing pale grayish brown. Second abdominal sternum with venula + apodeme.

Male genitalia (Fig. 6). Uncus with rounded apex; gnathos longer and more strongly curved apically than in *S. aequepulvella*; tegumen hood-like, evenly sclerotized; valva tapered to rounded apex, costa without projection; sacculus with apical half forming a free projection, projection slightly curved dorsomedially, apex pointed; phallus slender, tubular, everted vesica with microtrichia, apex of vesica with dense group of cornuti composed of unsocketed microspines.

Female genitalia (Fig. 12). Papillae anales densely setose. Posterior apophyses slightly longer than papillae anales. Anterior apophyses slightly longer than posterior apophyses. Ostium bursae with cup-shaped antrum, posterior margin divided medially and forming two invaginated pockets laterally. Ductus bursae membranous, more than 2× length of papillae anales, gradually widening anteriorly to spherical corpus bursae. Signum absent.

Distribution. USA (California, District of Columbia, Illinois, Indiana, Maine, Massachusetts, Maryland, New Jersey, New York, Pennsylvania, Vermont, Virginia), Europe.

Symmoca signatella Herrich-Schäffer (Figs. 3, 7, 13, 22)

Symmoca signatella Herrich-Schäffer, [1855,] 1854, Systematische Bearbeitung der Schmetterlinge Europa, 5: 111.

This Palearctic species is widespread in Europe and was first reported from the United States as an introduced species in Los Angeles, Riverside, and Orange Cos., California (Powell 1960).

Description. *Imago.* Head and thorax pale gray; labial palpus ascendant, extending beyond top of head. Forewing length 8.0–9.0 mm; ground color pale gray, apices of many scales brown to dark brown giving a peppered appearance, costa with dark brown spots at base, 1/3 length, and 2/3 length, basal 1/3 of wing with dark brown line angled from discal cell towards tornus, outwardly bordered by 1–2 pale yellow spots, a dark brown longitudinal streak on Rs near 1/2 wing length, bordered by pale yellow spot in discal cell, apical 2/3 of wing with triangular dark brown spot extending from apex of discal cell to tornus, bordered by pale yellow spot in discal cell, two dark brown, longitudinal streaks on M_1 and M_2 apical to discal cell, outer margin with dark brown spots between veins. Hindwing grayish brown. Second abdominal sternum with venula + apodeme.

Male genitalia (Fig. 7). Uncus with notched apex; gnathos large, strongly hook shaped; valva gradually widening apically, costal and apical margins forming right angle at apex, costal appendage long, extending from base of valva to near apex; saccular projection narrowed at 1/4 length and sharply curving dorsally over valva and

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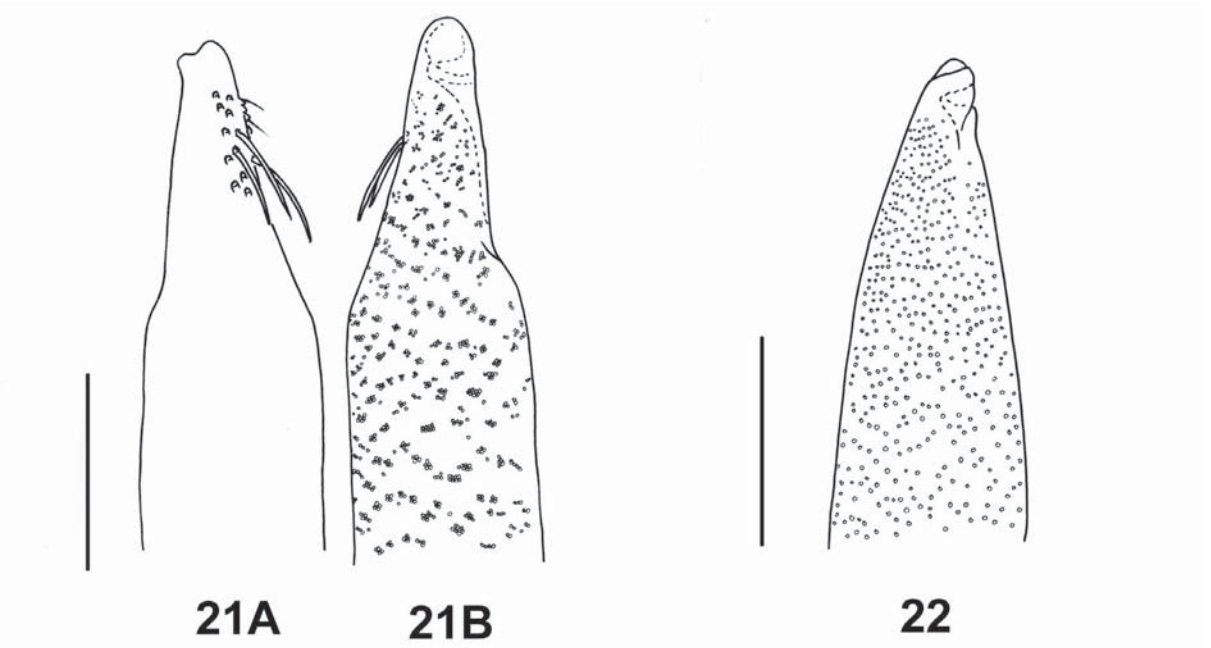

FIGS. 21–22. Metatibial base. **21,** *Spinitibia hodgesi*, lateral (A) and medial (B). **22,** *Symmoca signatella*. Scale bars: 0.25 mm.

extending beyond the costa; phallus short, stout, tubular, with numerous spiniform cornuti.

Female genitalia (Fig. 13). Papillae anales short, moderately setose. Posterior apophyses almost 2× length of papillae anales. Anterior apophyses slightly shorter than posterior apophyses. Ductus bursae short, sclerotized from ostium bursae to near ductus seminalis, widened and membranous from ductus seminalis to corpus bursae. Signum present on anterior end of corpus bursae, bidentate.

Distribution. USA (California, Illinois, Maryland, Massachusetts, New Jersey, New York, Oregon), Europe.

Spinitibia gen. nov.

Description. Head loosely scaled; labial palpus scaled, ascendant, reaching top of head, second and third segments subequal in length, third segment with acute apex, scales appressed, organ of vom Rath absent; antennae simple, apices of scales truncated; ocellus absent; posterior area of sitophore with four campaniform sensilla on posterior area in trapezoid pattern. Thorax with metascutellum wider than long, anterior margin rounded; dorsomedial margins of the epinotum separated. Metathoracic tibia with group of spiniform setae on dorsobasal surface, with much larger sockets than adjacent scales, scale sockets clustered into groups on medial surface and weakly defined rows on lateral surface. Forewing with apex angled between R_4 and R_5; eleven veins present; Sc–R_4 to costa; R_5–CuA_2 to termen; R_4 and R_5 stalked, $M_2$and M_3 fused, CuA_1 and CuA_2 present, CuP absent, 1A and 2A with distinct basal fork. Hindwing subquadrate, apex slightly pointed between Rs and M_1; all veins present; Rs and M_1 stalked; M_2 closer to M_3 than to M_1; M3(should be subscript) shortly stalked with CuA_1; CuA_2 and CuP present. Abdomen with second sternum having apodeme + venula; terga II–VII with bands of spiniform setae interspersed with scales.

Male genitalia. Uncus slender basally, widened and finely setose apically. Tegumen subtriangular, with widened ventral base. Gnathos large, heavily sclerotized, hooklike, non-articulated. Valva elongate, apex rounded, without costal and saccular process, with well-developed basocostal projection. Vinculum forming narrow, triangular band. Saccus not developed. Phallus tubular, cornuti absent.

Female genitalia. Papillae anales sparsely setose. Posterior apophyses longer than length of papillae anales. Anterior apophyses slightly shorter than length of posterior apophyses. Ostium bursae covered by subtriangular lamella antevaginalis. Ductus bursae long, membranous, gradually widening to spherical corpus bursae. Signum absent.

Diagnosis. *Spinitibia* is defined by the following apomorphies: 1) dorsobasal surface of metatibia with a group of enlarged spiniform setae having much larger sockets than adjacent scales (Figs. 17, 21); 2) antennal scales truncated (Fig. 19), instead of dentate (Fig. 20); 3) ocellus absent (shared with *Symmoca*, *Sceptea*, and *Oegoconia*); 4) organ of vom Rath absent (shared with *Sceptea*, and *Oegoconia*); 5) valva lacking saccular or costal projections (shared with *Sceptea* and *Exorgana*); 6) the clustering of scale sockets on the metatibia (Fig. 21B), in contrast to scattered (Fig. 22) or in rows, shared with Blastobasinae; 7) the metascutum with the anterior width greater than the length at middle and the anterior margin being rounded (Fig. 23), rather than the anterior margin being angled and longer at the middle (Fig. 24), an apomorphy shared with Autostichinae, and the terminal taxa of Peleopodidae, Amphisbatidae, and Gelechiidae in the phylogeny of Hodges (1999).

Etymology. The generic name, *Spinitibia*, refers the spiniform setae that are present on the hind tibia.

Spinitibia hodgesi sp. nov. (Figs. 4, 8–10, 14–19, 21, 23)

Description. *Imago.* Head and thorax yellowish white mixed with yellowish brown; prothorax with longitudinal median dark brown band and two lateral bands. Antennae yellowish white, 2/3 to 3/4 length of forewing, length of middle flagellomeres 2× width. Labial palpus with

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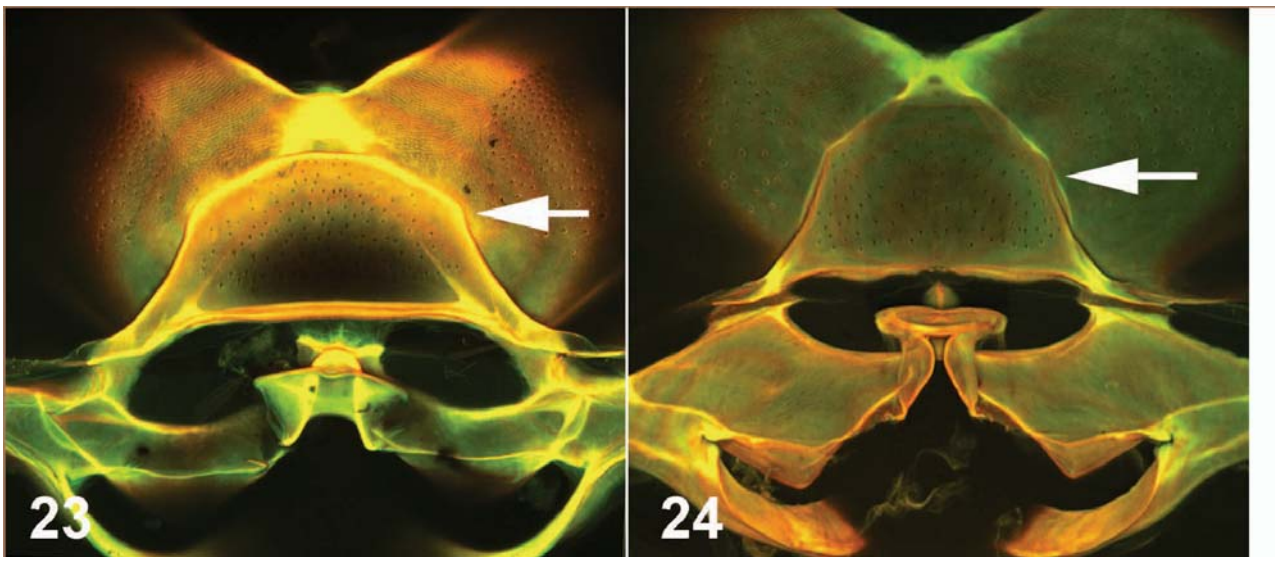

FIGS. 23–24. Confocal images of metascutellum (white arrow) and epinotum (blue arrow). **23,** *Spinitibia hodgesi*. **24,** *Glyphidocera juniperella* (Glyphidoceridae).

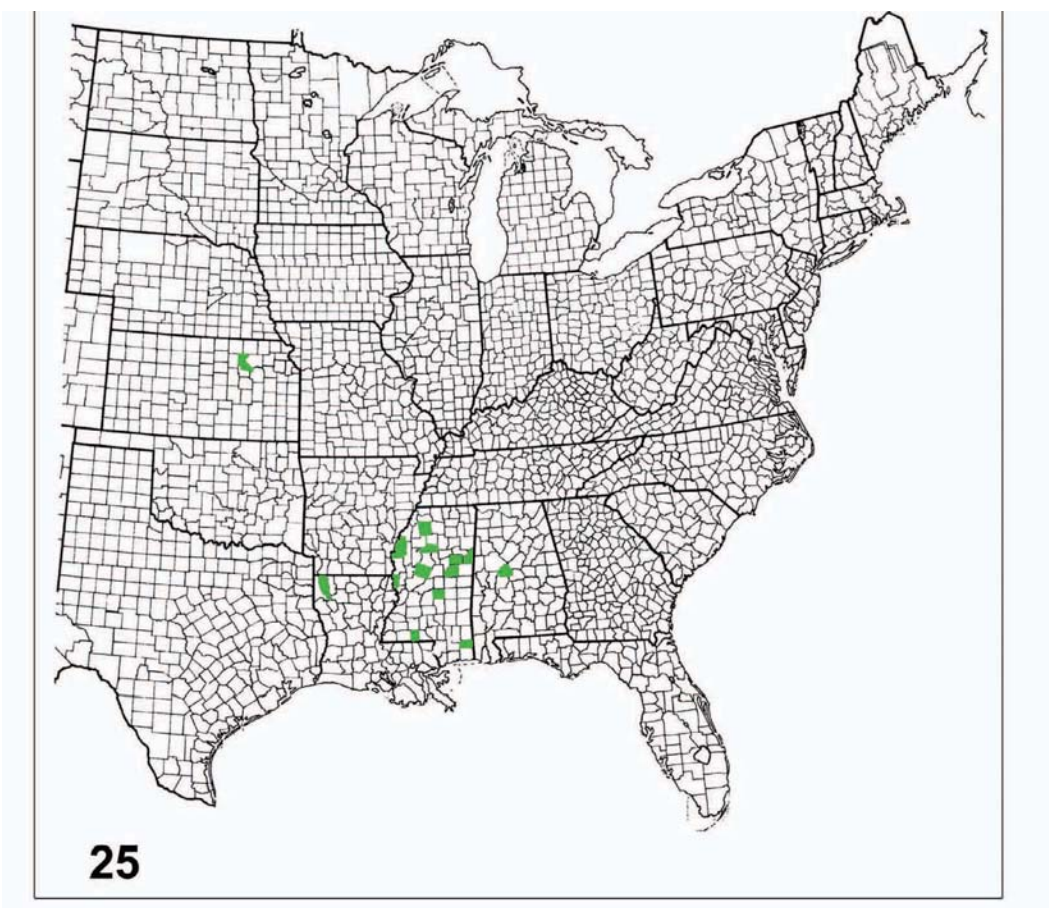

FIG. 25. Distribution of *Spinitibia hodgesi*.

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second segment dark brown mixed with variable amount of yellowish white laterally, yellowish white with scattered dark brown scales ventrally and medially, apical segment with dark brown spots or bands basally and preapically. Forewing length 5.0–8.0 mm, ground color yellowish white, with scattered dark brown scales except for longitudinal streaks of yellowish-white between Sc and R and on dorsum near base, in discal cell and between Cu and 1A+2A at midlength, and between R_5 and M_1, apical half of costa and areas between veins at outer margin with variable amounts of yellowish white, basal 1/4 of wing along Cu with dark brown streak, apical 1/3 of wing with variable dark brown streaks along some R and M veins, pale area in discal cell bordered basally and apically by dark brown spots. Hindwing pale brownish gray. Forelegs dark brown except tarsi pale brown banded with yellowish-white, midlegs with dark brown femur, tibia and tarsi yellowish-white mixed with grayish-brown, hindlegs yellowish white mixed with grayish-brown, tibia with fringe of yellowish-white setiform scales on dorsal surface in both sexes. Abdomen yellowish-gray, except terga posteriorly lined with yellowish-white.

Male genitalia. As in description of genus.

Female genitalia. As in description of genus.

Diagnosis. In addition to characters of the genus, *S. hodgesi* can be distinguished from other species of Symmocinae by the mesonotum having lateral and median longitudinal dark brown bands and the forewing having dark brown and yellow streaks.

Types. *Holotype.* ♂, Miss. Lowndes Co., Plymouth Bluff Center, 33º30'59"N, 88º29'56"W, 18 Jun 2007, R.L. Brown. MEM No. 38622. Deposited in U.S. National Museum of Natural History. The holotype is intact with all appendages present and is not dissected.

