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Cover illustration: *Plutella vanella,* 8 km NW of Winfield, Alberta, CANADA, 17 July 2003, Charles D. Bird. Photo by Charles Bird. See "New records of microlepidoptera in Alberta, Canada", this issue

NEW RECORDS OF MICROLEPIDOPTERA IN ALBERTA, CANADA

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ABSTRACT. Fifty-seven species of microlepidoptera are reported as new for the Province of Alberta, based primarily on specimens in the Northern Forestry Research Collection of the Canadian Forest Service, the University of Alberta Strickland Museum, the Canadian National Collection of Insects, Arachnids, and Nematodes, and the personal collections of the first two authors. These new records are in the families Eriocraniidae, Prodoxidae, Tineidae, Psychidae, Gracillariidae, Ypsolophidae, Plutellidae, Acrolepiidae, Glyphipterigidae, Elachistidae, Glyphidoceridae, Coleophoridae, Gelechiidae, Xyloryctidae, Sesiidae, Tortricidae, Schreckensteiniidae, Epermeniidae, Pyralidae, and Crambidae. These records represent the first published report of the families Eriocraniidae and Glyphidoceridae in Alberta, of Acrolepiidae in western Canada, and of Schreckensteiniidae in Canada. *Tetragma gei*, *Tegeticula corruptrix* (Prodoxidae), *Scythris mixaula* (Xyloryctidae), *Nemapogon acapnopennella* (Tineidae), *Plutella vanella* (Plutellidae), *Acrolepiopsis liliivora* (Acrolepiidae), *Glyphipterix montisella* (Glyphipterigidae), *Glyphidocera hurlberti* (Glyphidoceridae), *Synanthedon culiciformis* (Sesiidae), *Epinotia albicapitana* (Tortricidae), *Schreckensteinia festaliella* (Schreckensteiniidae), and *Epermenia lomatii* (Epermeniidae) are reported for the first time in Canada. As well, further Alberta records of the rarely collected species *Blastodacna curvilineella* (Elachistidae) and *Wockia asperipunctella* (Urodidae) are given.

Additional key words: distribution, faunistics.

Alberta is a large province (> 660,000 square km²) in western Canada, comprising primarily boreal forest in the northern half, and aspen parkland and prairie in the southern half, with the Rocky Mountains and foothills along the western border. Its lepidopteran fauna contains elements from all of these ecoregions, as well as some exotic introductions. Most of the province was covered by ice in the last glaciation; consequently its fauna contains many post-glacial immigrants and few endemic species. Nevertheless, it has a large and diverse lepidopteran fauna, estimated to contain approximately 3000 species, almost evenly divided between the macrolepidoptera (sensu Kristensen 1999; the superfamilies Mimalonioidea, Lasiocampoidea, Bombycoidea, Hesperioidea,

Papilionoidea, Drepanoidea, Geometroidea, and Noctuoidea) and the microlepidoptera (primitive groups up to and including the Pyraloidea and Thyridoidea).

The first checklist of Alberta Lepidoptera was published by Frederic Hova Wolley-Dod between 1901 and 1906 as a series of articles in The Canadian Entomologist (Wolley-Dod 1901a, b, 1904, 1905a-f, 1906a-c). It listed 613 species of macrolepidoptera, and a few of the larger microlepidoptera in the families Hepialidae, Cossidae, and Sesiidae. In 1951, Edmonton Lepidoptera collector Kenneth Bowman published a comprehensive list of Alberta Lepidoptera, including 657 microlepidoptera and 1168 macrolepidoptera species and varieties. Since

that time, many taxonomic revisions have been published detailing new records for the province. In recent years, the authors have collected microlepidoptera extensively in Alberta and have examined specimens in local public collections. The current paper reports 57 new Alberta records resulting from this work, and additional localities for two species previously reported in single locations in the province.

MATERIALS AND METHODS

This list is based on our examination of material housed in the Northern Forestry Centre Research Collection (NFRC), Edmonton; the Strickland Museum of the University of Alberta (UASM), Edmonton; the Canadian National Collection of Insects, Arachnids, and Nematodes (CNC), Ottawa, Ontario; the Agriculture and Agri-Food Canada Research Lab collection (AGRL), Lethbridge; the Olds College Insect Collection (OLDS), Olds; and the personal collections of the first two authors (POHL, BIRD) and of Douglas Macaulay (DAM) of Barrhead, Alberta. Identities have been confirmed via comparison with cited publications and reference collections, and consultation with appropriate taxonomic experts, as noted below. For the more difficult species, the genitalia were dissected and examined. When available, published revisions were used to make identifications; for groups which have not been revised in the past 100 years; identifications were made via comparison to authoritatively identified specimens at the CNC. Voucher specimens of all species are deposited at NFRC, except as noted. Unless otherwise noted, all BIRD specimens were collected by C.D. Bird, and all POHL specimens were collected by G.R. Pohl.

Abbreviations used are as follows: N, north; S, south; E, east; W, west; FIDS, Canadian Forest Service, Forest Insect and Disease Survey; FW, forewing; HW, hindwing; LT, light trap; MV, mercury vapour; UV, ultraviolet; WS, wingspan.

Species are presented in taxonomic order based on the higher phylogeny presented in Kristensen (1999), and species-level arrangements in the taxonomic revisions cited below.

For each species treated we provide a brief synopsis of information under the following headings: ID: diagnostic characters allowing identification of the species in the context of other species known from western Canada; AB REC: Alberta specimens examined by the authors; DIST: general distribution of the species, as represented in the literature; BIO: a summary of known biological information including host records; COM: any other comments.

SPECIES ACCOUNTS

ERIOCRANIIDAE

Eriocrania semipurpurella (Stephens, 1834)
ID: A small (12 to 14 mm WS) moth with dark brown FW. The FW has a purplish metallic lustre, and a small triangular white mark on the caudal margin, immediately basad of the tornus. Davis (1978) provides a full description and illustrations. Although it is very similar to other species in the family, it is the only species known to occur in western North America.

AB REC: Edmonton, 20 May 1948, K. Bowman [UASM]. Edmonton, CFS Northern Forestry Centre compound, 53.49138°N 113.54390°W, 28 April 1998, G.R. Pohl [NFRC]. 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 21 April 2000, diurnal [POHL]; 11 April 2001, diurnal [POHL]; 19 April 2001, diurnal [POHL]; 16 May 2002, at dusk, A.J.P. Deneka [POHL]. 8 km NW of Winfield, 53.01°N 114.50°W, 900 m, 5 May 2001, UV LT [BIRD]; 12 May 2001, MV light [BIRD]; 12 May 2003, UV LT [BIRD].

DIST: Previously known to occur in eastern North America as far W as Black Sturgeon Lake, Ontario (subspecies *semipurpurella* (Stephens)), and in western North America (subspecies *pacifica* Davis) in Alaska, British Columbia (Vancouver Island), and Washington (Davis 1978). It is widely distributed in southern and central Alberta in boreal and mixedwood areas.

BIO: This species is an inhabitant of moist aspen forests. Adults can be quite numerous on warm sunny days in early spring. Larvae are leaf blotch miners. Subspecies *semipurpurella* feeds on *Betula* (Betulaceae); in British Columbia, *pacifica* may feed on *Holodiscus discolor* (Pursh) Maxim. (Betulaceae) (Davis 1978).

COM: All Alberta specimens examined by the authors conform to the *pacifica* subspecies. This is the first report of the family Eriocraniidae in Alberta.

PRODOXIDAE

Lampronia russatella (Clemens, 1860)
ID: A small (13 to 15 mm WS) moth with a distinctive pattern of white or pale yellow marks on the FW (Fig. 1), comprising a complete basal band, median costal and dorsal patches, and a distal patch on the costal margin which may be absent in some specimens. The background color of the FW is bronzy brown with a metallic lustre. Dietz (1905) provides a brief treatment of the species, in the genus *Incurvaria* in the family Tineidae.

AB REC: 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 20 June 2000, at dusk [POHL]; 13 July 2000 [POHL]. 3 km W of Touchwood
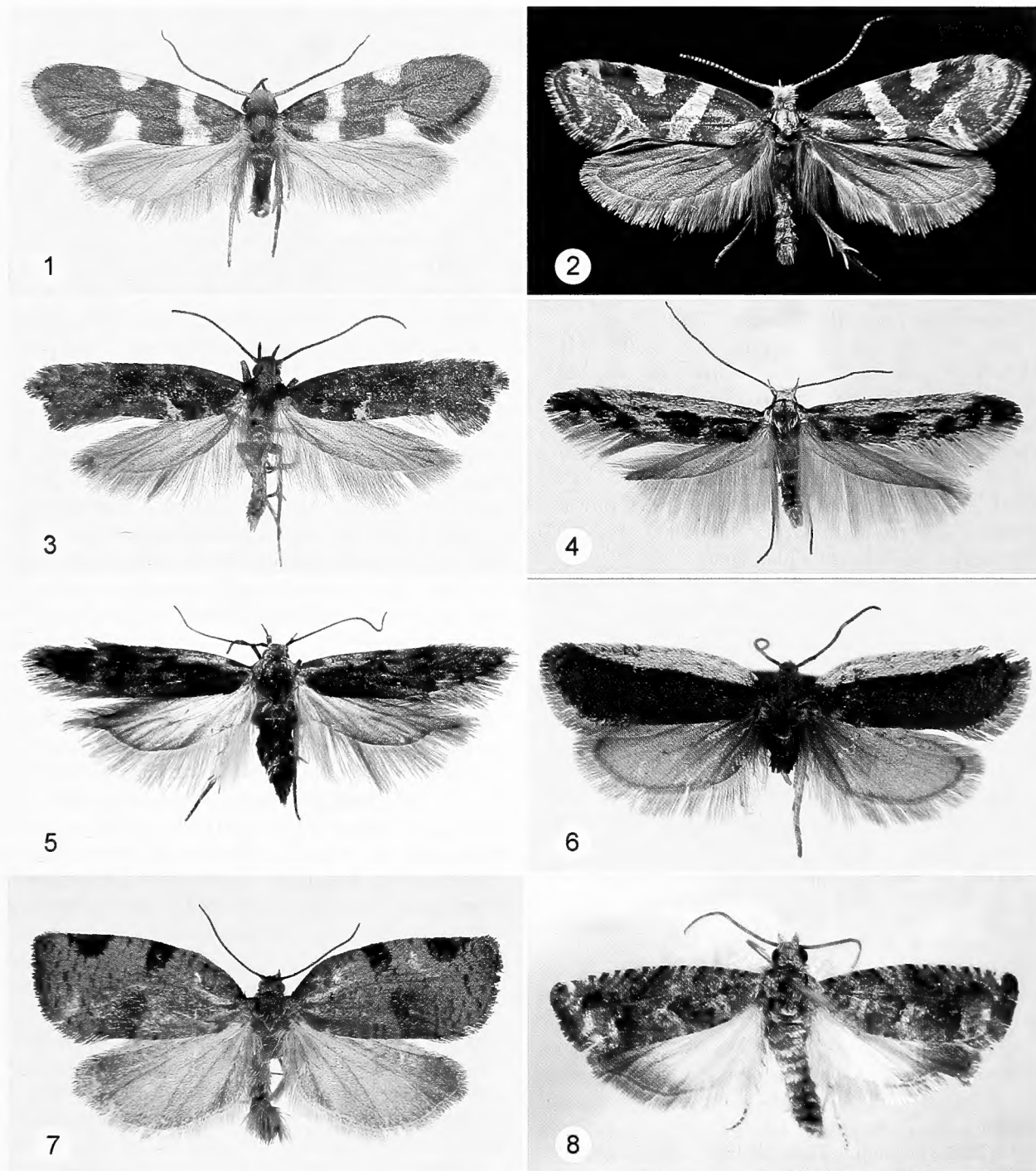
FIGS. 1-8. Microlepidoptera new to Alberta. **1**, *Lampronia russatella*, 13.5 mm WS, 3 km W of Touchwood Lake, 22 June 1994 J.-F. Landry; **2**, *Plutella vanella*, 17.0 mm WS, 8 km NW of Winfield, 17 July 2003 C.D. Bird; **3**, *Acrolepiopsis liliivora*, 14.5 mm WS, 8 km SE of Sherwood Park, 21 April 2001 G.R. Pohl; **4**, *Blastodacna curvilineella*, 16.3 mm WS, Rochon Sands Provincial Park, 1 May 2004 C.D. Bird; **5**, *Xenolechia velatella*, 14.1 mm WS, Rochon Sands Provincial Park, 3 May 2001 C.D. Bird; **6**, *Acleris paracinderella*, 16.8 mm WS, Kananaskis, Elbow Ranger Station, reared, emerged 29 August 1951; **7**, *Lozotaenia hesperia*, 23.2 mm WS, 20 km NE of Zama City, 7 July 1997 G.R. Pohl; **8**, *Gretchena semialba*, 12.6 mm WS, Wandering River.

Lake, E of Lac La Biche, 22 June 1994, daytime sweeping mosses and sphagnum in boggy swamp, J.-F. Landry [CNC].

DIST: Previously known only from eastern North America, from Montreal, Quebec, and Ithaca, New York (Dietz 1905).

BIO: Unknown.

COM: The genus *Lampronia* is in need of revision. The status of this and other species may need to be revised in light of a full examination of genitalic structures.

Lampronia capitella (Clerck, 1759)

ID: A small (13 to 15 mm WS) moth with a distinctive pattern of white marks on the FW, comprising an incomplete basal band, median costal and dorsal patches, and a distal patch on the wingtip. The background color of the FW is bronzy brown with a metallic lustre. This species has not been treated in the North American literature. Medvedev (1978) provides genitalia illustrations, and Parenti (2000: Plate 33) provides an excellent color photograph.

AB REC: Barrhead, 2 June 1997, D. Macaulay [DAM]. Long Lake, boreal forest at lakeshore, 17 June 1999, UV light [POHL].

DIST: A Holarctic species, reported in North America only from Quebec (Handfield 2002). There are specimens in the CNC from Ontario, Quebec, and British Columbia.

BIO: In Europe this species feeds on shoots and buds of *Ribes* (Grossulariaceae) (Medvedev 1978). Heath & Pelham-Clinton (1976) provide an account of its life history in Great Britain.

COM: Known in Europe as the Currant Shoot Borer. See note on the genus *Lampronia* under *L. russatella* above.

Tetragma gei Davis & Pellmyr, 1992

ID: A small to medium-sized (11 to 17 mm WS) light grey moth, with a few scattered darker scales on the FW. Females are larger than the males, and have an extremely long abdomen ending in a sharp ovipositor. Davis et al. (1992) provides a description and illustrations.

AB REC: Porcupine Hills, Skyline Road, 49.93597°N 113.97926°W, montane pine/fir meadow, 3 July 2002, diurnal, D.W. Langor & G.R. Pohl [NFRC] (2 specimens); [CNC] (2 specimens).

DIST: This is the first record of this species in Canada. It was previously known from the northwestern United Sates, in eastern Washington, Idaho, Wyoming, and South Dakota, although it was expected to have a broader distribution (Davis et al. 1992).

BIO: This species occurs in high elevation forb-rich

meadows, where it can be locally abundant. Larvae are known to feed on *Geum triflorum* Pursh (Rosaceae) (Davis et al. 1992).

Tegeticula corruptrix Pellmyr, 1999

ID: A relatively large (22 to 35 mm WS), stout-bodied moth with immaculate white FW and brownish grey HW. Pellmyr (1999) provides a description and illustrations, including mouthpart and genital characters for separation from other species of *Tegeticula*.

AB REC: Lost River Valley, 1 km N of the Montana border, 49.01046°N 110.44424°W, 28 June 2001, shortgrass prairie, hand collected from *Yucca glauca* flowers, Pohl, Macaulay & Machney [NFRC] (2 specimens). Onefour, 9 July 1950, A. Hewitt [AGRL]. Onefour, 9 July 1950, K. Bowman [UASM].

DIST: Although its occurrence in Alberta in sympatry with *T. yuccasella* (Riley) has been noted in a unpublished reports (Perry 2001; COSEWIC 2002), this is the first published record of *T. corruptrix* in Canada. It was previously reported from the western USA, from California to Texas, north to southern Montana. The Onefour area represents the northern limit of *Yucca glauca* Nutt. (Liliaceae) and of *Tegeticula* species in Canada.