Paratypes (n = 56). *Alabama:* Bibb Co., Bibb Co. Glades Preserve 33º03'28"N, 87º02'21"W, 5 Jun 2003, R.L. Brown and S. Lee (1♀). *Kansas*: Riley Co., Konza Prairie R.N.A., 39º05'57"N, 96º35'14"W, 12 Jun 1999, R.L. Brown (2♂), same data except 39º05'11"N, 96º34'29"W, 14 Jun 1999, D.M. Pollock (1♂). *Louisiana*: Bossier Parish, Barksdale A.F.B., 32º29'19"N, 93º35'20"W, 9 May 1996, D.M. Pollock (1♂), same data except 32º31'13"N, 93º35'46"W, 21 May 1996, R.L. Brown and D. Pollock (1♂), same data except 32º29'29"N, 93º35'07"W, 8 Aug 1996 (1♂), 21 May 1996 (1♂, genitalia slide MEM 2187), R.L. Brown and D. Pollock, 24 Aug 1996 (1♂), 13 Sep 1996 (1♂), R.L. Brown. *Mississippi*: Bolivar Co., Mississippi River Levee, 33º36'29"N, 91º07'34"W, 17 Aug 1993, D.M. Pollock (2♂). George Co., 3 mi North of Lucedale, 5–18 Aug 1996 (1♂), 19 Aug–17 Sep 1996 (2♂), 18 Sep–11 Oct 1996 (1♂), R. Kergosien. Grenada Co., T22N R3E, Sec. 31NW, 7–13 Aug 1991 (1♂), 23–29 Oct 1991 (1♂), R.L. Brown, same data except T21N R2E, Sec. 7S, 18N; 28 Aug–3 Sep 1991, R.L. Brown (2♂), same data except T21N R2E, Sec. 12,13N & R3E, Sec 7S, 18N, 21–28 May 1991 (1♂, wholebody slide MEM 2188), 24–30 Jul 1991 (1♂), R.L. Brown. Holmes Co., Holmes Co. St. Pk. 3 Jun 2001, R.L. Brown (2♂). Issaquena Co., 2 mi E of Tallulah [Louisiana], 1–5 May 1996, R. Kergosien (1♂, wing venation slide MEM 2095, genitalia slide MEM 2186). Lowndes Co., Plymouth Bluff Center, 33º30'59"N, 88º29'56"W, 18 Jun 2007, R.L. Brown (3♂), T17N R16E, Sec. 5, 11 May 1991, D.M. Pollock (3♂, genitalia slide MEM 1030), same data except T17N R16E, Sec. 34, 3 Jun 1991 (1♂), 10 Jun 1994 (4♂), D.M. Pollock, 20 May 1992, R.L. Brown (1♂), 16 May 1993, R.L. Brown and D. Pollock (2♂,), 10 Jun 1993, D.M. Pollock (1♂,), 24 Aug 1993, R.L. Brown and D. Pollock (1♂,). Oktibbeha Co., T18N R14E, Sec. 23, 28 May 1989, R.L. Brown and B.B. Brown (1♂, wing venation slide MEM 2096), same data except T19N R15E, Sec. 16, 27 Apr 1991, D.M. Pollock (1♂), same data except 6 mi SW Starkville, 19 Jun 1986, R.L. Brown and B.B. Brown (1♂); Osborn, 33º30'41"N, 88º44'08"W, 13 Jun 1997(1♀), 17 Jul 2002 (1♂, genitalia slide MEM 1305), R.L. Brown. Panola Co., John W. Kyle St. Pk., 34º25'38"N, 89º48'21"W, 1–3 Jun 1997, R.L. Brown (1♂). Pike Co., Percy Quin State Park, 311051N, 903154W, 1–3 Jun 1998, R.L. Brown (1♂). Scott Co., 2 mi E Forest Harrell Hill Prairie, T6N R8E, Sec. 25&26, 8 Sep 1990, D. and M. Hildebrandt (1♂). Smith Co., Bienville Natl. Forest, 32º10'06"N, 89º20'54"W, 30 May 2000, R.L. Brown (1♂, genitalia slide MEM 1221). Winston Co., Noxubee N.W. Refuge, T16N R14E, Sec. 13SE, 14 Jun 1992, T.L. Schiefer (1♂), same data except Tombigbee Nat. Forest, 33º16'05"N, 89º06'01"W, 17 May 1999 (2♂), 10 Aug 1999 (1♀) J.A. MacGown, same data except 33º10'20"N, 89º03'55"W, 25 May 1999, R.L. Brown (1♀, genitalia slide MEM 1031), same data except 33º10'31"N, 89º02'38"W, 3 May 1999, D.M. Pollock (1♀). Paratypes are deposited in the Canadian National Collection (Ottawa), Mississippi Entomological Museum (Mississippi), National Museum of Natural History (Washington D.C.) and The Natural History Museum (London).

Distribution. Fifty-seven specimens (52 males, 5 females) have been collected during April–October in the midsouthern states and Kansas (Fig. 23).

Etymology. The species epithet is a patronym for Ronald W. Hodges, who first recognized this species as being a new genus and new species.

DISCUSSION

The assignment of *Spinitibia* to Symmocinae is validated by presence of an unarticulated gnathos, abdominal terga with bands of spines, hooked gnathos, unique form of the female retinaculum, and absence of forewing vein CuP. The forms of the uncus and female genitalia (Fig. 10) are similar to those in other genera of Symmocinae.

Spinitibia hodgesi is the second known endemic species of Symmocinae in North America. Most specimens have been collected in a variety of dry forests, but 18 specimens have been collected in prairies, cedar glades, inland dunes, and old fields.

Scanning electron microscopy revealed spore-like structures on the spiniform setae of the hindleg, some of which are imbedded between longitudinal ridges (Fig. 15). DNA sequences from the hindlegs revealed the presence of a basidiomycete mushroom (*Russula* sp.) in one clone, and basidiomycete yeasts (*Cystofilobasidium* sp. and *Asterotremella* sp.) in three clones. However, the spore-like structures are not considered to be of fungal origin, and they are smaller than the smallest yeast cells (Steven Miller personal communication); thus, their identity remains unknown. Similar spore-like structures were detected on the antenna of a specimen of *Sceptea aequepulvella* borrowed from the U.S. National Museum. Such spore-like structures have not been seen on bodies of a large number of species of Tortricidae and Gelechiidae in the MEM that have been examined previously with scanning electron microscopy.

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NOTES ON, AND THE TAXONOMIC SIGNIFICANCE OF, THE IMMATURE STAGES OF *LINTNERIA JUSTICIAE* WALKER (SPHINGIDAE) FROM SOUTHEASTERN BRAZIL

LARRY E. VALENTINE
Itanhandu, Minas Gerais, Brazil

AND

JAMES P. TUTTLE
Melbourne, Australia; email: jtuttle164@hotmail.com

ABSTRACT. Confirmed aspects of the life history of *Lintneria justiciae* are discussed and illustrated for the first time. Observed larval characters represent a unique synapomorphy that has been shown to correlate with predictable adult forewing patterns. The significance and taxonomic implications of these recent discoveries confirm the placement of several South American taxa, including *L. justiciae*, in the recently reinstated genus *Lintneria*.

Additional key words: *Sphinx, Cryptophion, Microplitis, Hyptis sidifolia*, synapomorphy

In mid-April 2009, one of us (LEV) discovered larvae of an unidentified sphingid on a pungent, sprawling shrub on his fazenda (ranch) near Itanhandu, Minas Gerais, in southeastern Brazil. The site is at an elevation of 1066m in remnant Atlantic Rainforest. The discovery included a 3rd and two 5th instar larvae with very different larval forms.

The larvae were feeding openly during the daytime, and within a few days it became apparent that the larvae were parasitized. Photographs of the resulting parasitoid cocoons suggest they are a *Cryptophion* wasp (Ichneumonidae) and *Microplitis* wasps (Braconidae). Species-specific parasitoid identifications are pending.

Suspecting that open diurnal feeding was aberrant behavior related to parasitism, Larry and Donna Valentine returned to the same location and once again searched the larval host plants, this time with flashlights at dusk. Donna Valentine found a single fifth instar larva ascending one of the plants to feed. The larva was successfully reared to maturity and a healthy pupa was obtained. The resulting adult emerged on 22 October 2009, and although it failed to fully expand its wings, it was identified as *Lintneria justiciae*. Since that time, additional observations between October and April indicate that there are two annual generations.

L. justiciae is the southeastern most representative of this broadly distributed genus, which extends from extreme southern Canada to southern South America. It is the only member of the genus found in Brazil. The second member of *Lintneria* to be described, *L. eremitus* from North America being the first, *L. justiciae* has never been fully understood (Hübner [1823]; Walker 1856). It is unclear how Walker (1856) arrived at his etymology when he described *Lintneria justiciae* (as *Sphinx justiciae*). However, circumstances suggest that life history information or an unpublished manuscript name based upon life history information may have been available to him that led to the name *justiciae*. Supporting that suspicion is the fact that over 20 years later, Burmeister (1878) erroneously [in retrospect] reported the association of the larva of *L. justiciae* (as *Sphinx justiciae*) with a member of the plant genus *Justicia* (Acanthaceae). The following year, Burmeister (1879) provided an excellent color illustration of a "typical" sphingiform last instar larva purported to be *L. justiciae*. In the subsequent years, the life histories of no other South American members of the genus *Lintneria* were described. Almost 130 years later, Tuttle (2007) pointed out that the Burmeister larval illustration, presented as *L. justiciae*, was actually *Manduca rustica*. As a result, the larval form and biology of the South American *Lintneria* species remain undescribed.

Given the lack of life history information on *Lintneria justiciae*, a description of the available immature stages follows.

Third Instar: The head and ground color are a light lime-green. The larva has a large, mid-dorsal, fleshy, horn-like projection on the second thoracic segment. This structure is extremely rugose and tipped in brown. On the dorsum there are also two pairs of tiny spikes equally spaced between the fleshy horn and the head capsule. The entire larva is heavily stippled with tiny, whitish secondary tubercles giving it a very rough appearance. There are seven pale dorsolateral diagonal stripes beginning at the bottom of each abdominal segment and continuing into the dorsum of the next segment. The exterior of the prolegs is brown and the brownish color extends partially up each dorsolateral diagonal stripe. The true legs are brown [as best can be determined from the single image available]. The spiracle on the first abdominal segment is a light blue, encircled boldly in black, and highlighted by a small yellowish patch. The anal horn is predominantly brown and also extremely rugose. 27mm (n=1)

Fourth Instar: Not recorded.

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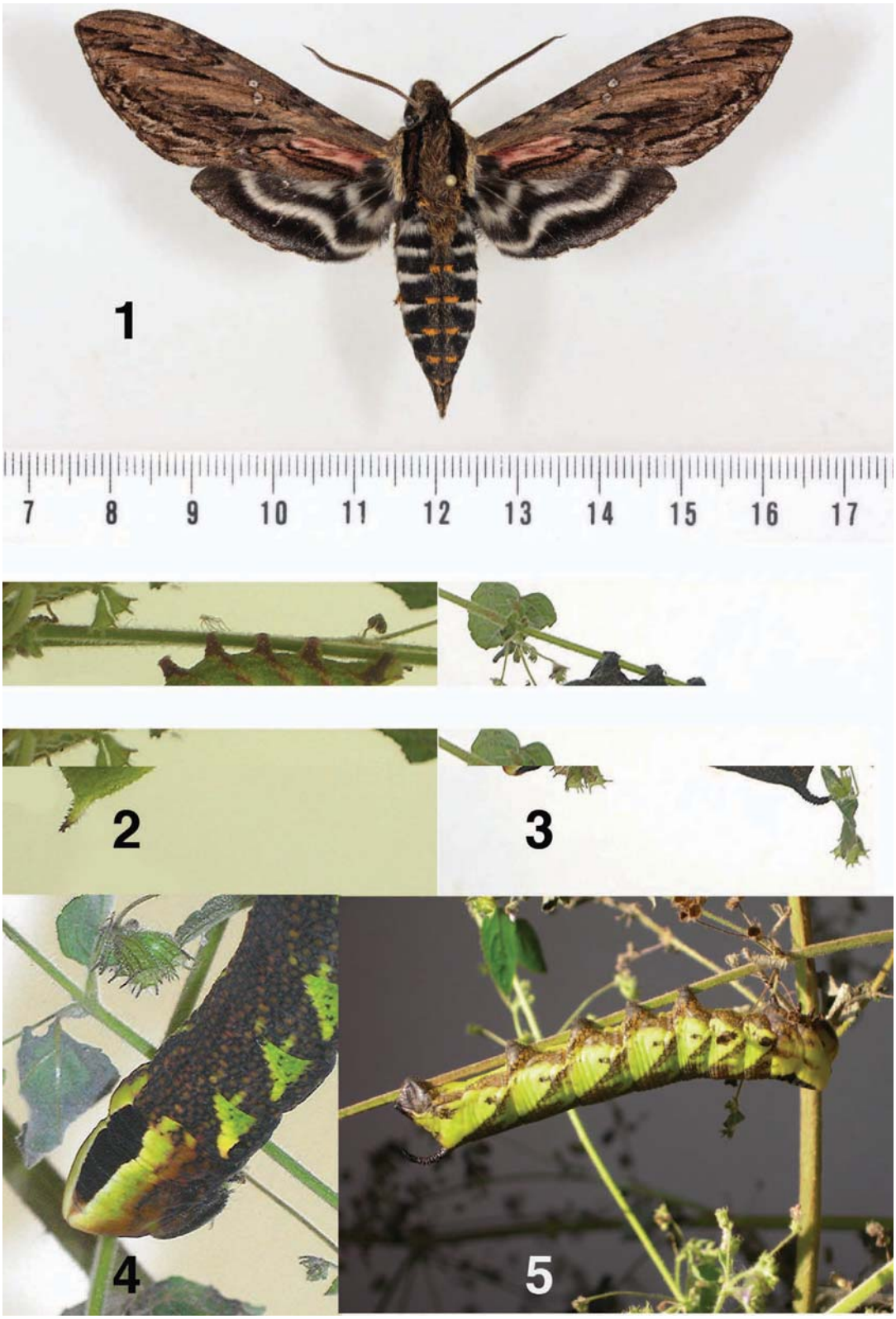

FIGS. 1-5. *L. justiciae* ♂, Santa Catarina, Brazil (coll. J. Haxaire). FIG. 2. 3rd instar larva of *L. justiciae* from Itanhandu, Brazil. **3,** Brown form 5th instar larva of *L. justiciae* from Itanhandu, Brazil (lateral view). **4,** Brown form 5th instar larva of *L. justiciae* from Itanhandu, Brazil (dorsal view). **5,** Green form 5th instar larva of *L. justiciae* from Itanhandu, Brazil (lateral view).

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FIG. 6. Pupa of *L. justiciae* pupa from Itanhandu, Brazil (lateral view).

Fifth Instar (Brown Form): As with all other known *Lintneria* larval histories, there is a dramatic change in general form in the last instar. The mid-dorsal thoracic protuberance is replaced by a large hump with a large black patch on thoracic segments two and three which is encircled in bright lime-green. The ground color of the larva, head, true legs, prolegs, and anal horn are a dark brown and the entire larva is heavily stippled with very faint, light spots. The brown frontal lobes of the head have a pair of green vertical stripes. Each abdominal segment has a bright, lime-green triangular patch, the base of which transects the spiracle horizontally and runs the entire width of the segment. This lime-green patch is heavily stippled with dark brown spots. The black anal horn is stout, extremely rugose, and curves sharply downward. 79–80mm (n=2)

Fifth Instar (Green Form): The morphology is as in the brown form. However, the ground color is green with a slight yellowish hue, as are the head and venter. The seven dorsolateral stripes are bordered dorsally by angular dark brown patches stippled with light brown. These patches merge into the dark brown dorsum. The green frontal lobes of the head have a pair of dark brown vertical stripes. The true legs, outer portion of the prolegs, and the lower portion of the subspiracular region are dark brown; the subspiracular region is heavily stippled with light brown. The anal horn is as in the brown form. 70mm (n=1)

Pupa: The fusiform pupa is a dark purplish brown, smooth, and somewhat glossy. The tongue case is free, fairly short (approximately 10mm), and closely appressed to the thorax. The black cremaster is very broad at the base, hollowed ventrally forming a scoop, and narrows rapidly into a fine bifurcate tip. 50mm (n=1)

Host Plant Identification. Images of various aspects of the larval host plant were sent to the Royal Botanic Gardens at Kew, London, UK. The plant was identified by Dr. Raymond M. Harley as *Hyptis sidifolia* (L'Herit.) Briq. (= *H. umbrosa* Salzm. ex Benth.) (Lamiaceae). *H. sidifolia* is widely distributed across much of South America and northward to southern Central America.

Taxonomic Significance. Although the above description of the larval stages of *L. justiciae* is incomplete, the morphology of the 3rd and 5th instar larva has significant taxonomic implications. Tuttle (2007) reinstated the genus *Lintneria* from long-standing synonymy under the genus *Sphinx*. As long treated, the genus *Sphinx* contained 48 species and a number of subspecies ranging from Europe, across to eastern Asia, North America, Central America, and South America (Kitching & Cadiou 2000). Although all species originally placed in the genus *Sphinx* have a fairly consistent adult morphology, two predominant adult forewing maculation patterns exist. One forewing pattern can be generalized as having minimal maculation and/or orderly linear patterns, whereas the second forewing pattern can be generally described as an intricate mosaic that includes a prominent pair of parallel lines that run from the inner margin into the basal area (except in *L. arthuri* and *L. maura*), and a pair of discal spots of varying sizes.

One of us (JPT), while carrying out investigation into the genus *Sphinx* for "The Hawk Moths of North America", discovered a possible correlation between adult forewing pattern and larval morphology. The species with minimal or orderly linear forewing maculation patterns had a "typical" sphingid larval form throughout all five instars—long and cylindrical. In contrast, the species with intricate mosaic forewing maculation patterns had a larval form with a large, fleshy mid-dorsal protuberance on the second thoracic segment in instars 1–4 (as described in 3rd instar above) which is replaced by a thoracic hump in the last instar (as described in 5th instar above).

FIG. 7. Close-up of larval host plant, *Hyptis sidifolia* (Lamiaceae).

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Fortunately, during the time frame of that research, the life histories of additional species long attributed to the genus *Sphinx* from North America and Central America came to JPT's attention. In each case, the correlation between adult forewing maculation and larval morphology held true, thereby confirming the earlier hypothesis. In addition, with one exception (*L. lugens*), all known *Lintneria* larvae are associated with members of the plant family Lamiaceae. As a result, 21 species from the Americas with mosaic forewing maculation patterns, including all of the South American species, were removed from *Sphinx* and reassigned to *Lintneria* (Tuttle 2007). This conclusion has been supported further by phylogenetic analysis of DNA sequence data (Kawahara *et al*. 2009). Tuttle (2007) further proposed that as the immature stages of additional *Lintneria* species became known, they too would exhibit the above-described unique larval synapomorphy.

The discovery of the partial life history of *L. justiciae*, which includes larval morphology and association with the plant family Lamiaceae, clearly confirms its placement within *Lintneria*. Although their life histories remain to be discovered, it also further corroborates the placement of the other South American species *L. arthuri*, *L. aurigutta*, *L. maura*, *L. phalerata*, *L. porioni*, and *L. praelongus* within the genus *Lintneria*.

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FIRST REPORT OF *HECATERA DYSODEA* (DENIS AND SCHIFFERMÜLLER) (NOCTUIDAE) IN THE PACIFIC NORTHWEST OF THE UNITED STATES

PETER J. LANDOLT
USDA, ARS Yakima Agricultural Research Laboratory, 5230 Konnowac Pass Road, Wapato, WA 98951; email: peter.landolt@ars.usda.gov

RICHARD A. WORTH
Oregon Department of Agriculture, 635 Capitol St. NE, Salem, OR 97301

AND

RICHARD S. ZACK
Department of Entomology, Washington State University, Pullman, WA 99164

ABSTRACT. New geographic records are reported for the noctuid moth *Hecatera dysodea* (Denis & Schiffermüller). It is a Palearctic species, but is now found in a broadly contiguous area of Oregon and Washington in the United States. This area is comprised of 7 counties across much of the north of Oregon and into 4 counties of southern Washington. Moths were captured in several types of survey traps baited with insect pheromones and feeding attractants, as well as blacklight traps, from 2003 to 2009. Larvae were collected on flower stalks of prickly lettuce, *Lactuca serriola* L. (Asteraceae), from June into September, suggesting multivoltinism. Collection records over time indicate a possibly rapidly expanding distribution of the species.

Additional key words: host plant, introduction, moth, trap, Oregon, Washington

Hecatera dysodea (Denis & Schiffermüller) has a widespread distribution in Europe and North Africa, east into Russia, western China and India (Wiltshire 1957; Poole 1989; Ivinskis & Miatleuski 1999; Hacker *et al*. 2002). The species was thought to have become extinct in England but has since reappeared (Skinner 1984; Pratt 1986; Agassiz & Spice 1998; Honey 2002), and may be expanding its distribution in other areas of Europe such as Denmark and Sweden (http://www.lepidoptera.dk/*dysodea*.htm (Hacker *et al*. 2002). Reasons for its prior decline in England are discussed by Pratt (1986).

The larvae feed on the flower buds, flowers, and seeds of species of *Lactuca* (lettuce), *Crepis* (hawksbeard) and *Sonchus* (sow thistle) (Asteraceae) (South 1920; Bretherton *et al*. 1979; Skinner 1984; Pratt 1986). Bretherton *et al*. (1979) report it as an occasional pest on domestic lettuce, *Lactuca sativa* L. However, Pratt (1986) logically suggests that such claims are in reference only to lettuce grown for seed production.

The larva is described by Beck (1999); the adult is illustrated by South (1920), Skinner (1984), and Hacker *et al*. (2002). The adult and male genitalia are also figured in this report (Fig. 1 & 2). We summarize first collections of *H. dysodea* in North America (e.g. Hodges *et al*. 1983), within Oregon and Washington of the United States.

METHODS AND RESULTS

Oregon. Collection information is summarized in Table 1 and Figure 3. First Oregon records for the species were in Wasco County, with the earliest moth capture in 2003 near Dufur, in a sticky wing type trap baited with a pheromone lure for trapping *Helicoverpa armigera* (Hübner), and placed as part of an insect survey by the Oregon Department of Agriculture. In 2005, 28 *H. dysodea* adults were captured in The Dalles area of Wasco County in Lindgren funnel traps (PheroTech Inc., Delta, BC, Canada) baited with ethanol lures and used in a survey for scolytid beetles. An additional 11 moths were captured between 5 June and 21 September 2006 in the same area with the same type of trap. In 2006, moths were also captured in the Dufur and The Dalles areas, in Universal Moth Traps (Great Lakes IPM, Vestaburg, MI) baited with a floral based chemical attractant, and in The Dalles in blacklight traps. The floral lure was a blend of phenylacetaldehyde, methyl salicylate, beta myrcene, and methyl-2-methoxy benzoate, developed for trapping flower-visiting Noctuidae such as the alfalfa looper *Autographa californica* (Speyer) (Landolt *et al*. 2007). The floral lure was tried as an attractant for *H. dysodea* because of the reported affinity of the moth for flowers (Bretherton *et al*. 1979). In 2006, seven larvae were collected from prickly lettuce, *Lactuca serriola* L.

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FIG. 1. Adult male moth of *Hecatera dysodea* reared from larva collected on *Lactuca serriola* in Dufur, Oregon.

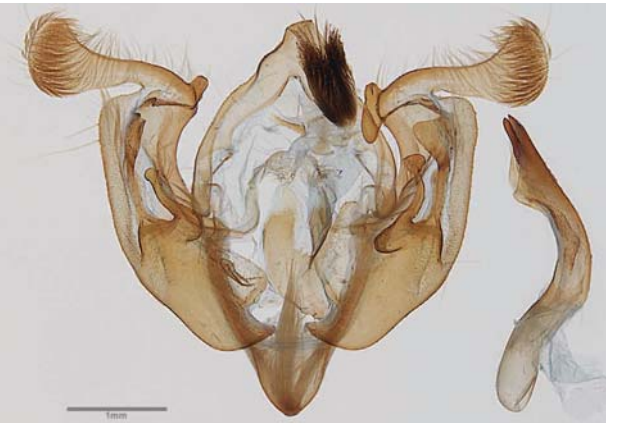

FIG. 2. Male genitalia with aedeagus removed and figured laterally. Note the slightly asymmetrical morphology of the valvae.

near Dufur and were reared to the adult stage following protocols similar to that described below for studies in Washington. However, these larvae were maintained in plastic bags instead of paper cups.

After 2006, *H. dysodea* were found over a wider area in Oregon. Moths were captured in survey traps baited with ethanol lures in Baker, Malheur, Umatilla, and Union Counties in 2007. In 2009, larvae were found on prickly lettuce flower stalks in Gilliam County, and two adults were collected from the side of a residence in the city of Portland, Multnomah County.

Washington. Collection information is summarized in Table 2 and Figure 3. In the state of Washington, the first collections of *H. dysodea* moths were two adult specimens at porch lights of a residence in Stevenson, Skamania County. In the summer of 2009, prickly lettuce flower stalks along several roadways in south central and southeastern Washington were searched for Lepidoptera larvae. This included: 1) State Route 14, which parallels the Columbia River, from Paterson west to Vancouver, 2) Interstate Highway 5 from Vancouver north to Tacoma, 3) U.S. Route 97 from the Columbia River north to Yakima, 4) Interstate Highway 82 from Yakima to Richland, 5) the vicinity of Yakima, 6) the vicinity of Pullman in Whitman County, and 7) State Route 24 from Colfax in Whitman County to Othello

TABLE 1. Collection information for *Hecatera dysodea* in the state of Oregon. Old world bollworm (OWB) trap was baited with the sex pheromone of *Helicoverpa armigera*.

County	Location	Date	Number	Stage	Collection Note
Baker	Baker City	27 VII 2007	1	adult	ethanol trap
Gilliam	Rts I-84 X SR 74	12 VIII 2009	several	larvae	on *L. serriola*
Malheur	Ontario	V to IX 2007	5	adult	ethanol trap
Multnomah	Portland	7 VIII 2009	2	adult	on wall
Umatilla	Hermiston	29 VI 2007	1	adult	ethanol trap
	Hermiston	15 X 2007	1	adult	ethanol trap
Union	La Grande	VII to IX-2007	9	adult	ethanol trap
Wasco	Dufur	24 IX 2003	1	adult	OWB trap
	The Dalles	V to VI 2005	28	adult	ethanol trap
	The Dalles	VI to IX 2006	11	adult	ethanol trap
	Dufur area	VI to IX 2006	10	adult	floral lure trap
	Dufur	2 VII 2006	7	larvae	on *L. serriola*
	The Dalles	VI to IX 2006	6	adult	floral lure trap
	The Dalles	VI toVII 2006	4	adult	blacklight trap

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in Adams County. Generally, when a patch of prickly lettuce was sampled, 30 plants were searched. Prickly lettuce plants are visually distinctive and are readily identified when flower stalks are developed (see Whitson *et al*. 1996). When captured, caterpillars were placed in 280 ml wax coated paper cups with plastic lids, along with cuttings of the host plant with flower buds and flowers. Cups with larvae were placed in an insulated chest for transport to the laboratory.

Larvae were reared to the adult stage in the laboratory, and were kept in the same wax-coated paper cups. Fresh cut sections of prickly lettuce flower stalks were placed in each cup with larvae daily, and any dead larvae or moldy frass and plant material were removed at that time. When larvae were ca 2 cm in length, 2 cm of potting soil (a one to one mixture of sand and peat moss) was placed in the bottom of the cup as a pupation medium. After larvae burrowed into and remained with the soil, the cups were transferred to screened cages for adult emergence. An emergence cage was maintained for each field site that yielded larvae. Emergence cages were checked daily for moths, which were killed and prepared as voucher specimens.

In 2009, from 9 July to 20 August, 99 Lepidoptera larvae were collected from flower stalks of prickly lettuce plants at eight sites in four counties in the state of Washington (Table 2). Seventy-two *H. dysodea* adult moths emerged from these samples from 28 July to 9 October 2009. Although some larvae died while held in the laboratory, we did not see the emergence of any parasitoids.

FIG. 3. Counties of the states of Oregon and Washington positive for collection of *Hecatera dysodea*.

Anecdotal observations were made of larvae during field sampling. Larvae varied in coloration and size, with smaller larvae green with a pale lateral stripe, and larger larvae tan to light brown. At several sites where multiple larvae per plant were encountered (Drano Lake, Mary Hill State Park, Roosevelt, Wishram), larvae collected on a single plant were of multiple sizes, indicating that oviposition on that plant occurred

TABLE 2. Collection information for *Hecatera dysodea* in the state of Washington.

County	Location	Date	Number	Stage	Collection Note
Benton	5 mi S Prosser	8 VII 2009	7	larvae	on *L. serriola*
Klickitat	Dallesport	18 VII 2009	7	larvae	on *L. serriola*
	Goldendale	8 VII 2009	1	larva	on *L. serriola*
	Goldendale	18 VII 2009	5	larvae	on *L. serriola*
	Mary Hill State Park	3 VII 2009	20	larvae	on *L. serriola*
	Mary Hill State Park	8 VII 2009	15	larvae	on *L. serriola*
	Mary Hill State Park	15 VIII 2009	6	larvae	on *L. serriola*
	Roosevelt	8 VII 2009	10	larvae	on *L. serriola*
	Wishram	18 VII 2009	13	larvae	on *L. serriola*
Skamania	Drano Lake	18 VII 2009	10	larvae	on *L. serriola*
	Stevenson	8 VIII 2008	1	adult	porch light
	Stevenson	9 IX 2008	1	adult	porch light
Yakima	Union Gap	12 VII 2009	1	larva	on *L. serriola*
	Union Gap	20 VIII 2009	2	larvae	on *L. serriola*

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over a period of at least several days (multiple oviposition bouts). All larvae burrowed into the potting soil and pupated within a cell made of soil. These cells were particles of soil loosely bound together to make an oblong sphere-shaped structure encompassing an air space holding the pupa. The pupae remained within this cell after eclosion and adult emergence.

DISCUSSION

The known distribution of *H. dysodea* in North America now includes a broad area within the Pacific Northwest of the United States, comprised of a contiguous area of seven Oregon and four Washington counties (Figure 3). Temporal and geographic aspects of the collection records suggest the distribution of the insect has expanded since 2006. However, the absence of positive collection records does not demonstrate its absence in an area. The host plant utilized, prickly lettuce, is widespread and can be extremely abundant. Collection sites near Dufur and in The Dalles in Wasco County of Oregon, as well as near Prosser in Benton County and in Union Gap of Yakima County, Washington are among abundant patches of prickly lettuce in areas of physical disturbance and irrigated agriculture. The population of this moth could very rapidly increase in those counties as well as in similar habitat of the Columbia River Basin to the north and the Palouse Prairie to the east. The host plant is also very abundant at disturbed sites in low elevation areas west of the Cascade Mountains, such as the Williamette Valley of Oregon and Puget lowlands of Washington.

At present, the introduction, range, and spread of this Eurasian species in the Pacific Northwest are not of particular concern. Prickly lettuce is itself an introduced Palearctic weed (Whitson *et al*. 1996). Two other introduced weeds that are potential hosts of *H. dysodea* in the Pacific Northwest are *Sonchus asper* (L.) (prickly sow thistle) and *Crepis setosa* (Haller) (rough hawksbeard). Two native species of wild lettuce, *Lactuca pulchella* (Pursch) (blue lettuce) and *Lactuca biennis* (Moench) Fernald are also potential hosts. There is commercial agricultural production of lettuce (*Lactuca sativa* L.) seed in the Pacific Northwest that may be at risk if the moth continues to expand its distribution. For example, commercial lettuce seed production occurs in Skagit County, Washington well to the north and west of the present known distribution of *H. dysodea*.

In Britain, the moth is reported to have one generation per year (Skinner 1984). The moth flight occurs there in late June and July, larvae are present on plants in July and August, and overwintering is in the pupal stage. However, in our Oregon and Washington records, the moth was collected in every month from May into October. Also, larvae were present on host plants at least from late June into late August. These observations suggest more than one generation of this insect per year in the Pacific Northwest of the United States.

Specimens of *H. dysodea* from Oregon were deposited in the Canadian National Collection of Insects, Ottawa, Ontario, and the United States National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM). Specimens of *H. dysodea* from Washington were deposited in the USNM, the collection of the Washington State Department of Agriculture, and the M. T. James Entomological Collection, Department of Entomology, Washington State University.

ACKNOWLEDGEMENTS

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A NEW SPECIES OF *SCHINIA* FROM CENTRAL CALIFORNIA (NOCTUIDAE: HELIOTHINAE)

KENDALL H. OSBORNE

Osborne Biological Consulting, 6675 Avenue Juan Diaz, Riverside., CA, 92509; email: Euproserpinus@msn.com

ABSTRACT. *Schinia carrizoensis* **new species**, is described from specimens collected on the Carrizo Plain National Monument, San Luis Obispo County and northeastern Santa Barbara County, California. This new *Schinia* is a member of the S. cupes (Grote) complex and is remarkable in the group for having subtle maculation with rusty coloration and a limited distribution.

Additional key words: *Ericameria linearifolia*, *Schinia mexicana*, genitalia, host plant, Asteraceae, interior coast range, *Schinia carrizoensis* n. sp., systematics.

In his canonical monograph to the Heliothinae of North America, Hardwick (1996) provided comprehensive coverage of the large North American Genus *Schinia* Hübner. The extensive descriptions of adult and larval characters, life histories, flight phenologies and distributions, along with color depictions of the larvae and adults, provided an easy means for identifying most species and recognizing new ones. Three new species of *Schinia* (Opler 2000), perhaps related to wide ranging *Schinia jaguarina* (Guenée), *Schinia miniana* (Grote), and *Schinia tuberculum* (Hübner), were subsequently described on the basis of differences in wing coloration of the few specimens examined. Several additional cryptic species of *Schinia* have been described, or resurrected out of synonymies, based on substantial anatomical characters examined in large series of specimens. Such characters include presence or absence of a well-developed second abdominal sternite hair pencil, genitalic characters, structures of frons, labial palps, and foretibial spination (Pogue & Harp 2003a, b, c, 2004, 2005; Knudson *et al*. 2003).

While conducting a survey of Lepidoptera on the Carrizo Plain National Monument in San Luis Obispo County, California, I collected numerous specimens of large, rust colored *Schinia* at the blacklight. These moths resembled no other *Schinia* and I immediately recognized this species as a new member of the *S. cupes* complex. During preparation of this manuscript, Mr. Thomas Dimock advised me of specimens he collected on the Carrizo Plain National Monument and a nearby portion of Santa Barbara County. Two of the Dimock specimens, also slightly worn, were sent first to Chuck Harp, then to Michael Pogue, both of whom found the moth new, Pogue initially concluding that maculation did not place it with the *S. cupes* group (Harp and Pogue, pers. comm.). This new *Schinia* is here described and a key to species of the *S. cupes* complex provided. My research of this group has lead me, in contrast to Pogue and Harp (2003a), to make the further addition of *Schinia mexicana* (Hampson) to the *Schinia cupes* complex.

Schinia carrizoensis, **new species**

(Figs. 1–2, 6–10)

Description. Adult Male. (Fig. 2) *Head*: Frons cream and rust brown with short narrow scales; vertex mixed cream and rust hairlike scales. Labial palpus cream with some light gray scales on middle and at apex of outer surface. Eyes large and globular. Antenna orange thinly covered with flattened tan scales and abundant ventrally directed closely spaced short tan setae. *Thorax*: Mixture of cream and rust, hairlike and (few) spatulate scales with tapered stalks, many tapered scales cream with rust subterminal band and cream tip. Foreleg femur and ventral fringe cream; tibia cream and light gray; largest and stoutest spine on inner side and closest to basitarsus; slender dorsal setae absent; lateral tibia with three (sometimes 4, N=1) stout spines, the dorsal being slightly shorter and less robust; tarsi light gray with tan-cream apical rings. Mid- and hindlegs tan-cream with some gray scales but mid tibia with some rust scales; tarsi gray with tan-cream apical rings. Underside tan-cream. *Forewing*: Length 11.8–13.0 mm, mean=12.3, (n=11). Ground color rusty-tan-cream; antemedial line tan-cream and sinuate; claviform spot absent; orbicular spot rust brown, outlined with darker rust brown, with some gray at center; reniform spot rust brown outlined with darker rust or rust-brown, with some gray on central portions; postmedial line tan-cream and sinuate; subterminal line tan-cream distally, irregular darker rust brown medially; costal markings tending to dark brown in some; fringe uniform rusty-tan-to tan-cream, dark tipped scales tending apically. Underside light gray basally with dark gray orbicular and reniform spots; tan-cream on costa and marginally. *Hindwing*: Ground color light gray, discal spot and broad marginal band dark gray brown; veins in light discal area highlighted with dark gray-brown scales. *Abdomen*: Tan-cream dorsally, lighter cream to tan-cream ventrally; hair pencils and associated scent pockets on second sternite present. *Genitalia*: Uncus approximately 0.34 times the length of valve; valve elongate, length approximately 5 times width; ampulla elongate approximately 0.1 times length of valve; vesica with three coils.

Female. (Fig 1) As in male except antenna without abundant short ventral setae, but with one pair of short ventral setae at base of antennal segments. Forewing length 12.0–13.5 mm, mean=12.8 mm (n=l1). *Genitalia*: Not telescopic; papillae anales slightly sclerotized, triangular with an angled ventral margin, apex round; surface of ninth segment with fine, minute spiculi; eighth segment with short, fine setae in irregular rows around distal margin; appendix bursae with three coils; signa consisting of four elongate scobinate ribbons.

Type material. HOLOTYPE: ♀, CALIFORNIA: San Luis Obispo County, Carrizo Plain National Monument, Caliente Range, 1 mi SE Painted Rock, 2555' Lat. 35° 07.639' Long. 119° 50.561', at BL and MV lights, 9 March 2005, to 2400 hrs, K. H. Osborne. USNM ENT 148333. Deposited in USNM.