BIO: The genus *Tegeticula* has a well-known mutualistic relationship with *Yucca* plants (Pellmyr et al. 1996). Moth larvae are dependent on the plant for food, and the plant is dependent on the moths for pollination. *Tegeticula corruptrix* is a recently recognized species that 'cheats' by ovipositing in the developing seeds without pollinating the flowers (Pellmyr 1999). Larvae are known to feed on a number of *Yucca* species (Pellmyr 1999). *Yucca glauca* is the only *Yucca* species occurring in Canada; it is restricted to several hundred plants at two sites near Onefour.

TINEIDAE

Nemapogon acapnopennella (Clemens, 1863)

ID: A small (14 mm WS) dark brown and pearly white mottled moth (Fig. 17). The wing pattern is rather nondescript, but is subtly different from other species of the genus known to occur in northwestern North America. Dietz (1905) provides a re-description. Genitalia illustrations of this species have not been published.

AB REC: Edmonton (edge of Fulton Ravine), 53.545°N 113.439°W, 21 July 2001, sesiid pheromone trap, G.G. Anweiler [NFRC] (5 specimens). Touchwood Lake, 30 km E of Lac La Biche, Rge. 10 Twp. 67 Sec. 32 W 4th Mer., 29 June 1994, UV trap M2-2, G.R. Pohl et al. [NFRC]; Rge. 10 Twp. 68 Sec. 3 W 4th Mer., 14 July 1995, UV trap O4-5/6, D.W. Langor et al. [NFRC] (2

specimens).

DIST: This is the first record of this species in Canada. It was previously known only in eastern USA, in Pennsylvania, Maryland, Washington DC, and Louisiana (Dietz 1905). Specimens in the NFRC from Saskatchewan have recently been identified as this species.

BIO: Unknown. Larvae of other members of the genus feed on bracket fungi (Lawrence & Powell 1969). Adults are rarely collected at lights.

COM: It is interesting that several adults were collected in a sesiid trap; they were males, and were observed in the trap performing complex behavior consistent with courtship. The pheromones of this species are not known, but may contain components chemically similar to those in the sesiid bait. The identity of the specimens listed above was confirmed by D. R. Davis (National Museum of Natural History, Smithsonian Institution, Washington DC, USA). Another, possibly undescribed species of *Nemapogon*, externally similar to *N. acapnopennella* but with different genitalia, has been collected in sympatry with *N. acapnopennella* at the Touchwood Lake site reported above (Pohl et al. 2004). It may prove to be conspecific with an undescribed species similar to *N. acapnopennella* reported from Quebec (Handfield 1997).

PSYCHIDAE

Taleporia walshella (Clemens, 1862)

ID: A small (12 to 15 mm WS) nondescript moth. Males have an indistinct FW pattern of chestnut brown marks over a light brown background; females are wingless and rarely collected. Davis (1964) provides a detailed description and illustrations. The larvae and females look very similar to those of *Dahlica triquetrella* (see below); the larvae of these species are indistinguishable, and the females are separable only via microscopical examination of abdominal spines, as described by Sauter (1956).

AB REC: Cypress Hills, Elkwater Lake, 17 June 1996, at light [POHL]. 29 km NE of Zama City, 59.33°N 118.43°W, boreal forest, 17 June 1997, UV trap, G.R. Pohl et al. [NFRC] (5 specimens); 27 May 1998, UV trap, H.E.J. Hammond et al. [NFRC] (4 specimens).

DIST: This is the first record of the species in northwestern North America. It was previously reported from eastern North America as far N as Sault Sainte Marie, Ontario (Prentice 1965), and as far W as Illinois (Davis 1964).

BIO: Larvae construct and live in elongate triangular cases made of sand grains and debris, from which they feed on lichens (Davis 1964). They have been reared from several tree species in eastern Canada (Prentice 1965); presumably feeding on lichens on the boles.

COM: This species was originally placed in the genus *Solenobia*, which is now considered a junior synonym of *Taleoporia* (Karsholt & Razowski 1996).

Dahlica triquetrella (Hübner, [1813])

ID: The adult female is a minute (3 to 5 mm length) wingless moth which remains associated with the larval case. Males have not been found in North America. Larvae are the most often encountered life stage; they can be found in distinctive three-sided cases approximately 8 mm long, moving about on house walls. Leech & Sugden (1967) provide a description and illustrations of the larva, larval case, and adult female; Medvedev (1978: Fig. 105) provides male illustrations. The larvae and females look very similar to those of *Talporia walshella* (see above); the larvae of these species are indistinguishable, and the females are separable only via microscopical examination of abdominal spines, as described by Sauter (1956).

AB REC: vicinity of Blackfalds, June 2000, J. Broatch [NFRC] (6 specimens). 8 km E-SE of Sherwood Park, October 1998, exterior house walls [POHL] (3 specimens); May 1999, reared [POHL] (2 specimens). 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, May 2000, exterior house walls [POHL].

DIST: This species has been introduced to North America from Europe. It was established in Vernon, British Columbia and Montreal, Quebec by 1927 (Leech & Sugden 1967). It was unknown in the Edmonton area as recently as the 1980s, but has become quite common since then.

BIO: Larvae feed on lichens, and can be found actively moving about throughout the summer and on warm winter days. They are abundant in the Edmonton area, on the walls of buildings. Females are short-lived, and lay eggs on their larval case.

COM: The North American population of this Palaearctic species appears to be entirely composed of parthenogenetic, wingless females. Winged males are known from Europe (Sauter 1956). Listed under **Solenobia** in Hodges et al. (1983), the species is now placed in **Dahlica** (Karsholt & Razowski 1996).

GRACILLARIIDAE

Micrurapteryx salicifoliella (Chambers, 1872)

ID: A minute (9 to 12 mm WS) moth with very narrow wings and a distinctive FW pattern of diagonal white marks on a dark brown background (Fig. 18). Ives & Wong (1988) provide a brief description and illustrations of the adult, larva, and blotch mine.

AB REC: Junction of Ft. Chipewyan winter road and

Richardson River, 58.0079°N 111.0271°W, river margin, 12 June 2000, diurnal, G.R. Pohl et al. [NFRC] (2 specimens); 13 June 2000, UV trap, G.R. Pohl et al. [NFRC] (2 specimens). Edmonton, Winterburn Road, 20 April 1983, G.D. Braybrook [CNC]. High Level, ex. *Salix* sp., reared, emerged 2-7 August 1963 [NFRC] (7 specimens); [CNC] (2 specimens). High Level, ex. *Salix* sp., reared, emerged 27-29 July 1964 [NFRC] (3 specimens). 30 km S of High Level, ex. *Salix* leaf mines, reared, 8 July 1993, D.W. Langor [NFRC] (7 specimens); [CNC] (4 specimens). Highway 35, 20 km S of Indian Cabins, ex. *Salix* sp., reared, 15 July 1990 [NFRC]. Keg River, ex. *Salix* sp., reared, 27 July 1965 [NFRC] (3 specimens). Marguerite Crag & Tail Provincial Wildland Park, 57.7107°N 110.3337°W, stream margin, 15 June 2000, adults on *Salix*, G.R. Pohl et al. [NFRC] (7 specimens). Maybelle River Provincial Wildland Park, 58.2092°N 110.9234°W, sand dunes, 12 June 2000, at dusk, G.R. Pohl et al. [NFRC]. Paddle Prairie, ex. *Salix* sp., reared, emerged 22-28 July 1964 [NFRC] (6 specimens). 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, 28 October 2001, diurnal [POHL]. Steen River, ex. *Salix* sp., reared, emerged 5-13 August 1963 [NFRC] (6 specimens); [CNC] (3 specimens). 29 km NE of Zama City, 59.33°N 118.43°W, boreal forest, 28 May 1997, 4 June 1997, 6 August 1997, UV trap, G.R. Pohl et al. [NFRC] (8 specimens).

DIST: Ives & Wong (1988) report this species from the Prairie Provinces, but give no specific provincial or locality records other than the fact that it has been abundant in north-central Saskatchewan. The NFRC contains specimens from Saskatchewan, Manitoba, and Northwest Territories.

BIO: Larvae are blotch miners on *Salix* (Salicaceae) species. Adults emerge in August and remain active into October. They overwinter as adults, and reappear on warm days from March to May the following spring. They tend to fly at dusk, but are sometimes collected at lights.