PARATYPES: CALIFORNIA: Same locality and date as type (6♂ 10♀): San Luis Obispo County, Carrizo Plain National Monument,

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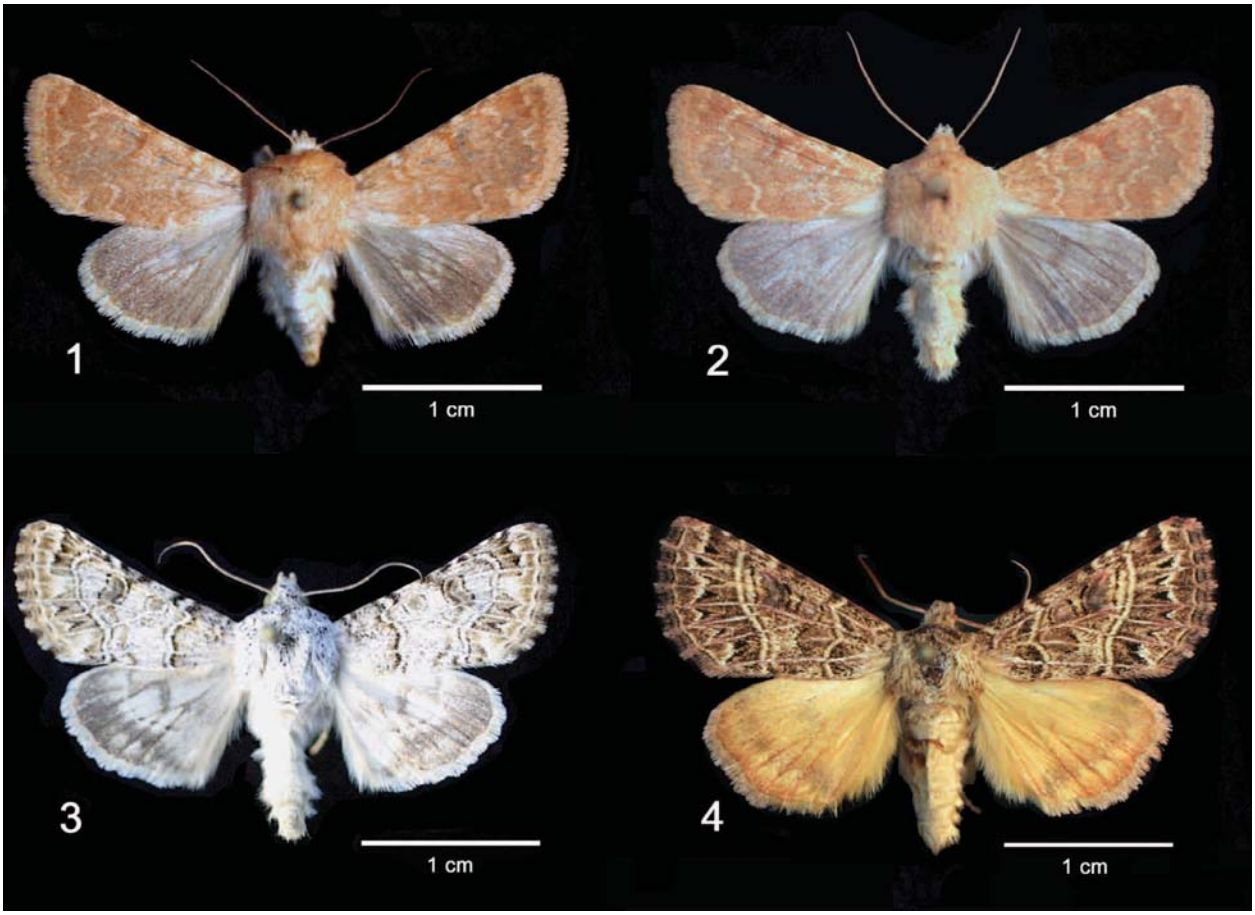

FIGS. 1–4. Adults. 1. *Schinia carrizoensis*, Holotype female. 2. *Schinia carrizoensis*, paratype male. California, San Luis Obispo County Co., Carrizo Plain National Monument, Caliente Range, 1 mi SE Painted Rock, 9 March, 2005. 3. *Schinia deserticola*, male, California, Imperial Co., Algadones Dunes, 7 mi. SE of Glamis, 6–7 March, 2005. 4. *Schinia mexicana*, male, Arizona, Cochise County, Huachuca Mountains, Copper Canyon, 0.5 mi S Montezuma Canyon Rd., 30–31 July, 2009.

FIG. 5. Noctuid larva found on *Ericameria linearifolia*, California, San Luis Obispo County Co., Carrizo Plain National Monument, Caliente Range, 1 mi SE Painted Rock, 2–3 April, 2006.

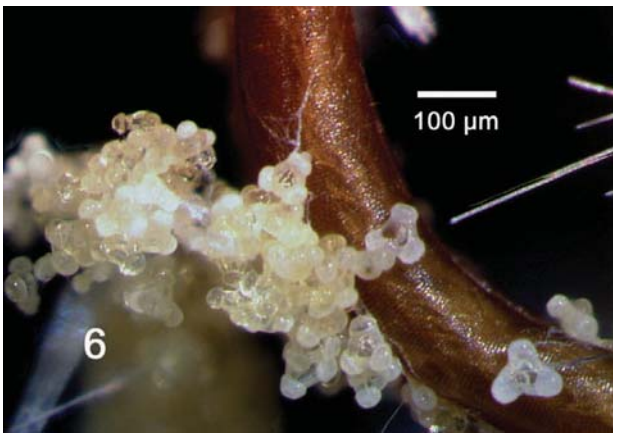

FIG. 6. Pollen on proboscis of *Schinia carrizoensis* (male of Fig. 2), California, San Luis Obispo County Co., Carrizo Plain National Monument, Caliente Range, 1 mi SE Painted Rock, 9 March, 2005.

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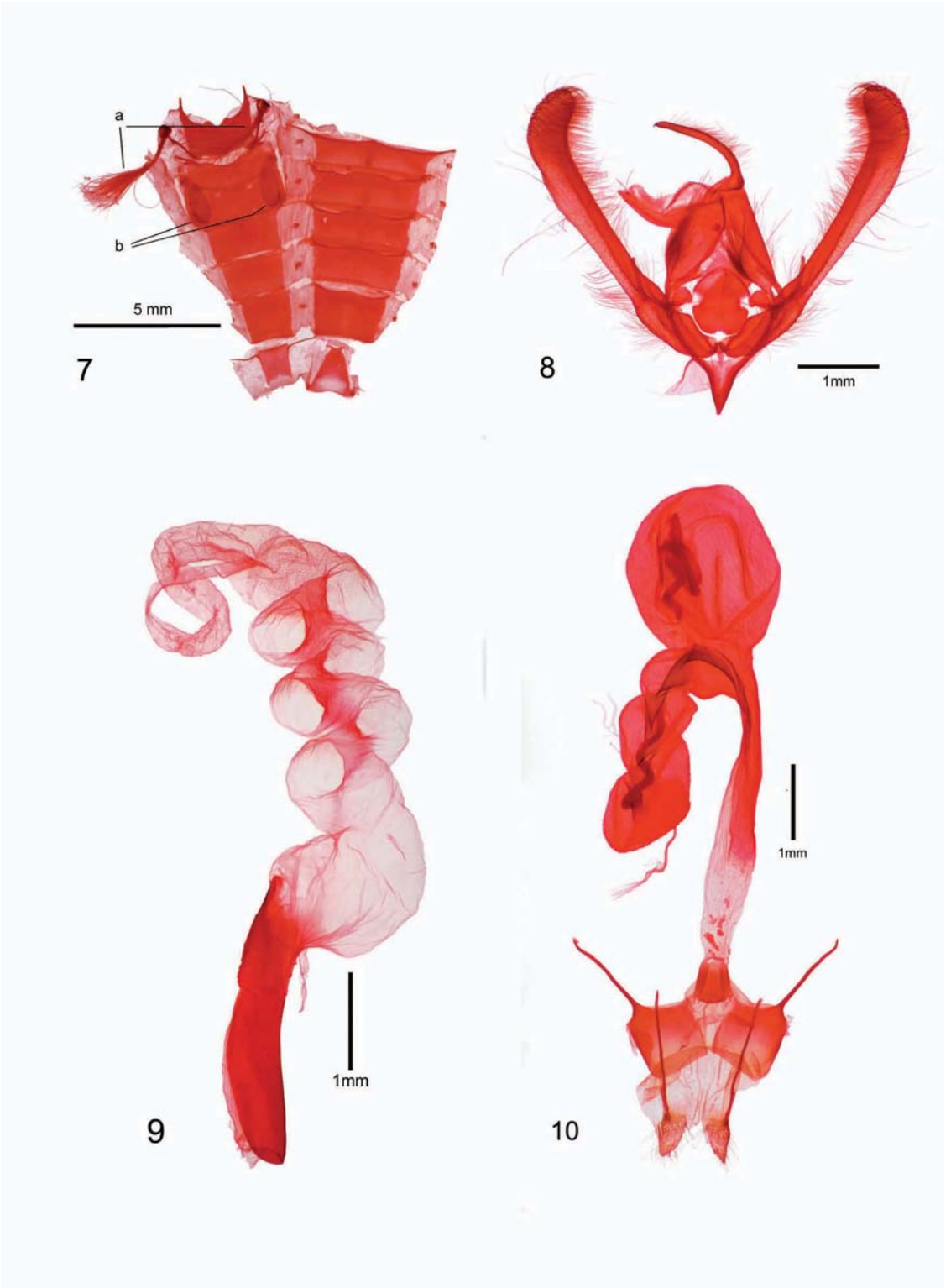

FIGS. 7–10. Genitalia. 7. *Schinia carrizoensis*, male, California, Santa Barbara County, Ballinger Cyn., abdomen, flattened, showing hair pencils (a) and associated scent pockets (b) on ventral second sternite, Genitalia slide USNM 51382. 8. Male genital capsule of same specimen. 9. Aedoeagus of same specimen. 10. *Schinia carrizoensis*, female, California, Santa Barbara County, Ballinger Cyn., Genitalia slide USNM 51383.

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Lat. 35.04644° N Long. 119.66029° W, at UV lights and traps. 29 March 2003, Thomas E. Dimock (1♂): San Luis Obispo County, Carrizo Plain National Monument, 2350' Lat. 35° 7.732' N Long. 119° 38.042' W, at UV lights and traps. 24 March 2008, David L Wikle and Peter Jump (1♂ 3♀): Santa Barbara County, Cuyama Valley, Deer Park Canyon 1.5 mi E Hwy 33, 3082 ft., 14 May 2005, Thomas E. Dimock (5♂): Santa Barbara County, Ballinger Cyn Rd, at National Forest boundary, 3025' Lat. 34° 52.851 N Long. 119° 27.194' W, at MV and UV light traps. 17 April 2009, David L Wikle (3♂ 2♀): Santa Barbara County, Ballinger Cyn Rd, east of National Forest boundary, 3070' Lat. 34° 52.983 N Long. 119° 26.952' W, UV light trap. 17 April 2009, David L Wikle (1♂).

Larval host plant: Unknown.

Etymology. The moth is named for the region from which specimens were collected.

Flight period. This species flies at least from early March to mid May.

Distribution (Fig. 11). Known only from southeastern San Luis Obispo County and adjacent northeastern Santa Barbara County, California, in the region of the Carrizo Plain and the southern Cuyama Valley. It is expected in adjacent Kern and Ventura Counties.

Diagnosis. Maculation subtle and lacking contrast. Head, thorax, upper forewing, with overall aspect of rust and tan coloration. The ground color is rusty-cream, maculation has elements with variable mixtures of cream, rust and light brown. Related *S. cupes*, *S. crotchii* Hy. Edw. and *S. deserticola* B. & McD all have ground colors of white or light gray with contrasting maculation of dark brown or dark gray.

DISCUSSION.

The pattern of maculation in *S. carrizoensis*, although subtle and colored differently, is homologous with and identical to the pattern of maculation in *S. deserticola* (Fig 3), *S. cupes*. and *S. crotchii*, indicating membership in the *S. cupes* species complex. Due to the subtlety of maculation, worn specimens would be more difficult to place with the *S. cupes* complex. Like all others of this species complex, *S. carrizoensis* is nocturnal and easily attracted to light.

A few interesting observations may facilitate further investigation of the *S. carrizoensis* host association. One male specimen of *S. carrizoensis* has pollen with fine threads entangled on the proboscis (Fig. 6). This pollen was carefully examined under magnification and compared with similar pollen and fine threads also entangled on the proboscis of a specimen of *S. deserticola* from Riverside County, CA. These pollen samples appear to be indistinguishable and compare very well with pollen of *Camissonia* Link (Onagraceae) specimens examined at the U. C. Riverside Herbarium. The strands or threads associated with this pollen are diagnostic of Onagraceae (Andy Sanders pers. comm.). Since both *S. deserticola* and *S. cupes* use Onagraceae (*Camissonia* and *Calylophus* Spach respectively) (Hardwick 1996; Pogue & Harp 2003a), it appears plausible that *S. carrizoensis* may use *Camissonia* as larval host. However, *Camissonia* is the

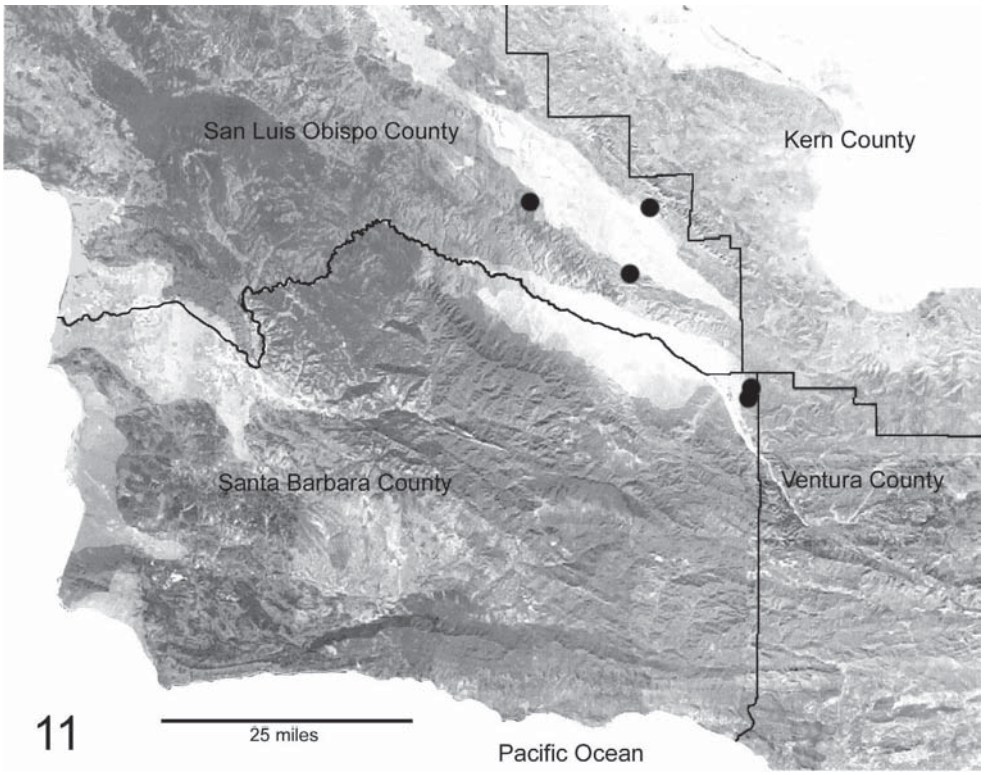

Figure 11. Map of central California showing distribution (black dots) of *Schinia carrizoensis*.

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most abundant Onagraceous plant on the Carrizo Plain, and may merely function as a nectar source for *S. carrizoensis*.

Nocturnal noctuid larvae, suspected as potential *Schinia* larvae, were found by the author (but not successfully reared) 2–3 April 2006 (Fig. 5) at the type locality, feeding on flowers of *Ericameria linearifolia* (DC.) Urbatsch & Wussow (Asteraceae), an abundant shrub at the site. This is a host not previously recorded for any *Schinia* and the phenology of these larvae and flowers are appropriate for *S. carrizoensis*. *Castilleja exserta* (A. A. Heller) Chuang & Heckard (Scrophulariaceae), host to related *S. crotchii* (Hardwick 1996), also occurs in abundance at the type locality of *S. carrizoensis*.

Regarding host associations among species of the *S. cupes* complex, a number of confusing editorial errors (Harp pers. comm.) from the work of Pogue & Harp (2003a) warrant clarification: Hardwick 1996 correctly associated *C. crotchii* with, and reared this on *Castilleja exserta* [as *Orthocarpus purpurascens* Benth.] (Scrophulariaceae).

I include *Schinia mexicana* (Hampson) with the *S. cupes* species complex due to substantial, apparently homologous, similarities in maculation among its congeners in the complex. Pogue (pers. comm.; Pogue & Harp 2003a) removed *S. mexicana* from the group based on anomalous proportional differences in genitalic anatomy (broad male valve of *S. mexicana*) and cites the preponderance of pattern convergence in lepidopteran maculation. Alternatively, I contemplate the prospect of these genitalic differences to be potentially more superficial (for their taxonomic implications) and derived from the interaction of more profound evolutionary selective pressures acting indirectly on linked male and female genitalic structure through (perhaps and for example) hostplant imposed pressures on female ovipositor structure. If female *S. mexicana* genitalic and ovipositional structures have been evolutionarily modified to accommodate some peculiarity of host inflorescence, then the male genitalic structure may be forced to concurrently track the female changes—perhaps in ways we cannot yet understand. With respect to patterns of forewing maculation, the *S. mexicana* duplication of every detail found generally in the *S. cupes* complex: Sinuate patterns of the antemedial, postmedial, and subterminal lines; same patterns and arrangements of various irregular medial, subcostal, costal, and apical markings (see Figs. 1–4), argue to me that these similarities are more probably congeneric and species group homologies rather than convergence by evolutionary coincidence. With *S. mexicana*, the *S. cupes* complex includes five species.