YPSOLOPHIDAE

Ypsolopha dentella (Fabricius, 1775)

ID: A medium-sized (18 to 20 mm WS) moth with falcate FW with a distinctive pattern; the costal three fourths of the wing is chocolate brown, separated from the yellow caudal area by a thin white line that extends into the brown area at about two-thirds the distance from the wing base. Parenti (2000: Plate 52) provides an excellent color photograph.

AB REC: Mountainview County, Olds, 4 September 1995, 14 September 1995, 27 July - 4 August 1997, 25

July 1998, 14 August 1998, 18-25 August 2000, 14 September 2000, LT, E. Mengersen [BIRD] (2 specimens); [NFRC]; [OLDS] (12 specimens). Stettler County, McKenzie Crossing, 13 km W of Big Valley, 15 September 2000, E. Mengersen [OLDS].

DIST: This introduced European species has not been previously reported in western North America. It is listed by Handfield (1997) as occurring in Quebec/Labrador, and by Forbes (1923) as occurring in northeastern USA (treated by the latter as "*Cerostoma* [=*Plutella*] *xylostella* Linnaeus", a name that now refers to the diamondback moth; however the description by Forbes unmistakably refers to *Y. dentella*).

BIO: Larvae feed on *Lonicera* (Caprifoliaceae). Agassiz (1996) provides a short account of the life history.

COM: This species is known as the European Honeysuckle Leafroller. It has probably been introduced to our area within the last four decades.

PLUTELLIDAE

Plutella vanella Walsingham, 1881

ID: A medium sized (15 to 17 mm WS) moth with a distinctive FW pattern, consisting of a chocolate-brown background, two diagonal white bands which converge on the caudal margin, and a white mark on the costal margin between the diagonal bands (Fig. 2). This species has not been treated in the Nearctic literature since its original description.

AB REC: Banff, ex. white spruce, reared, 26 July 1952 [CNC]. 23 [miles?] W [of] Banff, ex. white spruce, reared, 21 August 1953 [CNC]. Bearberry Creek near Sundre, 23 July 1926, C.H. Young [CNC]. Belly River, ex. white spruce, reared, 26 July 1954 [CNC]. Big Horn River, ex. white spruce, reared, 18 July 1952 [CNC]. 20 miles W-SW Claresholm, ex. willow, reared, emerged 22 July 1956 [NFRC]. Clearwater County, 30 km W of Sundre, NE 12 Twp. 34 Rge. 7 W 5th Mer., 1-14 August 1999, E. Mengersen [OLDS] (6 specimens). Clearwater County, 10 km NW of Bearberry, 24 July 2001, 4 August 2001, 15 July 2002, 19 July 2002, E. Mengersen [OLDS] (11 specimens). Entrance, 7 August 1963, LT [NFRC]. Erskine, 52.32°N 112.88°W, 800 m, aspen parkland, 20 July 2002, UV LT [BIRD]. Ft. McMurray, Hangingstone River Valley off Highway 63, 56.68490°N 111.35508°W, *Populus, Picea, Abies & Alnus* forest, 12 July 2001, MV light, A.D. Macaulay et al. [NFRC] (3 specimens). Grande Cache, 3 km N of South Smoky River Campground, at river, 53.89029°N 119.15671°W, 953 m, aspen/spruce forest, 8 August 2003, UV trap, D. Macaulay [DAM]. Grande Prairie, 16 July 1963, LT [NFRC]. Holmes Crossing Staging Area, 7.3 km SE of Fort Assiniboine, 54.29403°N 114.86665°W, pine forest,

18 July 2003, UV trap, D. Macaulay [DAM]. Jasper, 26 July 1926, J.H. McDunnough [CNC]. La Butte Creek Wildland Provincial Park, rock outcrop 13 km E of junction of La Butte Creek and Slave River, 59.36549°N 111.12988°W, open *Pinus banksiana/Picea*, 9 July 2001, UV trap, A.D. Macaulay et al. [NFRC]. La Butte Creek Wildland Provincial Park, 3 km S of junction of La Butte Creek and Slave River, La Butte Point, 59.40578°N 111.45251°W, *Picea glauca* forest, 8 July 2001, MV light, A.D. Macaulay et al. [NFRC]. Medicine Lake Recreational Area, 52.749°N 114.744°W, 950 m, aspen/alder woods beside lake, 5 August 2003, UV LT [BIRD]. 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 28 July 2003, MV light [POHL]. Mountainview County, 3 km NE of Bergen, 17 July 1989, E. Mengersen [OLDS]; Camp Harmattan, 26 July 1997, E. Mengersen [OLDS]; SW 13 Twp. 33 Rge. 4 W 5th Mer., 26 June 1988, E. Mengersen [OLDS]. 38 km NW of Sundre, bench above James River, 51.80°N 115.21°W, 1360 m, lodgepole pine, 28 July 2002, UV LT [BIRD] (3 specimens). 8 km NW of Winfield, 53.01°N, 114.50°W, mixed woods, 15 July 2000, 28 July 2000, 11 July 2001, 18 July 2001, 17 July 2003, UV LT [BIRD] (16 specimens); 17 July 2003, MV light [BIRD] (2 specimens). 29 km NE of Zama City, 59.33°N 118.43°W, boreal forest, 28 July 1997, 6 August 1997, UV trap, G.R. Pohl et al. [NFRC] (3 specimens).

DIST: This species is reported for the first time in Canada. It has been treated in the North American literature only in California (Powell & Hsu 1998; Powell 1999).

BIO: Unknown, other than the rearing note on one of the specimens listed above.

COM: It is odd that this common and distinctive species was missed by Bowman (1951). It appears to be generally distributed in the northern half of the province and in the parkland and foothills.

ACROLEPIIDAE

Acrolepiopsis liliivora Gaedike, 1994

ID: A small (12 to 15 mm WS) moth with brown FW with diffuse blackish irrorations and a small white triangular oblique mark in the middle of the caudal edge (Fig. 3). Gaedike (1994) provides a description and genitalia illustrations, including characters for distinguishing it from similar species of *Acrolepiopsis*.

AB REC: 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 21 April 2001 [POHL]; 20 June 2001, house light, G.R. Pohl [CNC]; 22 June 2002, MV light, G.R. Pohl [CNC], 14 April 2003, at dusk [POHL].

DIST: This is the first record of the species in Canada. It was previously known from California and Oregon (Gaedike 1994).

BIO: Some of the type material of this species was reared from the bulbs of *Lilium washingtonianum* Kell. (Liliaceae), which does not occur in Alberta. Several other Liliaceae species occur in Alberta (Moss 1983). In 2003 the authors collected a larva of an Acrolepiidae species which had been mining an unripened fruit of fairy bells (*Disporum trachycarpum* (S. Wats.) B. & H. (Liliaceae)), from the site where the above specimens were collected.

COM: The type material of this species included only six specimens and we are unaware of other published records besides the original series and the specimens reported here. This species was considered distinct from *A. californica* Gaedike by Gaedike (1994) on the basis of slight genitalic differences, and a different host plant (*A. californica* was reared from *Disporum hookeri*). Dr. J.A. Powell (pers. comm.) has reared *A. californica* from both *Lilium* and *Disporum* in California, and considers *A. liliivora* to be conspecific with *A. californica*. This is the first report of the family Acrolepiidae from western Canada.

GLYPHIPTERIGIDAE

Glyphipterix montisella Chambers, 1875

ID: A small (12 mm WS) moth with greenish brown FW, with a series of white marks along the costal and caudal wing margins. Heppner (1985) provides a description and illustrations, including genitalic characters for separation from similar species of glyphipterigids.

AB REC: Calgary, 17 August 1984, D. Lawrie [NFRC].

DIST: This is the first report of this species in Canada. It was previously known from western USA, as far north as Glacier National Park, Montana (Heppner 1985). G.R. Pohl has seen a specimen from the vicinity of Weyburn in SE Saskatchewan.

BIO: Larvae may feed on one or more species of *Juncus* (Juncaceae) (Heppner 1985).

ELACHISTIDAE
Depressariinae

Semioscopis merriccella Dyar, 1902

ID: A relatively large (22 to 30 mm WS) grey moth with grey FW extended into a blunt tip, and with an interrupted, wavy black line through the center. It can be separated from *S. packardella* (Clem.) by the wavy black line through the FW, which is uninterrupted in the latter species. Hodges (1974) provides a description and photograph; Clarke (1941) provides genitalia illustrations.

AB REC: Big Knife Provincial Park, 52.49°N

112.22°W, chokecherry/saskatoon, 1 May 2002, UV LT [BIRD]; 14 May 2003, UV LT [BIRD] (2 specimens). Holmes Crossing, 7 km SE of Fort Assiniboine, 12 May 2001, mixedwood forest, D. Macaulay [NFRC]. Red Deer, 3 May 1923, K. Bowman [UASM].

DIST: Hodges (1974) reports this species "from Maine west through the northern tier of States and southern Canada to British Columbia" but does not specifically mention Alberta. Though expected, these are the first records known from Alberta.

BIO: Unknown.

Depressaria atrostrigella Clarke, 1941

ID: A relatively large (22 to 25 mm WS) grey moth with a series of straight black dashes along the veins of the FW. It is similar in overall habitus to several other species of Depressariinae, but no other North American species has this FW pattern. Hodges (1974) provides a description and photograph; Clarke (1941: Fig. 194) provides male genitalia figures.

AB REC: Buffalo Lake Conservation Area, 52.53°N 112.70°W, aspen parkland, 17 September 2001, 24 September 2001, UV LT [BIRD] (2 specimens). Edmonton, 5 September 1950, K. Bowman [UASM]. Tolman Bridge, 51.33504°N 113.01042°W, 707 m, *Stipa/Artemisia* grassland, 24 August 2003, UV LT [BIRD] (2 specimens). Tolman Bridge, 51.83461°N 113.01139°W, 706 m, chokecherry/aspen, 24 Aug 2003, UV LT [BIRD].

DIST: Previously reported from Manitoba and Colorado (Hodges 1974).

BIO: Unknown.

Elachistinae

Elachista maritimella McDunnough, 1942

ID: A small (10 mm WS) variably colored moth with narrow wings. The FW is usually grey with two pairs of white transverse patches on the leading and caudal margins at one-third and two-thirds from the base. Individual specimens may vary from very dark to completely white. Kaila (1999) provides a description and illustrations, including genitalic characters for separation from many similar *Elachista* species.

AB REC: 8 km NW of Winfield, 53.01°N, 114.50°W, mixed woods, 24 June 2000, UV LT [BIRD].

DIST: Previously known from eastern Canada and from Saskatchewan (Kaila 1999).

BIO: Unknown.

Agonoxeninae

Blastodacna curvilineella (Chambers, 1872)

ID: A small (11 to 17 mm WS) moth with lanceolate wings. The FW is cream colored with a dusting of brown scales and two patches of black tufted scales (Fig. 4). A black dash is present on some specimens in the center of the FW. Forbes (1923) provides a brief description; we know of no published illustration of it.

AB REC: Cypress Hills, 49.57°N 110.35°W, mixedwood hillside, 15 June 1996, UV trap [POHL]. Cypress Hills, 49.63°N 110.40°W, aspen hillside, 15 June 1996, UV trap [POHL] (2 specimens). Cypress Hills, Elkwater Lake, 17 June 1996, at light, G.R. Pohl [NFRC]; [POHL] (2 specimens). Rochon Sands Provincial Park, 52.46°N 112.88°W, 720 m, chokecherry/saskatoon, 1 May 2004, UV LT [BIRD]. 8 km E-SE of Sherwood Park, wet meadow, 7 June 1996 [POHL]. 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 20 June 2000, MV light [POHL].

DIST: This species was previously known from eastern United States (Forbes 1923) and Quebec/Labrador (Handfield 1997), and has recently been reported from Touchwood Lake in east-central Alberta (Pohl et al. 2005). The current records indicate a broader distribution in Alberta.

BIO: Larvae are borers in the fruit of *Crateagus* and related species of Rosaceae (Forbes 1923).

COM: This species is extremely similar to *Blastodacna bicristatella* (Chambers) (not known from northwestern North America), and may be conspecific with it.

XYLORYCTIDAE
Scythridinae

Scythris mixaula Meyrick, 1916

ID: A medium-sized (18 mm WS), grey to dirty white slender moth, in some specimens with paler streaks highlighting the FW veins. Landry (1991) provides a description and illustrations, including genitalic characters for separation from similar species. The coloration of *S. mixaula* varies across its range from nearly immaculate ivory white in the South to darker grey in the North. The Tolman Bridge specimen is rather dark grey (though discolored by greasiness) whereas the Buffalo Lake specimen is pale dirty white with some pale brown dusting in the middle of the FW.

AB REC: Buffalo Lake Conservation Area, 52.4985°N 112.702°W, *Artemisia* grassland, 30 August 2003, UV LT [BIRD]. Tolman Bridge Recreation Area, 16 September 2000, LT, E. Mengersen [CNC].

DIST: This is the first record of the species in Canada. It was previously known from southern California to southwestern Texas and the western parts of the Great Plains, N to Montana (Landry (1991).

BIO: Larvae have been reared from cactus, including prickly pear cactus (*Opuntia* spp.) although details of

their life history are unknown (Landry 1991).

GLYPHIDOCERIDAE

Glyphidocera hurlberti Adamski, 2000

ID: A medium-sized (17 to 19 mm WS) moth with greyish brown FW and pale brown HW. Adamski (2000) provides a description and illustrations. It can be separated from all known Lepidoptera in western Canada by the combination of the evenly arcuate HW terminal margin (separating it from all gelechiids except *Anacampsis* spp.) and the unique pattern of four indistinct dark brown spots on the FW. It can be separated from other *Glyphidocera* species by the unique shape of the genitalic structures, as described by Adamski (2000).

AB REC: Big Knife Provincial Park, 52.486°N 112.206°W, 692 m, meadow with aspen/buckbrush, 8 July 2003, UV LT [BIRD]. Edmonton, 24 July 1939, 4 July 1940, 20 June 1941, 2 July 1943, 11-27 July 1945, 24 June to 13 July 1950, K. Bowman [UASM] (15 specimens). Edmonton, Windsor Park area, 8 July 1998, UV LT, F.A.H. Sperling [UASM]. Erskine, 52.32°N 112.88°W, 800 m, aspen parkland, 8 July 2000, 1 August 2000, 12 July 2001, 5 August 2002, UV LT [BIRD]. 12 km S-SE of Erskine, 52.20°N 112.83°W, 800 m, 24 July 2000, UV LT [BIRD]. Lowden Springs Conservation Area, 17 km S of Stettler, 52.09°N 112.425°W, 830 m, 23 July 2002, UV LT [BIRD] (3 specimens). 3 km S of Nevis, Allen Hall acreage, 52.31°N 113.05°W, 815 m, aspen parkland, 15 September 2002, 16 July 2003, UV LT [BIRD]. 8 km E-SE of Sherwood Park, wet meadow, 6 July 1999, at dusk [POHL]. 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 19 July 2000, houselight [POHL]; 11 July 2002, MV light [POHL] (2 specimens); 25 June 2003, houselight [POHL]. Strathcona County, Strathcona Wilderness Centre, aspen forest, 20 July 2001, MV light [POHL].

DIST: Previously known only from Colorado (Adamski 2000).

BIO: Unknown. Adults are active at dusk and at night, flying and running with rapid jerky movements.

COM: Prior to it being recognized as a distinct species in 2000, *G. hurlberti* specimens were often identified as *G. septentrionella* Busck. Specimens in the Bowman collection were found scattered in undetermined lots under several families. This is the first published report of the family Glyphidoceridae in Alberta.

COLEOPHORIDAE
Coleophorinae

Coleophora rosaefoliella Clemens, 1864

ID: A small (11 to 12 mm WS) cream-colored moth with the distal third of the FW light rusty brown and white, and with brown annulations on the antennae. Landry (1998b) provides illustrations of the genitalia and larval case, which allow separation from similar species of *Coleophora*.

AB REC: Edmonton, 14-19 June 1940, 11-18 June 1946, K. Bowman [UASM] (5 specimens).

DIST: This species was described from Pennsylvania, and has been reported from Nova Scotia, Ontario, Quebec, and British Columbia (McDunnough 1946, Landry 1998b).

BIO: Larvae are case-bearers, and feed attached to the base of leaf buds of *Rosa* species (Rosaceae) (McDunnough 1946).