KEY TO SPECIES OF THE *SCHINIA CUPES* COMPLEX

1. Forewing with dirty white, gray or light brown background, maculation with contrasting light gray or white and dark gray, brown or black elements; many dark brown to black tipped spatulate scales on dorsal thorax; lateral foretibia with three to five stout spines.....2
1'. Forewing predominantly of mixed tan, rust or golden brown color.....4
2. Forewing ground color white to dirty white; maculation light gray (Fig. 3); lateral foretibia with three stout spines, hair pencils in the male abdomen are present; ventral margin of papillae anales angulate; hostplant *Camissonia claviformis* (Torr. & Frem.) Raven (Onagraceae), of desert and arid environments SE Oregon to Utah and south through Arizona, SE California, and northern Mexico.....*deserticola*
2'. Forewing ground color light brown with most maculation contrasting whitish against dark browns, grays and black; lateral foretibia with three to five, usually four stout spines; central hair pencils in the male abdomen may be present or absent; ventral margin of papillae anales with the ventral margin straight.....3
3. Hair pencils in the male abdomen present; distribution Colorado and New Mexico, and east; may be associated with *Calylophus berlandieri* Spach (Onagraceae).....*cupes*
3'. Hair pencils in the male abdomen absent; Utah, Idaho, west to California and northern Baja California Mexico; may be associated with *Castilleja exserta* (Scrophulariaceae).....*crotchii*
4. Maculation of mixed dark brown or golden brown color, tan markings contrasting (Fig. 4); upper hindwing predominantly golden brown with darker marginal markings; lateral foretibia with one stout spine; male valve not elongate, length approximately 3x width; southeastern Ariz., central and southern Mexico.....*mexicana*
4'. Maculation of mixed tan and rust color, markings subtle and subdued (Figs. 1–2); upper hindwing of predominantly dark gray; lateral foretibia with three (sometimes two) stout spines; male valve elongate, length greater than 5x width; interior coast range of central California.....*carrizoensis*

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OVIPOSITION PREFERENCE AND NUTRITIONAL INDICES OF *PAPILIO POLYTES* L. (PAPILIONIDAE) LARVAE ON FOUR RUTACEOUS (SAPINDALES: RUTACEAE) HOST PLANTS

SUWARNO

School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia; Present Address: Department of Biology, Faculty of Science, University Syiah Kuala, 23111 Banda Aceh, Indonesia

M.R. CHE SALMAH

School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia; email: csalmah@usm.my

ARSHAD ALI

University of Florida, IFAS. Mid-Florida Research & Education Center, 2725 Binion Road, Apopka, FL 32703-8504

AND

A. ABU HASSAN

School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia

ABSTRACT. Oviposition preference and larval developmental performance of the butterfly, *Papilio polytes* L. on four rutaceous host plants, *Citrus aurantifolia* (Chrism.) Swing, *Citrus reticulata* Blanco, *Citrus hystrix* DC, and *Murraya koenigii* (L.) Sprengle, were investigated in outdoor cages. Maxima of eggs were laid on *C. reticulata*, followed by *C. aurantifolia*, but the numbers laid on the two host plants were not significantly different from each other; however, these numbers differed significantly ($F = 155.70$; $P < 0.01$) from those laid on *C. hysrix* and *M. koenigii*; the last host plant was the least preferred for egg laying. Leaves were significantly the preferred site (and in turn the underside of leaves) over stems for deposition of eggs in all host plants; negligible number of eggs was also laid on plant pots. The duration of 5th instar larval development was the shortest on *C. reticulata* and significantly different ($P < 0.01$) from that on *M. koenigii*, but did not differ significantly between the three *Citrus* species. The nitrogen content in leaves of all four host plants differed significantly ($P < 0.01$), with *C. reticulata* containing 4.52%, followed by *C. aurantifolia* (4.37%), *C. hystrix* (4.29%), and *M. koenigii* (3.73%), while the water content of leaves was significantly the lowest in *M. koenigii* (71.72%), compared to the three *Citrus* species (76.38–79.12%) among which the water content did not significantly differ. Relative consumption rate (RCR) and fecal dry weight of 5th instar larvae feeding on *M. koenigii* were the highest and significantly different ($P < 0.01$) from the other three host plants. Pupal dry weight, relative growth rate (RGR), efficiency conversion of digested food (ECD), efficiency conversion of ingested food (ECI) of *M. koenigii* were significantly lowest compared to the three *Citrus* species. The values of RGR, ECD, and ECI of the 5th instar larvae were similar for the three *Citrus* species; the approximate digestibility (AD) values were similar for all four host plants. This study shows that *C. reticulata* was the best host plant among the three *Citrus* spp. and *M. koenigii* was the least preferred.

Additional key words: Oviposition, larval performance, nutrition indices, host plant

The common mormon butterfly, *Papilio polytes* L. (Lepidoptera: Papilionidae) is a tropical or subtropical papilionid butterfly distributed from Southeast Asia to the Southwestern Islands of Japan (Corbet & Pendlebury 1992; Nakayama *et al*. 2003; Nakayama & Honda 2004). *Papilio polytes* is known to feed on various genera of Rutaceae, such as *Murraya, Triphasia, Glycosmis, Aegle, Zanthoxylum, Toddalia, Euodia, Atalantia* and *Poncirus* in the forests (Corbet & Pendlebury 1992). In recent years, this butterfly has adapted to the urban/suburban environments and is found to feed on citrus plants (Corbet & Pendlebury 1992); this feeding adaptation has made P. *polytes* a potentially serious pest in citrus orchards.

In Lepidoptera, host plant selection for larval development and propagation is commonly assumed to be the prerogative of the ovipositing female (Singer 1984; Udayagiri & Mason 1995). Based on this assumption, many studies have been conducted on the relationship between adult host preference and larval performance (Singer 1984; Nylin & Janz 1993; Berdegue *et al*. 1998; Jallow *et al*. 2001; Forister 2004).

In phytophagous insects, larval growth and longevity as well as fecundity of the adult are influenced by the nutritional value of the host plants (Bernays & Chapman 1994). Larval development and survival depend on the food quality determined by nutrient content and the presence of secondary compounds. The

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food quality affects larval developmental time as well as larval mass. A quantitative analysis of the consumption and utilization of host plants by herbivorous insects is a commonly used tool in studies of plant-insect interactions (Scriber & Slansky 1981). For these herbivores, time to achieve pupation and pupal mass are good measures of the suitability of a particular host plant (Penz & Araujo 1990).

Understanding the host plant selection behavior and the effects of various host plant species on growth and larval performance of *P. polytes* is an important prerequisite for developing pest management strategies for this insect (Nylin & Janz 1996; Janz & Nylin 1997; Barros & Zucoloto 1999; Catta-Preta & Zucoloto 2003). In the present study, the oviposition preference of *P. polytes* on three species of commercially grown citrus [*Citrus aurantofolia* (Christm.) Swing., *Citrus hystrix* DC. and *Citrus reticulata* Blanco] and a commonly domesticated spicy leaf rutaceous species, *Murraya koenigii* (L.) Sprengel was evaluated and the life cycle of this butterfly on four rutaceous host plants was studied. The performance of *P. polytes* larvae on the host plants in terms of nutritional indices was also assessed.

MATERIALS AND METHODS

Host plants. Selection of the rutaceous host plants for this study was based on their potential value as commercial plants. Three commercially grown citrus species, *C. aurantifolia*, *C. hystrix* and *C. reticulata*, and a partially domesticated spicy leaf species, *M. koenigii*, popularly used as an ingredient (curry leaf) in local food in Malaysia were selected. The citrus seedlings were supplied by a local nursery in Penang, Malaysia, while *M. koenigii* seeds were collected from wild plants in Penang, and planted in the nursery at the School of Biological Sciences, Universiti Sains Malaysia (USM), Penang, Malaysia. The young seedlings of citrus and *M. koenigii* were planted in plastic bags (25 cm diameter and 35 cm high) containing a 3:1:1 mixture of podsolic, compost, and manure, respectively. Each plant was fertilized on fortnightly basis with a half-teaspoonful of artificial fertilizer and 100 g manure.

The insect. Larvae of *P. polytes* were collected in July 2005 from citrus trees at the USM main campus in Penang. The collected larvae were reared in the laboratory on *Citrus microcarpa* to avoid potentially confounding effect of dietary history on host plant preference. The larvae were placed in a screen cage measuring 50 × 50 × 50 cm and were maintained at 24–26 °C, 60–85% relative humidity, and a photoperiod of L12:D12, until emergence. The emerged *P. polytes* adults were transferred to a field cage (2 × 2 × 2 m) to facilitate mating and oviposition. Flowers of *Ixora* sp. collected from the plants at USM campus were supplied as food for the caged adult *P. polytes*. The flowers contained in a glass jar filled with water were sprayed with 10% sucrose solution twice daily to ensure sufficient provision of nectar and placed in the cage; they were replaced with fresh flowers every three days.

Oviposition preference. Four plastic bags with each containing one seedling (50–60 cm high) of the four host plant species were placed opposite to each other in an experimental cage measuring 2 × 2 × 2 m. The plants were positioned one meter apart and any one plant was at least 50 cm away from the wall of the cage. Two pairs (2 males and 2 females) of newly emerged *P. polytes* were introduced into the cage. The number of eggs laid by the females on each host plant was recorded daily, until the females died. The host plants were replaced daily with fresh new plants. In this experiment, one cage represented one replication; the experiment was repeated 10 times (Greenberg *et al*. 2002; Nansen & Phillips 2003; Smyth *et al*. 2003).

Duration of immature stages. The eggs laid on each of the four host plants were recovered and were placed in four respective petri dishes (10 cm diameter), each dish layered with a wet tissue paper. Each petri dish contained 50 eggs. A plastic screen cover with a ventilation window made of fine wire (2 × 2 cm) was placed over each petri dish. The duration of the egg stage on each host plant was noted from the time of egg laying to hatching of first instar larva. Thirty newly hatched active larvae from each petri dish were selected and were reared individually on each of the four respective host plants serving as treatment. For this, a total of 120 cages (each 50 × 50 × 50 cm) were used, with 30 separate cages employed for each host plant. For example, for *C. reticulata*, 30 cages were used with each cage containing a newly hatched *P. polytes* larva placed on a young *C. reticulata* twig (two leaves) cut from a mother plant and placed in a bottle (one cm diameter, 10 cm high) filled with water. In this manner, newly hatched *P. polytes* larvae were individually reared on each of the other three host plants as well. As for *M. koenigii*, the larvae were provided with a young twig with four to five leaves. The leaves in each bottle were daily replaced with fresh leaves. Observations were made daily for the duration of larval stages and the data recorded until the larvae metamorphosed to the pupal stage. The duration of pupal stage was also recorded. These observations were replicated thirty times for each host plant.

Larval nutritional indices. This experiment was conducted using fifth instar *P. polytes* larvae. Newly moulted 5th instars were reared individually on a twig of respective host plant in a screen cage (50 × 50 × 50 cm).

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Weight of each larva and the host plant twig were recorded prior to releasing the larva on the twig. The host plant twig in the cage was placed in a bottle filled with water to maintain its vigour. The host plant twigs were replaced daily with fresh twigs from respective hosts. Unconsumed twig and the larval faeces were collected daily and dried in an oven at 60°C for seven days (Suwarno 1999). The experiment was continued until pupation of the larva. The prepupa was subsequently collected and dried in the oven at 60°C for seven days. All dry weights of the above components recorded for each host plant were used to calculate the nutritional indices for each host plant according to Slansky & Scriber (1985) as follows:

i) Relative Consumption Rate (RCR) = F/HT (gram/day)
ii) Relative Growth Rate (RGR) = G/HT (gram/day)
iii) Efficiency of Conversion of Digested food (ECD) = G/F-E × 100%
iv) Efficiency of Conversion of Ingested food (ECI) = G/F × 100%
v) Approximated Digestibility (AD) = F-E/F × 100%.

where G = additional larval weight; F = weight of consumed food; E = faeces weight; H = mean of larval weight [(the initial weight + the final weight)/2]; and T = duration of fifth instar larva.

Nitrogen content of host plant leaves. One hundred grams young leaves of each of the four experimental host plants were analyzed in the laboratory for nitrogen content using the standard micro Kjeldahl method (Hwang & Feng 2004; Eaton *et al*. 2005).

Water content of host plant leaves. Twenty young leaves from each *Citrus* species and *M. koenigii* host plants were collected. All leaves of each species were separately weighed for wet weight (WW) and dried in an incubator at 80°C for 24 h and then weighed again for dry weight (DW). The water content of leaves of each species was calculated as percentage (WW – DW/WW) × 100% (Barros & Zucoloto 1999).

Data analysis. Oviposition preference of *P. polytes* for the host plants, its development (life stage) on the hosts and the larval nutritional indices related to the host plants were evaluated using the one-way analysis of variance (ANOVA). When significant F value was indicated, means associated with each variable of the host plant were further separated using the Tukey's test (Rao 1998). All data were analyzed using the SPSS software version 12 (Dytham 2003; Pallant 2005).

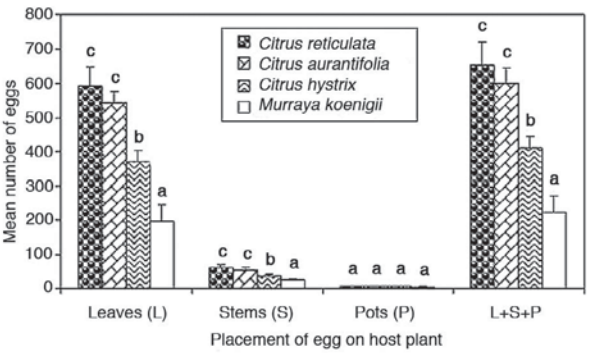

FIG. 1. Mean number of *Papilio polytes* eggs laid on leaves (L), stems (S), and pots (P) and on total plant, including pots (L+S+P) of host plants. Means accompanied by a different letters are significantly different ($P < 0.01$; Tukey's test).

RESULTS

Nitrogen and water content of host plants. The nitrogen as well as water content in the leaves of *M. koenigii* were the lowest and significantly different ($F_{3,8} = 7.198$, $P < 0.01$) from all three *Citrus* spp. analyzed. Nitrogen content in the leaves of *C. reticulata* was the highest and significantly different from the other two citrus species; however, the water content in the leaves of all three citrus species was somewhat similar (Table 1).

Oviposition preference. The number of eggs laid on *C. reticulata* was found to be the highest and significantly different ($P < 0.01$) from the numbers laid on *C. hystrix* and *M. koenigii*, but not significantly different from the numbers laid on *C. aurantifolia*. Between *C. hystrix* and *M. koenigii*, the former host plant was preferred by *P. polytes* as significantly more ($F_{3,36} = 155.70$, $P < 0.01$) eggs were laid on *C. hystrix*. Leaves were a preferred site for egg deposition as more eggs were observed on leaves of all host plants, whereas relatively small numbers were laid on the stems, and those deposited on the pots were negligible (Fig. 1).

TABLE 1. Values of nitrogen and water content (mean ± SE) in leaves of four different rutaceous host plants of *Papilio polytes* butterfly. Means in the same column followed by a different letters are significantly different (P < 0.01; Tukey's test). All n = 3.

Host plant	Nitrogen content (%)	Water (%)
Citrus aurantifolia	4.37 ± 0.01c	78.47 ± 1.03b
Citrus hystrix	4.29 ± 0.01b	76.38 ± 0.79b
Citrus reticulata	4.52 ± 0.01d	79.12 ± 1.55b
Murraya koenigii	3.73 ± 0.01a	71.72 ± 1.46a

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TABLE 2. Duration (mean no. of days ± SE) for development of immature stages of *Papilio polytes* reared on four different rutaceous host plants. Means in the same column followed by different letters are significantly different ($P < 0.01$; Tukey's test). All $n = 30$.

	Mean ± SE duration of stages (days)		
Host plant	Larva	Pupa	Total period *
Citrus aurantifolia	15.30 ± 0.19 a	9.90 ± 0.09 ab	29.20 ± 0.24 ab
Citrus hystrix	14.73 ± 0.13 a	10.13 ± 0.09 b	28.87 ± 0.17 ab
Citrus reticulata	14.63 ± 0.22 a	9.77 ± 0.09 a	28.40 ± 0.25 a
Murraya koenigii	16.13 ± 0.30 b	9.60 ± 0.09 a	29.73 ± 0.32 b

* Including eggs incubation period

Among the host plants, the number of eggs on the leaves and stems of *C. reticulata* were the highest and significantly different ($F_{leaves} = 160.04$, df = 3,36, $P < 0.01$; $F_{stems} = 40.04$, df = 3.36, $P < 0.01$) from those laid on *C. hystrix* and *M. koenigii*. There was no significance difference ($P > 0.05$) between the numbers of eggs on the pots on all host plants (Fig. 1).

Duration of larval and pupal stages. *Papilio polytes* required 28.40 to 29.73 days to complete their life cycle from egg to adult. All eggs hatched after three days. The larval development was completed in 14.63–16.13 days. There was a prepupal stage that lasted for only a day. The pupae took 9.6 to 10.13 days before adult emergence. Host plant had an effect on feeding period ($F_{larva} = 9.887$, df = 3,116, $P < 0.01$), pupal period ($F_{pupa} = 6.145$, df = 3,116, $P < 0.01$) and the duration of immature stages *P. polytes* ($F_{total} = 4.25$ df = 3,116, $P < 0.01$). The shortest immature period (egg until emergence, 28.40 ± 0.25 days) was recorded on *C. reticulata*. The duration of immature on *C. reticulata* was significantly shorter ($P < 0.01$) than on *M. koenigii* (29.73 ± 0.32 days), but not significantly different from those on other *Citrus* species. However, there was no significant difference in developmental time of immature stages among *P. polytes* reared on *C. aurantifolia*, *C. hystrix* and *M. koenigii* (Table 2).

Papilio polytes spent the longest larval period on *M. koenigii*, which was significantly longer compared to all other host plants. Among the citrus species, the larval developmental period on *C. reticulata* was the shortest, but on *C. aurantifolia* and *C. hystrix* there was no significant time difference. The duration of pupal stage of *P. polytes* on *M. koenigii* was significantly shorter than that on *C. hystrix*, but no significant difference was detected in time duration of pupal stage on *C. aurantifolia* and *C. reticulata* (Table 2).

Larval nutritional indices. The fifth larval stadium of *P. polytes* was the longest in term of developmental time and its fecal dry weight was the highest when reared on *M. koenigii*. Similarly, the duration of pupal stage on *M. koenigii* was the longest and significantly different from all three *Citrus* species (Table 3). In contrast, the pupal dry weight of *P. polytes* developed on *M. koenigii* was the lowest and significantly different from the other three host plants (Table 3).

Table 4 shows the values of various parameters of *P. polytes* larval nutritional indices on the four host plants. The relative consumption rate (RCR) of *P. polytes* reared on *M. koenigii* was the highest but the values of relative growth rate (RGR), approximate digestibility

TABLE 3. Duration (mean ± SE) for *Papilio polytes* 5th instar larval development, its fecal dry weight and pupal dry weight, when fed on four different rutaceous host plants. Means in the same column followed by a different letters are significantly different ($P < 0.01$; Tukey's test). All $n = 20$.

Host plant	5th instar duration (mean ± SE, days)	Fecal dry weight (mean ± SE, grams)	Pupal dry weight (mean ± SE,grams)
Citrus aurantifolia	5.40 ± 0.11 a	0.76 ± 0.03 a	0.19 ± 0.005 b
Citrus hystrix	5.35 ± 0.17 a	0.76 ± 0.03 a	0.19 ± 0.003 b
Citrus reticulata	5.30 ± 0.13 a	0.78 ± 0.03 a	0.20 ± 0.003 b
Murraya koenigii	6.05 ± 0.15 b	0.91 ± 0.04 b	0.15 ± 0.003 a

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TABLE 4. Values of mean ± SE parameters of nutritional indices, relative consumption rate (RCR), relative growth rate (RGR), efficiency of conversion of digested food (ECD), efficiency of conversion of ingested food (ECI), and approximated digestibility (AD) of 5th instar Papilio polytes reared on different host-plants. Means in the same column followed by a different letters are significantly different ($P < 0.01$; Tukey's test). All $n = 20$.

Host plant	RCR ($g.g^{-1}.d^{-1}$)	RGR ($g.g^{-1}.d^{-1}$)	ECD (%)	ECI (%)	AD (%)
C. aurantifolia	1.84 ± 0.06 a	0.23 ± 0.01 b	38.54 ± 2.19 b	12.87 ± 0.30 b	34.88 ± 1.45 a
C. hystrix	1.96 ± 0.06 a	0.25 ± 0.01 b	34.68 ± 2.06 b	12.51 ± 0.28 b	37.77 ± 1.70 a
C. reticulate	1.88 ± 0.04 a	0.25 ± 0.01 b	40.63 ± 1.76 b	13.14 ± 0.28 b	33.53 ± 1.64 a
M. koenigii	2.32 ± 0.04 b	0.19 ± 0.01 a	25.04 ± 0.93 a	8.19 ± 0.22 a	33.23 ± 1.17 a

(AD), efficiency of conversion of digested food (ECD), and efficiency of conversion of ingested food (ECI) were the lowest and significantly different compared with those on all citrus species. However, the approximate digestibility (AD) was not significantly different among the four host plants. All studied parameters of nutritional indices of *P. polytes* larvae reared on three citrus species were not significantly different from each other (Table 4).