GELECHIIDAE

Coleotechnites laricis (Freeman, 1965)

ID: A small (10 to 11 mm WS), narrow-winged black and white moth, very similar to other species of *Coleotechnites* which feed on conifers. Freeman (1965) provides a description and illustrations. It can be identified most easily by the mining habits of the larva (see below); structural differences separating it from other species are very slight.

AB REC: Edmonton, ex. *Larix* sp., reared, 3 June 1985 [NFRC].

DIST: Previously known from the type series, collected at various localities in Ontario (Freeman 1965), and more recently from Quebec/Labrador (Handfield 1997).

BIO: This species is known as the Orange Larch Tubemaker. Larvae are needle miners in larch (*Larix* spp. (Pinaceae)) (Freeman 1965).

COM: The specimen listed above was identified in 1985 by A. Mutuura.

Xenolechia velatella (Busck, 1907)

ID: A medium-sized (14 to 16 mm WS) dark grey moth with a unique pattern on the FW; a pale tan costal margin proximally, and a distinct pattern of raised patches of black scales (Fig. 5).

AB REC: Big Knife Povincial Park, 52.494°N 112.222°W, 675 m, chokecherry/saskatoon, 14 May 2003, UV LT [BIRD] (3 specimens); MV light [BIRD] (3 specimens). Buffalo Lake Conservation Area, 52.53°N 112.70°W, aspen parkland, 7 May 2001, UV LT [BIRD]. Edmonton, 30 May 1946, 26 April 1949, 22 May 1951, K. Bowman [UASM] (3 specimens). Erskine, 52.322°N 112.883°W, 830 m, aspen woods, 20 May 2003, UV trap [BIRD]. Rochon Sands Provincial Park, 52.463°N 112.895°W, 830 m, chokecherry/saskatoon, 13 May 2003, UV LT [BIRD] (8 specimens). 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 4 June 2000, houselight [POHL]; 2 June 2001, at dusk

G.R. Pohl [NFRC]; 25 May 2003, houselight [POHL]; 26 May 2003, MV light [POHL].

DIST: This species was described from Arizona (Busck 1907). The only published record of it in northwestern North America is its inclusion in a list of Lepidoptera specimens collected by FIDS in Saskatchewan and Manitoba, by Wong & Melvin (1969).

BIO: The specimens on which the Wong & Melvin (1969) report is based are housed in the NFRC; they were reared from Black Knot Fungus (*Apiosporina morbosa* (Schw.) Arx on *Prunus* species (Rosaceae) tree branches.

Caryocolum pullatella (Tengström, 1848)

ID: A small (11 mm WS) black moth, with two median grey patches on the caudal margin of the FW, and a white postmedial line. Huemer (1988) provides a description and illustrations, including genital characters for separation from other species of *Caryocolum*.

AB REC: J. J. Collett Natural Area, 11 km NE of Lacombe, 52.33°N 113.28°W, 850 m, 27 August 2002, UV LT [BIRD].

DIST: This holarctic species is known from Europe, northern Asia, and Japan. In North America it has been reported in the United States from New York to Oregon, and from Canada in Nova Scotia (Huemer 1988).

BIO: Unknown. All known hosts of other *Caryocolum* species are in the family Caryophyllaceae (Huemer 1988); the host plant of *C. pullatella* is likely a Caryophyllaceae species as well.

Caryocolum cassella (Walker, 1864)

ID: A small (12 to 13 mm WS) black moth, with two median grey patches on the caudal margin of the FW, and an interrupted white postmedial line. Huemer (1988) provides a description and illustrations, including genital characters for separation from other species of *Caryocolum*.

AB REC: Big Knife Provincial Park, 52.49°N 112.22°W, 8 August 2002, UV LT [BIRD]. 13 km W of Big Valley, McKenzie Crossing, 52.375°N 112.96°W, 16 July 2000, UV LT [BIRD].

DIST: This Holarctic species has been reported from British Columbia (Vancouver Island), and from Utah, Oregon, Michigan, and Kentucky (Huemer 1988).

BIO: In Europe, this species feeds on *Stellaria nemorum* L. (Caryophyllaceae) (Huemer 1988). The larvae feed in webbed-together shoots, "particularly in shadowy woodland" (Huemer 1988).

Dichomeris bilobella (Zeller, 1873)

ID: A medium sized (16 to 17 mm WS) blue-grey and black moth with a triangular FW, featuring a distinctive tan costal band bordered by a black mark. Hodges (1986) provides a re-description and illustrations. It can be separated from other species of *Dichomeris* by details of the FW maculation, or by genitalic characters, as detailed in Hodges (1986).

AB REC: 5 miles E Belloy, undisturbed young forest, reared [host recorded as "probably *Aster* species"], larva collected 8 June 1967, emerged 28 June 1967 [NFRC]. 12 km S-SE of Erskine, 52.23°N 112.83°W, aspen parkland, 15 August 2000, UV trap [BIRD]. 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 5 August 2000, houselight [POHL].

DIST: Previously known from eastern North America, as far W as Minnesota and eastern Kansas (Hodges 1986). Handfield (1997) reported it from Quebec/Labrador.

BIO: Larvae are leaf rollers on *Solidago* and *Aster* species (Compositae) (Hodges 1986).

Dichomeris costarufoella (Chambers, 1874)

ID: A small (15 mm WS) moth with dark bluish brown FW. Hodges (1986) provides a description and illustrations, including characters for separation from similar species of *Dichomeris*.

AB REC: 8 km E-SE of Sherwood Park, wet meadow, 17 July 1998, at light, G.R. Pohl [NFRC].

DIST: Previously known from the central United States, as far W as Nebraska and New Mexico. A single record was previously known for Canada, at Riding Mountain National Park, Manitoba (Hodges 1986).

BIO: At Riding Mountain National Park, *D. costarufoella* was reared from *Rudbeckia* species (Compositae) (Hodges 1986). In Michigan, this species is commonly found in loose webs on the underside of *Rudbeckia* species leaves, especially in areas with sandy soils (G. J. Balogh pers. com.). No *Rudbeckia* species is present at the Sherwood Park locality, so it must have other hosts as well.

SESIIDAE

Paranthrene robiniae (Edwards, 1880)

ID: A relatively large (28 to 35 mm WS) slender moth with a wasp-like appearance. The wings have clear areas and dark brown veins dusted with yellow scales. Eichlin & Duckworth (1988) provide a description and illustrations, including characters for separation from similar species of sesiids.

AB REC: Calgary, poplar, 14 June 1970, C. Hergert [CNC] (2 specimens). Calgary, 8 June 1988, A.B. Nearling [OLDS]. Crowsnest, 29 June 1957, R. Gooding [UASM]. Devon, 28 May 1976 [NFRC]. Frank, 18 June 1962, W.R.M. Mason [CNC].

DIST: Eichlin & Duckworth (1988) describe the

range of this species as the Rocky Mountains from Alaska to California, with a single record from western Kansas. No specific records are mentioned from Alberta. The Kansas and Devon specimens are the only known records from outside the Rocky Mountains.

BIO: Larvae are borers in *Populus*, *Salix* (Salicaceae) and *Betula* (Betulaceae) species stems and branches, preferring weak or damaged trees (Eichlin & Duckworth 1988). They can cause damage to ornamentals.

Synanthedon pictipes (Grote & Robinson, 1868)

ID: A relatively large (20 to 22 mm WS) clear-winged moth with a bluish-black body and yellow markings on the legs and body. Eichlin & Duckworth (1988) provide a description and illustrations, including maculation and genitalic characters for separation from other *Synanthedon* species.

AB REC: Edmonton (edge of Fulton Ravine), 53.545°N 113.439°W, 12 July 2001, sesiid pheromone trap, G.G. Anweiler [UASM]; 10-13 July 2003, sesiid pheromone trap, G.G. Anweiler [UASM]; [CNC].

DIST: Ives & Wong (1988) report this species from the Prairie Provinces, based on specimens from Saskatchewan and Manitoba in the NFRC. It was reported from eastern North America as far W as Minnesota, by Eichlin & Duckworth (1988).

BIO: Larvae bore into stems and branches of Rosaceae species, preferring sites of injury or disease (Eichlin & Duckworth 1988). Series of specimens have been reared in Saskatchewan and Manitoba from Black Knot Fungus (*Apiosporina morbosa* (Schw.) Arx infections on *Prunus virginia* L. (Rosaceae) trees.