DISCUSSION

Oviposition and larval developmental performance of herbivorous insects are determined by the nutritional content of the host plants selected by the female. This study showed that *P. polytes* females preferred to oviposit the most on *C. reticulata* compared to other host plants; *M. koenigii* was the least preferred host. In several earlier studies, the host plants which had higher nitrogen content were shown to be the most preferred hosts (Udayagiri & Mason 1995; Hwang & Feng 2001; Kid & Orr 2001; Wheeler 2003; Chen *et al*. 2004; Moreau *et al*. 2006). In the present study, results of leaf analysis revealed higher nitrogen and water levels in *Citrus* spp. than in *M. koenigii*. These underlying properties presumably attracted the female to prefer *Citrus* spp. over *M. koenigii*. Among the three *Citrus* species, *C. reticulata* had the highest nitrogen and water contents; consequently, the larval developmental period of *P. polytes* reared on *C. reticulata* was shorter than on *C. aurantifolia* and *C. hysterix*. The butterfly spent the longest larval developmental period on *M. koenigii*.

The nitrogen content of leaves of *M. koenigii* was relatively lower (3.73%) than that of *C. reticulata* (4.52%), *C. aurantifolia* (4.37%) and *C. hystrix* (4.29%). Consequently, the developmental period of fifth instar larva of *P. polytes* reared on *M. koenigii* was relatively longer than those reared on *C. aurantifolia*, *C. hystrix*, and *C. reticulata*.

Many factors could have influenced the oviposition behavior of *P. polytes* on the host plants, such as the texture, nutrition and chemical compounds of the host plant leaves. Morphologically, the upper surface of *Citrus* spp. leaves was smoother than *M. koenigii* leaf. However, nutritional and chemical contents of the host plants have been reported to be more important for purposes of oviposition and food preference by adult female butterfly and its larvae (Portillo *et al*. 1996; Barros & Zucoloto 1999; Ulmer *et al*. 1996; Smyth *et al*. 2003; Chen *et al*. 2004). In several laboratory experiments, the nitrogen and water contents of the leaf were found to be useful for prediction of upper limits of larval developmental performance (Scriber & Slansky 1981; Simpson & Simpson 1990; Ojeda-Avila *et al*. 2003). For instance, the nutrient content of the host plant—especially protein—has been reported to determine growth and larval performance of several insects, such as *Manduca sexta* (Lepidoptera: Sphingidae) (Ojeda-Avila *et al*. 2003), *Oxyops vitiosa* (Coleoptera: Curculionidae) (Wheeler 2003), *Pieris rapae crucivora* and *P. candida candida* (Lepidoptera: Pieridae) (Chen *et al*. 2004) and *Orius albidipennis* (Heteroptera: Anthocoridae) (Groenteman *et al*. 2006), on their respective host plants.

Besides nutrient contents, Nakayama & Honda (2004) found that contact chemical stimuli from the host plants play the decisive role at the final step of egg laying process. The compound *trans*-4-hydroxy-*N*-methyl-L-proline and 2-C-methylerythronic acid have been identified as oviposition stimulants for *P. polytes* from the host plant, *Toddalia asiatica*. Meanwhile, a compound identified as trigonelline (*N*-methylpyridine-3-carboxylic acid) from *Murraya paniculata*, exhibited moderate oviposition deterrence to female *P. polytes*.

In many *Papilio* butterflies, extreme synergism of multiple components has been reported to feature in their stimulatory system of oviposition (e.g., Nishida *et al*. 1990; Ohsugi *et al*. 1991; Nishida 1995; Ono *et al*. 2000a, b; Nakayama *et al*. 2002, 2003; Nakayama & Honda 2004). Nakayama *et al*. (2003) found that oviposition response of *P. polytes* to a 5% concentration of the chemical compound, *trans*-4-hydroxy-*N*-methyl-L-proline (HMP) from *Toddalia asiatica*, was 34.8%;

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this response increased to 70.8% even at much lower concentration (0.25%) of HMP after the addition of an equivalent amount of acidic fraction from the same host, although 2-C-methyl-D-erythronic acid (MEA), isolated from acidic fraction of *T. asiatica* was almost inactive in itself (response below 10%). The combination of higher and lower amounts of HMP and MEA (0.4% and 0.1%, respectively) strongly stimulated oviposition by females of *P. polytes* to 95.3% response. The results suggested that *P. polytes* females make use of at least two simple compounds as the crucial chemical cues in recognizing *T. asiatica* as a host.

During this investigation, the lowest oviposition preference of female of *P. polytes* was on *M. koenigii*. This condition may be attributed to the presence of some chemical compound that could act as oviposition deterrents. In an earlier study, Nakayama & Honda (2004) found that trigonelline, a chemical compound isolated from *Murraya paniculata* foliage was responsible for the avoidance of *M. paniculata* by *P. polytes* females. Interestingly, although trigonelline deterred egg-laying process, the compound had no inhibitory effects on larval feeding. It is likely that *M. koenigii* contains this compound, which makes it less preferred by the ovipositing *P. polytes*.

The oviposition preference of *P. polytes* in the present study was indicated by placement of offspring by the female on the most suitable host plant. The larvae of *P. polytes* reared on all three *Citrus* spp. performed much better in term of development than those on *M. koenigii*. The dry weights of pupae developing on *Citrus* spp. were higher than the pupa developed on *M. koenigii* and this probably was a consequence of higher nitrogen content of the *Citrus* host plants compare to *M. koenigii*. It was observed earlier in Taiwan that the pupal weight of *Daphnis nerii* L. (Lepidoptera: Sphingidae) from the larvae fed on periwinkle Madagascar (*Chatharanthus roseus*) containing 3.86% nitrogen was significantly higher than those fed on yellow oleander (*Thevetia peruviana*) that contained 2.44% nitrogen (Hwang & Feng 2001). Wheeler (2003) found that the biomass of the prepupa, pupa, and adult of *Oxyops vitiosa* (Coleoptera: Curculionidae) was greater when fed on leaves that were fertilized with high N2 fertilizers compared to the unfertilized leaves with N2.

The water and protein contents of the host plant are extremely important to herbivore insects. Low amount of water and protein will result in low values of RGR, ECD and ECI, reflecting poor growth, and reduced efficiencies of digestion and ingestion, respectively. As observed in *M. koenigii* in the present study, the values of RGR, ECD and ECI were the lowest and correlated to its lower water and protein contents, compared to the three *Citrus* species. Scriber & Slansky (1981) reporting on the performance of *Papilio polyxenes* on several Umbeliferae hosts showed that it was closely paralleled to the nitrogen and water contents (2.0–4.5% and 66–89%, respectively) of the host leaves with an extremely strong correlation between ECI and leaf nitrogen. Furthermore, Barros & Zucoloto (1999) found that the pupal weight, ECD and ECI of *Ascia monuste* (Lepidoptera: Pieridae) larva living on *Brassica oleracea* (4.58 % nitrogen) were higher than those feeding on *Brassica juncea* (3.13 % nitrogen).

The value of ECI is strongly influenced by nitrogen content of the host plant because nitrogen is efficiently converted into body tissue of the larva. Low value of ECI is mainly due to decrease of ECD rather than AD because ECI and ECD are closely related to growth. Low nitrogen content in the food results in increase of RCR which consequently decreases the ECI. Furthermore, AD and ECD have also been found to vary inversely on the same food under different regimes of deprivation, but these results are confounded by differences in RCR (Simpson & Simpson 1990).

Papilio polytes larvae developing on *M. koenigii* took more food (higher RCR) than those reared on the three *Citrus* spp. host plants. The fifth larval stadium developmental time was longer; consequently the fecal dry weight was also heavier on *M. koenigii*. In contrast, the pupal dry weight was the lowest on *M. koenigii* compared with the other three *Citrus* spp. plant hosts. In a study with *Tyria jacobaeae* (Lepidoptera: Arctiidae), Tinney *et al*. (1998) found that the larval development time was negatively correlated to plant nitrogen content, whereas the larval weight, growth rate, and pupal weight were positively correlated to plant nitrogen content. Henriksson *et al*. (2003) also reported that low concentrations of water and nitrogen were the main factors reducing pupal mass of *Epirrita autumnata* (Lepidoptera: Geometridae).

More food intake (RCR) does not automatically increase the RGR because other factors, such as nutrient contents especially protein and water content contribute to the RGR. For example, the consumption rate of *O. vitrosa* larvae feeding on *Melaleuca quinquenervia* receiving low dose of fertilizer increased compared with the larvae feeding on *M. quinquenervia* receiving the higher dose of the fertilizer, but the biomass of pupae and adults on lower dose fertilizer was lower (Wheeler 2003). The digestion of food (AD, ECI, and ECD) also strongly affects the RGR. Ingested nutrients must meet an insect's requirement for growth and other metabolic processes. In this relationship, the amount of nutrients allocated to tissue growth and

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storage represents the growth target, and the intake targets is the amount the insect must consume in order to meet its growth and metabolic needs (Simpson & Raubenheimer 1995 cit. Telang *et al*. 2001). Wheeler (2003) also found that larvae fed on leaves from highly fertilized plants converted absorbed food more efficiently to insect biomass than those fed on less fertilized plants.

The *P. polytes* larval AD values on all four host plants in the present study were not significantly different from each other. It was assumed that all these host plants were equally suitable for the larval development and none of them has chemical compound that could obstruct the digestive process. Scriber & Slansky (1981) reported that the value of AD was lower in the presence of higher content of fiber, lignin, tannin, waxes or silica. The decline of AD especially for leaf chewers is often associated with less selective feeding by later instars. Summarizing all nutrition indices Scriber & Slansky (1981) suggest that: RGR = RCR × ECI and ECI = AD × ECD.

In summary, this study has shown a positive relationship between oviposition preference and larval developmental performance of *P. polytes*. The host plant oviposition preference hierarchy of *P. polytes* corresponds to nutritive value of the potential host plant selected for oviposition. Larval developmental performance was better when fed on plants (*Citrus* spp.) with higher nutritive values than those fed on lower nutritive value (*M. koenigii*); the hierarchy of oviposition preference of *P. polytes* on the studied host plants was *C. reticulata* ≥ *C. aurantifolia* > *C. hystrix* > *M. koenigii*.

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HISTORICAL RECORDS OF THE BUTTERFLY FAUNA AT A COASTAL SAGE SCRUB SITE IN SOUTHERN CALIFORNIA, USA

EDWARD PFEILER

Centro de Investigación en Alimentación y Desarrollo, A.C., Unidad Guaymas, Apartado, Postal 284, Guaymas, Sonora C.P. 85480, México; email: pfeiler@ciad.mx

AND

PETER M. JUMP

12727 Koenigstein Road, Santa Paula, California 93060, USA

ABSTRACT. Surveys of the butterfly fauna at single sites in endangered coastal sage scrub (CSS) habitat in southern California are rare. Here we resurrect historical records of the butterfly species encountered at Hall Canyon, a relatively undisturbed CSS site in the coastal foothills adjacent to Ventura, Ventura County, California, obtained over an eight-year period of collecting and observation from 1955 to 1962. A total of 57 species was recorded from an area of <5 km^2, representing half of the total species presently recorded for Ventura County. Documentation of past species richness at this site provides important background data for assessing future range shifts and changes in butterfly diversity related to urbanization and its effect on the health of the remaining CSS habitat in southern California.

Additional key words: endangered habitat, species diversity, urbanization, Ventura County.

The composition, distributions and life histories of the butterfly fauna of cismontane southern California have been studied extensively for over a century, and early reference works, especially Comstock (1927) and Emmel & Emmel (1973), have documented the butterfly diversity of the region. Numerous publications, popular guides and checklists have also appeared on the butterfly fauna of different counties in southern California, or localized regions within counties, including Santa Barbara (Miller 1985), Los Angeles (Gunder 1930; Mattoni 1990), Orange (Orsak 1978), San Diego (Brown & Bash 2000; Shiraiwa 2009), and the offshore Channel Islands (Meadows 1937; Langston 1981; Miller 1985), to cite just a few. County butterfly records for southern California, as well as for all of the USA and Mexico, are also available online (http://www.butterfliesandmoths.org/) (Opler *et al*. 2010).

Although a wealth of faunal information is now available for the region, and populations of federally listed species such as the El Segundo blue, *Euphilotes battoides allyni* (Shields) (Lycaenidae), and the quino checkerspot, *Euphydryas editha quino* (Behr) (Nymphalidae) are continually being monitored (e.g. Arnold 1986; Mattoni *et al*. 1997; Pratt *et al*. 2001), there is little published information on surveys of the entire butterfly fauna at single localities in southern California. One exception is the study of Shields (1967) who described the faunal composition and hilltopping behavior of butterflies over a two-year period at a single coastal sage scrub (CSS) site in San Diego County. Comprehensive surveys at single sites within the CSS plant community can provide important baseline data for following changes in faunal composition over time that are related to habitat changes, as recently demonstrated for birds (Chase *et al*. 2005). These surveys are especially important in the endangered CSS community in southern California. Although determining the actual extent of CSS loss from anthropogenic sources is complicated by a lack of documentation of the historic vegetation, especially in the Los Angeles basin (Minnich & Dezzani 1998), estimates range from ~40–90% (Klopatek *et al*. 1979; Westman 1981), with much of this loss occurring within the last fifty years. Although estimates of the extent of the loss vary widely, large tracts of relatively intact CSS habitat can be found today in only a few areas of southern California, principally those that have been off-limits to urban development and agriculture, including Camp Pendleton Marine Corps Base and sections of the Santa Monica Mountains, with the remaining patches often being highly fragmented and degraded by domestic livestock grazing, air pollution (ozone and nitrogen oxides) and invasion of exotic plants (Minnich & Dezzani 1998).

The scant published information on the butterfly fauna at single CSS sites in southern California prompted us to review our collecting and observation records from the mid 1950s to early 1960s at Hall Canyon located in the coastal foothills adjacent to the city of Ventura, Ventura County, California (Fig. 1). The study area is privately owned and undeveloped, resulting in CSS habitat that was relatively undisturbed

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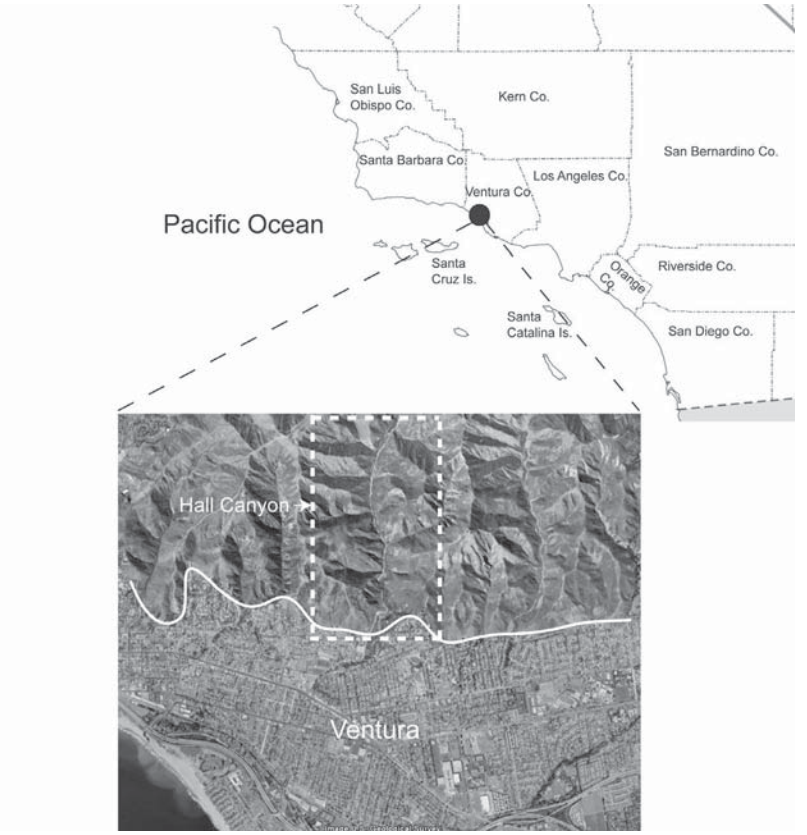

FIG. 1. Map of southern California, USA, showing the location of the survey area in Hall Canyon, Ventura County, California. The expanded portion is a Google™ Earth satellite photograph showing details of the canyon, enclosed by white dashed lines, as of September, 2007. The solid white line shows approximate limits of urban development in the city of Ventura adjacent to the Hall Canyon region; the almost complete absence of development in the coastal foothills is visible.

at the time of our study. During this time, the general public was allowed entrance to the canyon. Today, however, access is restricted. As far as we are aware, no other comprehensive single-site butterfly survey has been reported for Ventura County.

MATERIALS AND METHODS

Study area. Butterfly records were obtained for the Hall Canyon area (Fig. 1) from 1955 to 1962. Hall Canyon is ~3 km in length and ~1 km wide, and is surrounded by coastal foothills and ridges reaching elevations of ~180–335 m above sea level (asl). The mouth of the canyon (34° 16' 50" N; 119° 15' 30" W) is located ~2.5 km from the Pacific Ocean. Prince Barranca drains the canyon during periods of rainfall, but there is no permanent water flow. The elevation of the canyon floor ranges from ~55 m asl at the mouth to ~120 m asl at the upper end. The vegetation type is what has been termed the Venturan floristic association of the southern California CSS plant community, an association that occurs from cismontane San Luis Obispo County to Los Angeles County (Westman 1983; Davis *et al*. 1994). Except for a narrow paved two-lane road in the canyon, and some exposed pipelines, the CSS plant community was relatively undisturbed at the time of our study. The area is subject to periodic wildfires, and in the late spring sheep were brought to the canyon on a temporary basis to graze. A satellite view of the Hall Canyon area with Google™ Earth (Fig. 1) suggests that the canyon remained relatively undisturbed as of September 2007, and most probably remains so to this day. The climate is Mediterranean, typical for coastal southern California, with mild summers and cool winters. Average annual rainfall based on data from 1892 to 2001 is 38.66 cm (= 15.22 in.; Ventura County Public Works Agency).

Collecting and observations. Flight activity for butterfly species observed in the canyon was typical for cismontane southern California (Emmel & Emmel 1973; Mattoni 1990), occurring mainly from February through August. Thus, most of our collecting efforts and records are for this period. Because flight periods for butterfly species are well documented for southern California, we provide specific data only for a few species that were either rarely seen or present at unusual times. Collecting was typically carried out

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between ~0900–1300 h and was focused mainly on the canyon floor, although the surrounding hills were often sampled. Usually the entire 3 km length of the canyon was traversed, but systematic sampling in specific transects (e.g. Longcore *et al*. 2004) was not attempted. The haphazard and opportunistic sampling strategy used here, termed "convenience sampling" (Anderson 2001), precludes statistical analysis of the data, and has been criticized on these grounds, but our focus was not on determining population sizes and trends over time of individual species, but rather on obtaining an estimate of species diversity. A conservative estimate of overall collecting effort for each author over the eight-year period is ~230 h. This estimate is based on the 78 recorded collecting trips logged by EP [16 (1958), 21 (1959), 29 (1960), 7 (1961) and 5 (1962)], and assumes an average of ~3 h per trip.

Species were identified using Comstock (1927). We have assigned the species of the problematic *Pyrgus albescens* Plötz / *P. commuis* (Grote) complex (Hesperiidae) to *P. albescens* based on geographic distributions given in Burns (2000). The nomenclature of Pelham (2008) is followed throughout (i.e. the spelling of the original specific epithet is retained and not changed to conform to the gender of the genus name). Where a change in the name of a genus suggested by Pelham (2008) might present confusion, we also include the replaced name in parentheses. Voucher specimens for most species reported here are found either in the personal collection of EP, which is now deposited in the Santa Barbara Museum of Natural History (SBMNH), Santa Barbara, California, or the personal collection of PMJ.

Results and Discussion

In our survey, we recorded 57 species of butterflies at the Hall Canyon study site of <5 km^2 (Table 1), a relatively high value for species richness given that only 115 species are presently recorded for Ventura County (Opler *et al*. 2010). The butterfly diversity for Ventura County itself is also notable given that about 167 butterfly species have been recorded for the entire southern California region, including the desert areas (Emmel & Emmel 1973). The high biodiversity of butterflies in such a small geographic area [Ventura County represents only about 3% of the land area of southern California as defined by Emmel & Emmel (1973)] can be attributed to the diverse biotic communities present, encompassing coastal sand dune habitats to Canadian Zone conifer forests. Of the 57 species recorded at Hall Canyon, 37 of these were also noted by Shields (1967) at Dictionary Hill near Spring Valley in San Diego County, a CSS site where 46 species

Table 1. List of butterfly species recorded from Hall Canyon from 1955–1962. Nomenclature follows Pelham (2008).

HESPERIIDAE
- *Erynnis funeralis* (Scudder & Burgess, 1870)
- *Pyrgus albescens* Plötz, 1884
- *Heliopetes ericetorum* (Boisduval, 1852)
- *Panoquina errans* (Skinner, 1892)
- *Hylephila phyleus phyleus* (Drury, 1773)
- *Polites sabuleti sabuleti* (Boisduval, 1852)
- *Poanes melane melane* (W.H.Edwards, 1869)
- *Ochlodes sylvanoides sylvanoides* (Boisduval, 1852)
- *Ochlodes agricola agricola* (Boisduval, 1852)

PAPILIONIDAE
- *Papilio zelicaon* Lucas, 1852
- *Papilio rutulus* Lucas, 1852
- *Papilio eurymedon* Lucas, 1852 (1805)

PIERIDAE
- *Nathalis iole* Boisduval, 1836
- *Abaeis nicippe* (Cramer, 1779)
- *Colias eurytheme* Boisduval, 1852
- *Colias harfordii* Hy. Edwards, 1877
- *Zerene cesonia cesonia* (Stoll, 1790)
- *Zerene eurydice* (Boisduval, 1855)
- *Phoebis sennae marcellina* (Cramer, 1777)
- *Anthocharis sara sara* Lucas, 1852
- *Pieris rapae rapae* (Linnaeus, 1758)
- *Pontia beckerii* (W. H. Edwards, 1871)
- *Pontia protodice* (Boisduval & Le Conte, [1830])

LYCAENIDAE
- *Lycaena helloides* (Boisduval, 1852)
- *Atlides halesus corcorani* Clench, 1942
- *Satyrium tetra* (W.H. Edwards, 1870)
- *Callophrys perplexa perplexa* W. Barnes & Benjamin, 1923
- *Callophrys augustinus iroides* (Boisduval, 1852)
- *Strymon melinus pudica* (Hy. Edwards, 1877)
- *Leptotes marina* (Reakirt, 1868)
- *Brephidium exilis exilis* (Boisduval, 1852)
- *Cupido* (=*Everes*) *amyntula amyntula* (Boisduval, 1852)
- *Celastrina echo echo* (W.H. Edwards, 1864)
- *Glaucopsyche lygdamus australis* F. Grinnell, 1917
- *Echinargus isola* (Reakirt, [1867])
- *Plebejus acmon* (Westwood, [1851])

RIODINIDAE
- *Calephelis nemesis dammersi* McAlpine, 1971
- *Apodemia virgulti virgulti* (Behr, 1865)

NYMPHALIDAE
- *Danaus plexippus plexippus* (Linnaeus, 1758)
- *Danaus gilippus thersippus* (H. Bates, 1863)
- *Limenitis lorquini lorquini* Boisduval, 1852
- *Adelpha californica* (Butler, 1865)
- *Agraulis vanillae incarnata* (N. Riley, 1926)
- *Euptoieta claudia* (Cramer, 1775)
- *Vanessa virginiensis* (Drury, 1773)
- *Vanessa cardui* (Linnaeus, 1758)
- *Vanessa annabella* (W.D. Field, 1971)
- *Vanessa atalanta rubria* (Fruhstorfer, 1909)
- *Nymphalis californica* (Boisduval, 1852)
- *Nymphalis antiopa antiopa* (Linnaeus, 1758)
- *Polygonia satyrus satyrus* (W.H. Edwards, 1869)
- *Junonia coenia grisea* Austin & J. Emmel, 1998
- *Euphydryas chalcedona chalcedona* (E. Doubleday, [1847])
- *Chlosyne leanira wrighti* (W.H. Edwards, 1886)
- *Chlosyne gabbii gabbii* (Behr, 1863)
- *Phyciodes mylitta mylitta* (W.H. Edwards, 1861)
- *Coenonympha tullia california* Westwood, [1851]

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were found in two years of sampling.

In the 1961 season we found that several species whose flight period typically begins in February or later were on the wing in mid-to-late January. These included *Pyrgus albescens* (14 January; *N* = 1), *Colias eurytheme* (14 January; *N* = 6), *Anthocharis sara sara* (15 January; *N* = 1), *Plebejus acmon* (15 January; *N* = 1), *Euphydryas chalcedona chalcedona* (28 January; *N* = 3), and *Coenonympha tullia california* (15 January; *N* = 2). The records for *E. c. chalcedona* are especially noteworthy given that adults of this species usually begin to emerge in April.

Records for several butterfly species at Hall Canyon are based on only a few sightings or vouchered specimens, and thus these species are probably not resident or regular migrants to the area. Two females of *Zerene cesonia cesonia* in the PMJ collection were taken on the same day in the mid 1950s (no date) at the mouth of the canyon. These are apparently new county records. The species is not listed for Ventura County on The Lepidopterists' Society Season Summary website (http://www.flmnh.ufl.edu/lepsoc/) (accessed 14 May 2010) or in Opler *et al*. (2010), although it was found by Ken Davenport just east of Ventura County at Castaic Lake in Los Angeles County on 15 July 2005 [News of the Lepidopterists' Society Vol. 48, Suppl. S1, 2006 (2005 Season Summary)]. *Euptoieta claudia* is only rarely encountered in southern California (Emmel & Emmel 1973) and is listed as a very rare migrant for the Los Angeles area (Mattoni 1990). We recorded three individuals of *E. claudia* during the summer of 1956 or 1957, two sight records (PMJ) and one specimen collected by D. Stover (identification verified by both authors). We recorded only six individuals of *Chlosyne leanira wrighti* over the eight-year period [22 June 1958 (*N* = 1); 3 April 1960 (*N* = 1); 16 April 1960 (*N* = 1); 22 June 1960 (*N* = 1) and 29 June 1960 (*N* = 2)]. Two specimens of *Phyciodes mylitta mylitta* were recorded, both collected on 2 June 1958. Additional sightings by PMJ include *Nymphalis californica*, *Papilio eurymedon*, *Danaus gilippus thersippus*, *Atlides halesus corcorani* and *Adelpha californica*.

Several other species that we recorded deserve special mention. A colony of the coastal species *Panoquina errans* is found at the mouth of the Santa Clara River, only a few kilometers from the mouth of Hall Canyon. However, we also found *P. errans* to be abundant in the summer months at the upper end of the canyon where a semi-permanent water seep supports a stand of its host plant, *Distichlis spicata*. *Echinargus isola* was relatively common in the late 1950s, but apparently disappeared from the study area in the 1960s. Two females of *E. isola* collected in June 1960 at Montecito, ~40 km W. of Ventura in Santa Barbara County, were listed as non-resident, or not a regular migrant, for this region (Miller 1985). Emmel & Emmel (1973) also noted the presence of *E. isola* in unlikely areas of California (Sierra Nevada) during the period of our study, and commented on the dramatic population fluctuations associated with this species in the state.

Three exotic species dependent on introduced food plants were either common (*Agraulis vanillae incarnata* and *Abaeis nicippe*) or periodically encountered (*Phoebis sennae marcellina*) during the study. Emmel & Emmel (1973) noted that *A. nicippe* experienced a reduction in numbers in the Los Angeles area after about 1960, a trend also observed in the Ventura area. This species may now be extirpated from Hall Canyon and surrounding metropolitan Ventura. The fact that the larval food plant, introduced *Cassia* spp., is no longer commonly planted as an ornamental in Ventura probably contributed to the reduction in the population of *A. nicippe*. It is probable that *P. s. marcellina*, which utilizes the same food plant, was affected as well. Another species that was common at the time of our study, *P. zelicaon*, also has experienced a population decline and is now uncommon to rare in the Ventura area. During our survey, we would routinely encounter larvae of *P. zelicaon* on its widespread host plant, wild anise *Foeniculum vulgare*. Because the host plant is still abundant in the area, reduction in numbers of *P. zelicaon* may be related to extensive spraying of insecticides to control invasive exotic insect pests.

At the time of our survey reports of the Citrus-feeding *Papilio cresphontes* Cramer, 1777 (Papilionidae) were beginning to appear from agricultural areas in desert regions of southern California (Emmel & Emmel 1973). This species has continued its range expansion into cismontane southern California, with the first confirmed records for Ventura County reported from Camarillo on 9 May 2007 and subsequently from the city of Ventura on 8 September 2007 [News of the Lepidopterists' Society Vol. 50, Suppl. S1, 2008 (2007 Season Summary)]. Thus it is possible that *P. cresphontes* has now expanded into the Citrus groves present near the mouth of Hall Canyon.

In summary, the inventory of butterfly species presented here documents the species richness at a single site within the Venturan floristic association of CSS from 1955–1962. As an historical record from an endangered plant community in southern California, these data represent an important resource for helping to understand how changes in the health of the CSS ecosystem over time might affect range shifts and changes in butterfly diversity. Substantial habitat

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degradation and fragmentation of the CSS have occurred since the time of our study, and the projected continued urbanization of southern California will put additional pressure on remaining CSS habitat. Our data also provide a glimpse of how human activities not directly related to CSS degradation might affect both faunal composition and abundance of butterflies in densely populated urban areas.

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POSSIBLE FUNCTION OF SPATULATE SETAE SURROUNDING THE PAPILLAE ANALES OF *SAROTA* BUTTERFLIES (RIODINIDAE: HELICOPINI)

Additional key words: Camouflage, Costa Rica, Ecuador, epiphylls, oviposition

Lepidopteran eggs can face high levels of mortality due to a variety of factors including environment, predators, and parasitoids (e.g., Hilker 1994; Obermaier et al. 2006; Sansone & Smith 2001). Ovipositing females are thought to show various traits that may help escape these pressures, including egg placement, shell toxins, and chemical crypsis (e.g., Obermaier *et al*. 2006; Scoble 1992).

During the course of fieldwork in Central and South America, we observed oviposition by several species of *Sarota* (Riodinidae) butterflies. As far as is known, larvae of this genus feed on tiny epiphyllic lichens, mosses, and liverworts growing on the surface of tropical leaves (DeVries 1988, 1997). We observed a distinctive behavior associated with egg laying in *S. subtessellata* (Costa Rica, n = 1), *S. gyas* (Ecuador, n = 2), and *S. chrysus* (Ecuador, n = 1). After landing on a leaf, females walked slowly across its surface, dragging the tips of their abdomens, sometimes for up to five minutes before depositing an egg (Fig. 1). They occasionally walked to the lower surface of the leaf, sometimes pausing for several minutes, but always returning to oviposit on the upper surface. Upon close examination of the eggs, we noted that each was entirely covered with scraps of epiphylls glued to the chorion. Subsequently, when observing the external morphology of female genitalia of these and other *Sarota* spp., we noted the obvious presence of strange, stiff, apically-recurved, spatulate setae surrounding the papillae anales. These have been described and illustrated by Hall (1998), though he indicated their function remains a mystery. Although these setae are considered a synapamorphy of the Helicopini, encompassing *Helicopis*, *Sarota*, *Anteros*, and *Ourocnemis* (Hall 1998), similar structures are present in some moths in the Geometridae and Tortricidae (Pellmyr 1980; Scoble 1992). For *Sarota*, we also clearly observed the spine-like setae described by Hall (1998), located between the spatulate setae and the ostium bursae.

Fig. 1. A female *Sarota subtessellata* drags her abdomen across an epiphyll-covered leaf, presumably using modified setae surrounding the papillae anales to scrape and gather epiphyll scraps for camouflaging her eggs. (Photo P. J. DeVries).

In at least one tortricid moth these spatulate scales are considered to facilitate covering eggs with debris (Scoble 1992). In concert with these assertions, our observations strongly suggest that spatulate and spine-like scales and setae of *Sarota* are used to scrape and gather scraps of epiphylls, which are then glued to the egg. This behavior likely provides effective visual and chemical camouflage for eggs deposited on their epiphyll-covered oviposition substrates. Future observations and experiments on the covering of eggs with debris by lepidopterans may yield important clues as to the effectiveness of this behavior in deterring ants and/or egg parasitoids. Similarly, observations on the function of these structures in other genera within the Helicopini may shed light on their evolutionary origin.

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HAROLD F. GREENEY, *Yanayacu Biological Station and Center for Creative Studies, Cosanga, Ecuador c/o Foch 721 y Amazonas, Quito, Ecuador, email: revmmoss@yahoo.com*, CARLA M. PENZ & PHILLIP J. DEVRIES, *University of New Orleans, Department of Biological Sciences, New Orleans, LA 70148, and* THOMAS R. WALLA, *Department of Biology, Mesa State College, 1100 North Avenue, Grand Junction, CO 81501, USA.*

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LIMENITIS ARTHEMIS ASTYANAX (FABRICIUS) (NYMPHALIDAE) SIPPING CERCOPID-SPITTLE ON TALL GOLDENROD, *SOLIDAGO ALTISSIMA* L. (ASTERACEAE)

Scores of insects use the resources provided by goldenrod plants (*Solidago* spp.). In the Finger Lakes Region of New York alone, Root & Cappuccino (1992) documented 138 species of insects that feed on leaves, stems, or sap of tall goldenrod, *Solidago altissima* L. With its prodigious flowering display in late summer and early autumn, *S. altissima* is also visited by numerous species of pollen-, nectar-, flower-, and seed-feeding insects (Gross and Werner 1983; Sholes 1984). Therefore, I was not surprised during my studies of goldenrod in Virginia to see adults of the red-spotted purple, *Limenitis arthemis astyanax*, making repeated visits to *S. altissima* in early September—until I realized that the plants had yet to open any flowers. A closer examination of the interaction revealed a very unusual behavior: The butterflies were imbibing spittle excreted by the nymphs of spittlebugs (Cercopidae) that were abundant on *S. altissima* (Fig. 1).

Adults of the genus *Limenitis* are known to have rather eclectic feeding habits. In addition to nectar, they also feed on rotting fruit, dung, and carrion (Downes 1973). They have also been reported to feed on sap exuding from woodpecker holes in trees and on honeydew excreted by aphids (Rosenberg 1989). However, there are apparently no previous reports of *L. a. astyanax* or any other species of butterfly, utilizing the excretions of spittlebugs. It is quite possible that this behavior has not been officially documented for any insect.

It might seem like a small step from feeding on aphid honeydew to spittlebug excretions, as both aphids and spittlebugs tap into the flow of plant sap and excrete copious amounts of liquid waste. However, the similarities end there. Aphids feed on phloem sap, which is rich in sugars manufactured by the plant through photosynthesis. Because aphids obtain more carbohydrates than they need from phloem sap, their excretions (honeydew) are rich in sugars. Many insects, most notably ants, are able to take advantage of this honeydew as a source of sugar.

In contrast to aphids, spittlebugs ingest xylem sap, which is relatively dilute, with small amounts of inorganic nutrients and amino acids and smaller amounts of sugar (Wiegert 1964a; Horsfield 1977). Spittlebug nymphs introduce bubbles into their liquid excrement and cover their bodies with the foamy spittle, which may serve as protection from predation or desiccation (Guilbeau 1908; Weaver and King 1954; Wiegert 1964a; Whittaker 1970; Turner 1994). Spittlebugs extract most of the sugars and other nutrients from the xylem sap, such that spittle is expected to be of little nutritional benefit to other insects (Wiegert 1964b). It has been suggested that the spittle may be toxic to other insects due to the presence of ammonia (Turner 2000).

The fact that *L. a. astyanax* repeatedly returned to spittle masses raises several questions. For instance, do the butterflies sip spittle to their own detriment, or do they gain a net benefit from it? If the latter, then what is the nature of the benefit? Are there undigested amino acids from the xylem or nutrients from decaying exuviae and small organisms trapped in the spittle, or do the butterflies simply use the spittle as a source of moisture? Would the costs and benefits of sipping spittle differ depending on the species of cercopid producing the spittle?

The most abundant spittlebug nymph on *S. altissima* in Virginia in September is the sunflower spittlebug (*Clastoptera xanthocephala* Germar), a rather polyphagous species that is best known for feeding on plants in the Asteraceae. Nymphs of two other cercopid species, *Philaenus spumarius* (L.) and *Lepyronia quadrangularis* (Say), are common on *S. altissima* during the late spring and early summer, but I have not observed

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FIG. 1. Adult *L. a. astyanax* sipping spittle produced by the spittlebug *C. xanthocephala* on its host plant *S. altissima* (Photograph by M. J. Wise on 2 September 2009 at Blandy Experimental Farm in Clarke County, Virginia.).