COM: This species is known as the Lesser Peach Tree Borer, and is a serious pest in fruit-growing regions. Identification of specimens listed above was confirmed by Dr. T.D. Eichlin (CDFA/Entomology, Plant Pest Diagnostics Centre, Sacramento, CA, USA).

Synanthedon fatifera Hodges, 1962

ID: A small to medium-sized (12 to 20 mm WS) clear-winged moth with a bluish-black body. Eichlin & Duckworth (1988) provide a description and illustrations, including maculation and genitalic characters for separation from other *Synanthedon* species.

AB REC: 35 km NW of Dixonville, EMEND site, 56.733°N 118.333°W, 26 July 2000, pheromone trap, L. Morneau [UASM] (3 specimens). Edmonton, Devon Ravine, 20 July 1971, J. Belicek [UASM]. Edmonton, 21 July 1971, J. Belicek [UASM]. Edmonton (edge of Fulton Ravine), 53.545°N 113.439°W, 6 July 2000, sesiid pheromone trap, G.G. Anweiler [UASM]; [CNC]. Fort McMurray, 56.73°N 111.38°W, 3 July 1999, sesiid

pheromone trap, D. Macaulay [DAM]. Gregoire Lake, 54.476°N 111.193°, 22 June 1998, B.C. Schmidt [UASM]. Manning, 10-15 July 2001, *Choristoneura fumiferana* pheromone trap, D. Macaulay [NFRC] (10 specimens); [UASM]. Ministik Lake, 15 km W of Tofield, 19-26 May 1998, *Malacosoma disstria* pheromone trap, B.C. Schmidt [UASM]; 30 July 1999, B.C. Schmidt [UASM]. 8 km NW of Winfield, 53.01°N 114.50°W, 900 m, mixed woods, diurnal, 21 July 2003 [BIRD]. 29 km NE of Zama City, 59.33°N 118.43°W, boreal forest, 10-15 July 2001, *Choristoneura fumiferana* pheromone trap, D. Macaulay [NFRC].

DIST: Previously known from eastern North America, as far W as Wisconsin and southern Ontario, with a single record from Idaho (Eichlin & Duckworth 1988).

BIO: Larvae are borers in *Viburnum* species (Caprifoliaceae) stems (Eichlin & Duckworth 1988).

COM: *Synanthedon fatifera* appears to be the most common and widespread species of *Synanthedon* in the boreal forest region of Alberta, and probably occurs across the boreal forest of western Canada. It appears that previous reports of *S. viburni* (Engel.) in Alberta (Ives & Wong 1988) are actually misidentified *S. fatifera*. The only confirmed Alberta specimens of *S. viburni* are two specimens found in Forest Tent Caterpillar pheromone traps at Gregoire Lake in 2002 by B.C. Schmidt (specimens in UASM). It is noteworthy that adults of *S. fatifera* were collected in Spruce Budworm (*Choristoneura fumiferana* (Clem.)) and Forest Tent Caterpillar (*Malacosoma disstria* Hübner) pheromone traps.

Synanthedon culiciformis (Linnaeus, 1758)

ID: A medium sized (15 to 20 mm WS) clear-winged moth with a black body and a red transverse band around the abdomen. Eichlin & Duckworth (1988) provide a description and illustrations, including maculation and genitalic characters for separation from other *Synanthedon* species.

AB REC: 35 km NW of Dixonville, EMEND site, 56.733°N 118.333°W, 19 July 2000, pheromone trap, L. Morneau [UASM] (2 specimens). Ministik Lake, 15 km W of Tofield, 19-26 May 1998, pheromone trap, B.C. Schmidt [UASM] (6 specimens); [NFRC]. 80 miles NW of Peace River, date unknown, pheromone trap, L. Morneau [UASM].

DIST: This is a holarctic species, previously known in North America from Alaska to California and Utah, but not specifically reported from Canada (Eichlin & Duckworth 1988).

BIO: Larvae are borers in *Alnus* and *Betula* species (Betulaceae). In North America they prefer the former.

while in Europe they prefer the latter (Eichlin & Duckworth 1988). They prefer to attack trees that are injured, or growing in disturbed or exposed areas.

COM: This species is known as the Large Red-Belted Clearwing.

Synanthedon helenis (Engelhardt, 1946)

ID: A medium-sized (18-22 mm WS) clear-winged moth with completely dark antennae and a blue-black body with two narrow pale yellow bands on the abdomen. Eichlin & Duckworth (1988) provide a description and illustrations, including maculation and genitalic characters for separation from other *Synanthedon* species.

AB REC: Ministik Lake, 15 km W of Tofield, 29 June 1999, pheromone trap, B.C. Schmidt [UASM] (4 specimens). Wagner Fen Natural area, 15 km W of Edmonton, 19 July 1999, pheromone trap, A. Ngui [UASM] (2 specimens); 27 July 1999, pheromone trap, A. Ngui [UASM] (5 specimens). Caribou Mountains, Wentzel River near outlet, 7-9 July 2003, malaise trap, G. Hilchie [UASM].

DIST: Previously known from three specimens collected in Saskatchewan and Manitoba (Eichlin & Duckworth 1988), and from a single locality in Quebec (Handfield 2002).

BIO: Unknown.

COM: Identification of specimens listed above was confirmed by T.D. Eichlin.

Synanthedon saxifragae (Edwards, 1881)

ID: A relatively large (20 to 25 mm WS) clear-winged moth with a bluish-black body and orange legs. Eichlin & Duckworth (1988) provide a description and illustrations, including maculation and genitalic characters for separation from other *Synanthedon* species.

AB REC: Banff, 5 July 1922, C.B.D. Garrett [CNC]. Frank, 18 June 1962, K.C. Herrmann [CNC]. Prospect Creek, 2000 m, open conifer willow subalpine at treeline, on flower, 13 July 2001, G.G. Anweiler [UASM].

DIST: This is a transcontinental boreal species, reported from Laborador to Alaska, and S at higher altitudes to Colorado and California (Eichlin & Duckworth 1988). It has not specifically been reported from Alberta.

BIO: Nothing is known of the biology of this species, except that its host plant is "definitely not a saxifrage" (Eichlin & Duckworth 1988).

COM: Identification of the specimens listed above was confirmed by T.D. Eichlin.

Synanthedon proxima (Edwards, 1881)

ID: A medium-sized (17 to 22 mm WS) clear-winged moth with a bluish-black body. Eichlin & Duckworth (1988) provide a description and illustrations, including maculation and genitalic characters for separation from other *Synanthedon* species.

AB REC: Tolman Bridge Recreation Area, 51.8325°N 113.0106°W, 1 July 2001, pheromone trap, G.G. Anweiler [UASM] (4 specimens).

DIST: Previously known from eastern and central North America, as far W as Manitoba (Eichlin & Duckworth 1988).

BIO: Larvae are borers in stems of *Salix* species (Salicaceae) (Eichlin & Duckworth 1988).

COM: *Synanthedon proxima* and S. *albicornis* are sister species. Eichlin & Duckworth (1988) believed that the former was restricted to eastern forests only as far W as Manitoba, and that the latter was restricted to the Rocky Mountains. Identification of the specimens listed above was confirmed by T.D. Eichlin.

TORTRICIDAE
Tortricinae

Acleris paracinderella Powell, 1964

ID: A medium-sized (15 to 20 mm WS) moth with bluish-grey FW and cream colored HW (Fig. 6). The FW has a dusting of black scales, and a distinctive white stripe on the costal margin, which may be poorly developed in some specimens. Powell (1964) provides a description and genitalia illustrations. It is very similar to *A. minuta* (Robinson) and *A. celiana* (Robinson) form *albilineana* Kearfott; *A. minuta* is without, or with a vaguely suggested, white costal margin on the FW; *A. celiana* form *albilineana* has the white stripe separated from the costal margin by a grey fringe. The genitalia have unique features, which can be used to identify doubtful specimens (Powell 1964, Razowski 1966). An orange summer form, similar to the orange summer form of *A. minuta* (Powell 1964) has been found in California (J.A. Powell pers. comm.).

AB REC: Kananaskis, Elbow Ranger Station, ex. "s. birch" [=*Betula pumilla* L. (Betulaceae)], reared, emerged 29 August 1951 [NFRC].