L. a. astyanax visiting goldenrods when these spittlebugs were present. This difference in *L. a. astyanax* behavior may be caused by differences in the physical or chemical properties of the spittle created by the different species, or it may simply be a result of changing needs of the butterflies from spring to fall. Notably, the weather in the period in which I observed the spittle sipping was particular warm and dry. Changes in plant size or chemical constituents of xylem as the season progresses could also affect the attractiveness of cercopid spittle to *L. a. astyanax*. It would be interesting to determine if the butterflies feed on spittle derived from plants other than goldenrods.

Finally, in order to characterize the ecological interaction among the butterflies, spittlebugs, and goldenrod, it would be necessary to know whether spittle sipping by butterflies affects the fitness of the spittlebug nymphs. My observations suggest that *L. a. astyanax* only takes a small proportion of available spittle per feeding bout from any given spittle mass, and thus a single visit is likely to have only a minor effect on the nymphs. If the butterflies were to return frequently, then they might shrink a spittle mass faster than the nymphs can replace it. In addition, a butterfly's proboscis might disturb a nymph's feeding, causing it to leave the spittle mass to relocate elsewhere on the plant. During the time period needed to re-establish its spittle mass, the nymph would be vulnerable to desiccation and predation (Wise *et al*. 2006). Clearly, the observation of spittle sipping by *L. a. astyanax* introduces a number of interesting physiological and ecological questions that will require further study to resolve.

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MICHAEL J. WISE. *Blandy Experimental Farm, University of Virginia, 400 Blandy Farm Lane, Boyce, VA 22620, USA. e-mail: mjw6j@virginia.edu*

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Journal of the Lepidopterists' Society
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LIFE HISTORY OF THE DOUBLE TUFTED WASP MOTH, *DIDASYS BELAE* GROTE (EREBIDAE: ARCTIINAE)

Additional key words: sedge, wasp mimicry, *Fuirena*

The Double Tufted Wasp Moth, *Didasys belae* Grote (Fig. 1), is one of eastern North America's most beautiful tiger moths. Adults are scarce in collections, in large measure because the species is extremely local, but also because *Didasys* is believed to be diurnal or crepuscular and closely tied to its hostplant, *Fuirena scirpoidea* Michaux (southern umbrella sedge). Despite the moth's broad distribution in Florida, the early stages of *Didasys* were unknown prior to this report (Heppner 2007).

Didasys belae occurs from Monroe County north to Escambia County, Florida. There is also a specimen from Delchamps, Mobile County, Alabama collected in August 1933 (Vernon A. Brou, Jr. personal communication). While adults are seen in a variety of habitats, the species is most frequently encountered in marshlands (Kimball 1965) and other wetlands. The adults occur nearly year-round in southern Florida. JS discovered the larva by scouring a marsh along Lake Mary Jane in Orange County (Fig. 2), where the adults can be found flying or resting on various plants including the host. Larvae were found resting upon and were reared to maturity on *Fuirena scirpoidea*. Below we describe the insect's early stages, emphasizing the last instar larva, and provide notes on the insect's life history.

Description of immature stages: *Egg.* 0.86–0.92 mm in diameter by 0.63–0.66 mm high (n=3), hemispherical, pale cream, without obvious surface sculpturing (Fig. 3). *First instar.* Pale red-orange, shiny, with long dark primary setae borne from raised pinacula; T2 thickened; D and SD setae on T2, T3, and A8 grouped onto a single pinaculum (Fig. 4). *Middle instars.* Ground color dark to nearly black with white dorsal and subspiracular stripes, both of which become obscure rearward of A8; both stripes may include ill-defined yellowish patches in intersegmental areas of the first eight abdominal segments; T1 with numerous forward-directed setae; T2 enlarged with hypertrophied setae that extend well forward of head; A7 and A8 elongate, nearly half again as long as preceding segments; long, caudally directed setae on A8–A10 extend beyond abdominal terminus (Fig. 5). *Last Instar.* Length: 27 mm. Body modestly compressed dorsoventrally with prominent black and creamy yellow striping (Figs. 6, 7). Thick middorsal, broad lateral, and narrow subventral black stripes separate thick yellowish dorsal and mostly white subspiracular stripes. Yellow dorsal stripe includes both the D1 and D2 verrucae; mostly white subspiracular stripe narrower than dorsal and infused with more yellow. T1 with reduced secondary setae and verrucae. Dorsal verrucae fused on T2 and T3. T2 with subdorsal verrucae bearing elongate, black, splayed hairpencils that project forward of head. A9 and A10 with elongated black setae that project behind body. No setae gathered into pencils. Venter dusky orange on segments bearing legs and prolegs; intervening segments more yellow. Most setae pale but longer ones darkened at mid-length and becoming nearly black by apices. Setae with conspicuous barbs; elongate black setae somewhat feathery in appearance. Head slightly broader than thorax with diagnostic pattern: dark patch above and to either side of frons; frons edged with white along upper half; red-brown snowflake spotting over each lobe (Fig. 8). Clypeus yellow. Base of antenna yellow, second segment black. *Pupa* (described from two exuviae). Length: circa 10 mm. Orange with conspicuous (aposematic?) black stripes or pattern elements on A5-A8, pupal appendages, and along wing veins (Fig.10). Spiracles borne from pimplelike warts on A2–A7. **Cocoon:** Length 17 mm (n=1), thin-walled (with pupa visible within), spun along axis of stem or blade (Fig. 9). Wall of cocoon with numerous, mostly white interwoven setae. Anterior end with numerous black setae extending forward of emergence exit. Pupa positioned ventral side up in cocoon.

Life History Notes and Discussion. So far as known, southern umbrella sedge (*Fuirena scirpoidea*) is the only host. We observed a female oviposit on this sedge and we have found six larvae perched on this

FIGS. 1-2. *Didasys belae* (Orange County, FL). (1) Adult male. (2) Habitat.

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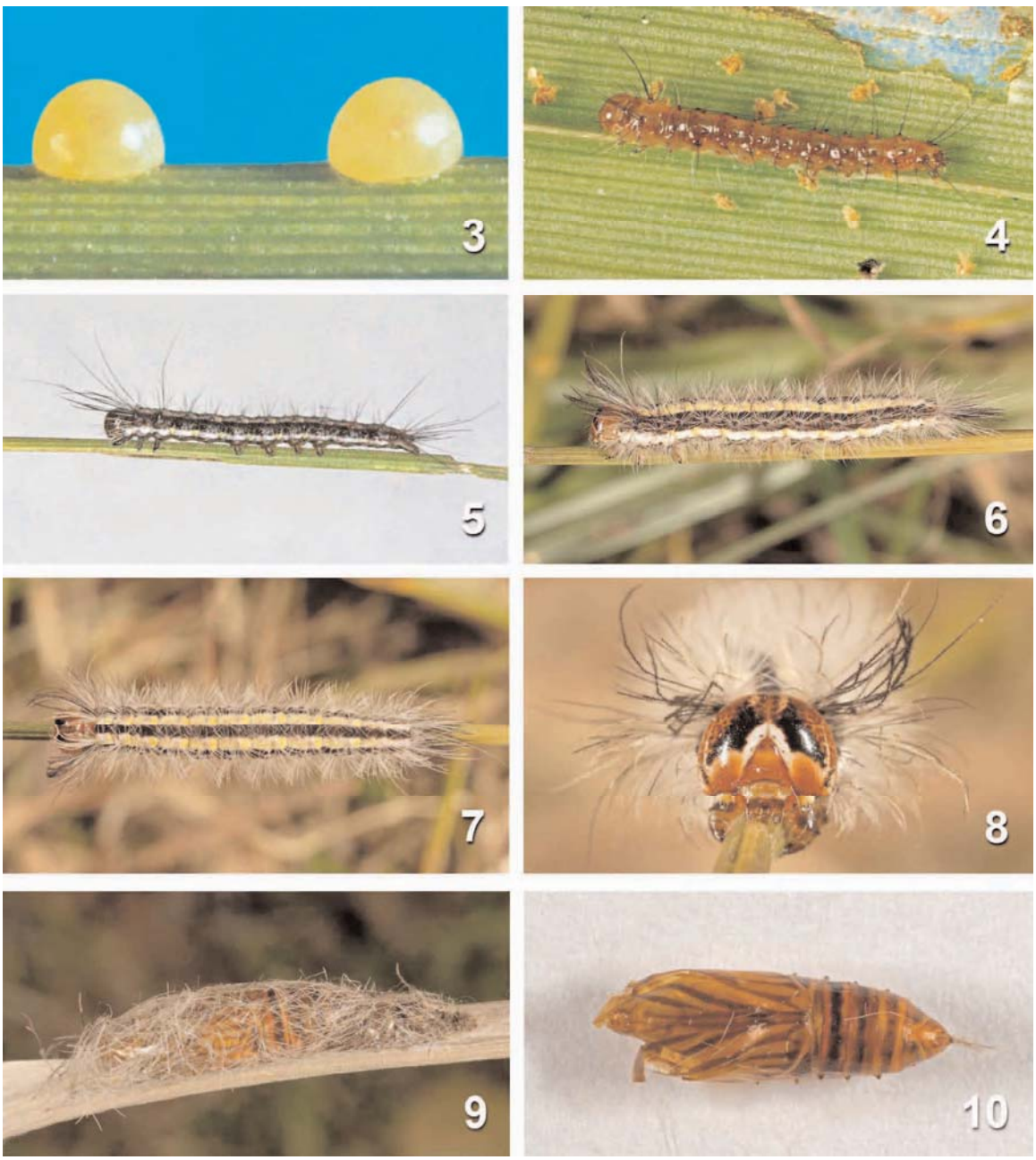
plant in the wild. In 2007 we were able to rear a cohort of ex ova larvae through to maturity on southern umbrella sedge. Our efforts to switch the larvae to other sedges, grasses, or rushes were unsuccessful—larvae nibbled on *Carex stricta*, but straggled and died. Late instars perch conspicuously on stems, often about midway up a given stalk. In a crude fashion, the larvae resemble the white flower or seed heads of *Fuirena scirpoidea*. We are uncertain if larvae consume inflorescences, although one larva was found perched at the top of a stalk that showed signs of feeding. Larvae tend to occur in low numbers—we logged more than eight hours searching stems of southern umbrella sedge to recover six wild larvae.

Larvae displayed different defensive behaviors. When initially disturbed, caterpillars held their grip, but if further molested dropped to the ground and curled into a C or scurried off into vegetation, wedging their



FIGS. 3–10. *Didasys belae* early stages (all Orange County, FL). **(3)** Eggs. **(4)** First instar. **(5)** Middle instar. **(6)** Last instar, lateral. **(7)** Last instar, dorsal. **(8)** Last instar head, frontal. **(9)** Cocoon. **(10)** Pupal shell.

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body into a hideaway, in a fashion common to other ground-dwelling arctiines (see Wagner 2009). Some displayed an animated alarm response after being touched, repeatedly snapping the anterior end of their body back towards the caudal end of the body—a response that would surely dislodge small invertebrate natural enemies (e.g., parasitic flies or ants).

Females flew low to the ground in a fashion similar to the flight of some wasps seen in the same habitat. Males tended to fly higher but were also noted to land head down on scattered sedge and plant stems. JS saw one mating pair in the late afternoon in June of 2008. Mindy Conner observed a single adult male feeding at dusk on the roots of a dog fennel plant (*Eupatorium capillifolium*) that had been pulled and hung up at the Archbold Biological Station to attract *Cosmosoma myradora* (Dyar) and other PA-collecting arctiids (Goss 1979; Conner & Jordan 2009; Mindy Conner personal communication).

We saved a single cocoon for study. While we endeavored to carefully extract the pupa from the wispy cocoon, a large portion of the cocoon wall tore free, attached to the cremaster, when the shell was removed for study. Upon microscopic examination, we noted that silk and setae from the cocoon wall had been tightly wound about the base of the cremaster, indicating that the pupa had spun repeatedly (in a single direction) while in the cocoon. The extent to which this represents an anomalous observation, or an adaptive behavior to ensure that the pupa is locked into the cocoon wall or that larval setae accompany the pupa should the pupa be ripped free of the cocoon, is worthy of further investigation.

The prominent orange and black patterning of the pupal shell and open nature of the cocoon suggest that the pupa enjoys some form of either physical or chemical protection. Such is common among ctenuchids (Subtribe Euchromiina) (see Wagner 2009). The fact that the cocoon is spun exposed on a stem, rather than secreted among dense vegetation or litter, also suggests that the pupa (and/or cocoon) is somehow protected. The basis of any chemical protection that the caterpillars and pupae might enjoy, presumably, would be based on self-manufactured defensive substances, as sedges are not known to produce defensive substances that could be sequestered by arctiine larvae.

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DLW described the immature stages and prepared the text; JRS discovered the larva and hostplant, reared a cohort for *D. belae* larvae on umbrella sedge, and carried out the field work. Mindy and Bill Conner alerted JRS to the presence of *Didasys* at Archbold Biological Station, which catalyzed our efforts to discover the early stages of this seldom seen tiger moth. It was Don Stillwaugh that first discovered *Didasys belae* at the Lake Mary Jane site and who guided us to the marsh where the caterpillars were first found. Moria Robinson and one anonymous reviewer offered suggestions for improvements of an earlier draft. We thank Patti Anderson and Richard Weaver of the University of Florida Herbarium, who identified the plants mentioned in this note. Plates were assembled by Amy Fernald.

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DAVID L. WAGNER, *Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, Connecticut 06269-3043, USA; email: david.wagner@uconn.edu, and* JEFF R. SLOTTEN, *Research Associate McGuire Center and FSCA, Gainesville. Florida, 5421 Northwest 69th Lane, Gainesville, FL 32653, USA; email: jslotten@bellsouth.net*

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MARIPOSAS SERRANAS DE ARGENTINA CENTRAL. By Luis Volkmann and Ezequiel Nunez Bustos. Tomo 1: Papilionidae, Pieridae, Lycaenidae, Riodinidae. 140 pp. Equipo Grafico, Huerta Grande, Cordoba, Argentina. 2010. ISBN 978-987-25088-3-8.

After decades of slumber, butterfly study in Argentina is undergoing an awakening. And well it should! Argentina spans an array of life zones that rivals any country in the world: from tropical jungles to the stark high-altitude steppes, grasslands and deserts of the Andean altiplano, to the wind-swept plains of Patagonia and the dark, brooding subantarctic beech forests of the magellanic region. With such geographic diversity, the Argentine butterfly fauna offers taxonomic, biogeographic, ecological and evolutionary challenges aplenty. (This is, after all, a place where you can see parrots, penguins and rheas in one day, though not Morphos and subantarctic Whites.) At the same time, Argentina is a developed country with an infrastructure fully capable of supporting faunistic and monographic butterfly study; the biggest deterrent to such work has long been the perennially shaky state of the nation's economy, with little to spare in support of such frivolities.

This book represents an entirely home-grown effort by two Argentine nationals, one (Volkmann) an environmental educator, the other (Nunez Bustos) a field naturalist, ecotourism guide, and dedicated amateur Lepidopterist. It is envisioned as the first in a series of regionalized faunal guides to Argentine butterflies. The area covered (parts of the Provinces of Cordoba, San Luis, La Rioja, Catamarca and Santiago del Estero) is not by any means among the most diverse or interesting parts of the country, but it still has its charms, and plenty to offer. The term "Serranas" in the title is a tad misleading unless one is familiar with Argentine usage. It means "of the highlands" or "of the mountains." There are some very high mountains indeed in La Rioja and Catamarca. They are so remote as to be accessible only by packing in with livestock, flying in, or (as is increasingly popular) going in in all-terrain vehicles—though many of the most interesting areas here as elsewhere in Andean Argentina are controlled by mining companies and are strictly off-limits. But these places and their butterflies are outside the focus of this book, which instead concentrates on the relatively low Pampean Sierras—which, despite their not being so imposing, have until recently been little-collected. As a result there could be surprises yet to be found there, including perhaps even species new to science—if so, probably in the Lycaenidae and/or Hesperiidae. But none shows up in the book. The highest elevations of the Sierras Pampeanas have floristic ties to the Andes proper (and the Sierras of Cordoba have a dilute tropical element). Much of the area is dominated by shrubsteppe or thorn scrub. Those familiar with the American Southwest would feel more or less at home among creosotebush, mesquite, acacia, and a variety of cacti. At higher elevations, with higher rainfall, the vegetation becomes denser, more exotic and more diverse. At low elevations, much of the native grassland in Cordoba and San Luis, traditionally devoted to open-range cattle pasture, has been converted in recent years to a monoculture of soybeans for export. We do not know what, if anything, may have been lost in the process.

Much of the butterfly fauna is clearly derived from the nearby tropics, though only a smattering of lowland-Neotropical lineages is represented. Some of the seemingly strictly-temperate elements are probably ultimately derived from the Neotropics, but their phylogeny has not been worked out yet. There are 21 Lycaenids: Hairstreaks are numerous and diverse; Blues are very poorly represented, though one of those (*Madeleinea moza*) is of special phylogenetic-biogeographic interest since its lineage is richest not in the tropics but in the temperate Southern Cone. There are 14 Riodinids. The Pierid and Papilionid faunas are small too (17 and 5 respectively). So this volume covers a total of 57 species, quite a manageable number. The second volume is projected to cover Nymphalidae in the broad sense (34 species) and Hesperiidae (45). The Satyrids, dominated by the temperate-latitude Pronophiline radiation, should be of special interest given that there is plenty of their preferred bunchgrass habitat in the Sierras Pampeanas and the group appears to be evolutionarily very dynamic. There are no regional endemics at all in this book, which may be something of a disincentive to collectors. But then, there are apparently no butterflies at the species level endemic to our own Great Basin, but the fauna and its distribution continue to generate great interest.

The species descriptions are accompanied by splendid, accurately-reproduced photographs from life, by both authors. Some of the species have never been reproduced photographically before. Early stages are also pictured when available (not very often; the life-histories of many of these insects are poorly if at all documented). Some of the life-history information is

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new. The only error I found was the repetition of the canard that the White *Tatochila orthodice* feeds on Brassicaceae. It doesn't, but we only suspect that it actually eats either Fabaceae or Valerianaceae; someone should find out.

The introductory matter includes brief treatments of butterfly study, butterfly biology and conservation, and regional geography and vegetation. The plants shared with our own Southwest will be familiar to North American readers, but the South American ones by and large will not. Fortunately, we have on-line sources to help us visualize them.

For those who read Spanish and are interested not only in butterflies but also in the natural history of Argentina, this is an immensely useful as well as beautiful little book. Books are expensive in Latin America, and this is no exception: the quoted price at publication was US $40. As of this writing there is no US distributor; it can be ordered directly from the authors at (Nunez Bustos) argentinebutterflies@hotmail.com or (Volkmann) volkmann2009@hotmail.com.

ARTHUR SHAPIRO, *Center for Population Biology. University of California, Davis, CA 95616; e-mail: amshapiro@ucdavis.edu*

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Biology Department
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Charleston, South Carolina 29424-0011, USA
scholtensb@cofc.edu

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706 Lake Road
Eureka, Illinois 61530
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