DIST: Powell (1964) reported this species from "mountainous areas of the Pacific coast from south-central British Columbia south to the northern Sierra Nevada, California."

BIO: Powell (1964) reports the larval host as *Prunus* species (Rosaceae); the rearing reported above from *Betula* represents a new host record.

Sparganothis unifasciana (Clemens, 1864)

ID: A relatively large (20 to 25 mm WS) moth with dark yellow FW with a unique pattern of brown marks. Pogue & Lavigne (1981) provide a description and

illustration.

AB REC: Big Knife Provincial Park, 52.49°N 112.22°W, 675 m, 9 July 2002, 26 August 2002, UV LT [BIRD] (2 specimens). Buffalo Lake Conservation Area, 52.53°N 112.70°W, aspen parkland, 22 June 2001, 27 July 2002, 15 July 2001, UV LT [BIRD] (3 specimens). Dominion Range Station, Manyberries [=Onefour], 3 August 1951, D.F. Hardwick [CNC] (2 specimens). Dry Island Buffalo Jump Provincial Park, 51.93°N 112.97°W, 12 July 2002, UV LT [BIRD] (2 specimens). Erskine, 52.32°N 112.88°W, 800 m, aspen parkland, 20 July 2002, UV LT [BIRD]. Kneehill Co., Tolman Bridge Recreation Area, 51.8325°N 113.0106°W, 21 July 1989, 4 July 2000, 3 July 2001, UV light, E. Mengersen [BIRD]; [OLDS] (5 specimens). 3 km S of Nevis, Allen Hall acreage, 52.31°N 113.05°W, 815 m, aspen parkland, 7 July 2002, UV LT [BIRD]; 22 July 2002 [BIRD] (2 specimens). Olds, 23 July 1998, 20 August 1998, UV light, E. Mengersen [OLDS] (2 specimens). Writing-On-Stone Provincial Park, 20 July 1982, UV light in riverine habitat with willows, J.-F. Landry [CNC].

DIST: Previously known from eastern North America and W as far as Saskatchewan and Utah (Pogue & Lavigne 1981).

BIO: A wide variety of host plants have been reported for this species, including *Trifolium* species (Leguminosae), *Prunus virginiana* L., *Malus*, *Rhubus*, and *Crataegus* species (Rosaceae), *Pinus* species, *Picea glauca* (Moench) Voss (Pinaceae), and *Fraxinus* species (Oleaceae) (Pogue & Lavigne 1981).

Argyrotaenia quadrifasciana (Fernald, 1882)

ID: A small to medium-sized (14 to 17 mm WS) moth with bright orange FW and grey-brown HW. The FW has a unique pattern of two narrow diagonal bands and a wide diffuse area at the wingtip; these markings are purple in males, and dark orange in females. Freeman (1958) and Pogue & Lavigne (1981) provide descriptions and adult habitus images; the latter also provides genitalia illustrations.

AB REC: Big Knife Provincial Park, 52.49°N 112.22°W, 675 m, 26 August 2002, UV LT [BIRD]. Edmonton, ex. *Cotoneaster*, emerged 28 June 1971 [NFRC] (2 specimens).

DIST: Previously known from eastern North America, as far W as eastern Wyoming in the South (Pogue & Lavigne 1981), and Manitoba in the North (Prentice 1965).

BIO: Larvae feed on *Prunus*, *Malus*, and *Crataegus* species, and *Amelanchier alnifolia* Nutt. (Rosaceae) (Pogue & Lavigne 1981). The life history has been studied by Chapman & Lienk (1971). It overwinters as a third-instar larva, in a hibernaculum attached to host tree branches.

COM: This species is known as the Fourlined Leafroller. It is a conspicuous moth, and larval feeding is quite noticeable on ornamental trees; if it were a native species in Alberta, it likely would have been collected more than once by FIDS rangers, or by Kenneth Bowman. It has probably arrived within the past four decades in Alberta.

Argyrotaenia mariana (Fernald, 1882)

ID: A medium-sized (18 to 22 mm WS) moth with light greyish brown FW crossed by a diagonal band of dark brown. Freeman (1958) provides a description and adult illustration.

AB REC: Big Knife Provincial Park, 52.49°N 112.22°W, 675 m, 3 June 2002, MV light [BIRD]. Medicine Lake Grazing Reserve, 9 km SW Winfield, 53.91°N 114.52°W, 975 m, 15 June 2002, UV LT [BIRD]. Rochon Sands Provincial Park, 52.463°N, 112.895°W, 730 m, chokecherry/saskatoon, 28 May 2003, UV LT [BIRD] (4 specimens). 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 4 June 2000, houselight [POHL] (2 specimens); 20 June 2000, MV light [POHL] (4 specimens); 13 June 2002 [POHL]. Wildwood, ex. *Populus tremuloides*, reared, collected 1962, emerged 5 February 1963 [in lab] [NFRC]. 8 km NW of Winfield, 53.01°N, 114.50°W, mixed woods, 17 June 2000, MV light [BIRD]; 15 June 2002, UV LT [BIRD] (2 specimens).

DIST: Previously known from eastern North America as far W as Saskatchewan (Prentice 1965).

BIO: This species is a pest of *Malus* species (Rosaceae). It has also been reported from many other species, including *Vaccinium* species (Ericaceae) and possibly *Quercus* species (Fagaceae) (Freeman 1958), and from *Betula*, *Alnus* (Betulaceae), *Prunus* (Rosaceae), *Salix*, *Populus* (Salicaceae), *Ulmus* (Ulmaceae), and *Acer* (Aceraceae) species (Prentice 1965).

COM: This species is known as the Grey-Banded Leafroller. It is probably a recent arrival in Alberta. It is now common in the Edmonton area; if it had been present at current population levels when Kenneth Bowman was collecting and the FIDS program was active, it would have undoubtedly been collected regularly.

Lozotaenia hesperia Powell, 1962

ID: A relatively large (22 to 24 mm WS) moth, with maculation consisting of two dark brown spots on the costal margin of the brownish-grey FW (Fig. 7). Powell (1962) provides a description and genitalia illustrations. It can be separated from other *Lozotaenia* species via examination of the genitalia, and comparison to figures

in Powell (1962), Obraztsov (1962), and Franclemont (1986).

REC: 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, 25 July 2000, houselight [POHL]. Watson Creek Campground, 5 km NE of Cadomin, 27 June 1982, morning in *Myrica gale* on river bank, J.-F. Landry [CNC]. 29 km NE of Zama City, 59.33°N 118.43°W, boreal forest, 7 July 1997, 15 July 1997, UV trap, G.R. Pohl et al. [NFRC] (5 specimens).

DIST: This species was described from specimens collected in Yukon Territory and Alaska, and it has since been reported from Quebec (Handfield 2002). The NFRC and POHL collections also have specimens from Saskatchewan.

BIO: Unknown.

Olethreutinae

Apotomis paludicolana (Brower, 1953)

ID: A medium-sized (15 to 18 mm WS) moth with dark greyish brown on the distal two-thirds, and white on the apical one-third of the FW. Adamski & Peters (1986) provide a description and illustrations, including maculation and genital characters for separation from other *Apotomis* species.

AB REC: Edmonton, 15 June 1933, 20 June 1938, 11 June 1941, 7 June 1948, 6 June 1949, K. Bowman [UASM] (5 specimens).

DIST: This species was described from Maine, and has since been reported from New Brunswick (Adamski & Peters 1986) and Quebec (Handfield 2002).

BIO: This species is known from bog habitats (Brower 1953). Adamski & Peters (1986) state that according to Brower (1953), the host is *Myrica gale* (L.) (Myricaceae). However, Brower (1953) contains no such information. *M. gale* is a bog species, but is not known within 500 km of Edmonton (Moss 1983).

COM: The above specimens were likely identified by Bowman (1951) as *A. capreana* (Hübner) or *A. tertiana* (McDunnough). They were determined by D. Adamski in 1981 as *A. paludicolana*, but they were not incorporated into Adamski & Peters' (1986) revision of the genus. Their identity was confirmed by the first author of the current paper.

Phaneta lapidana (Walsingham, 1879)

ID: A medium-sized (18 to 19 mm WS) brownish grey moth with no markings on the FW. Wright et al. (1997) provide habitus and genitalia illustrations, and describe genital characters for separation from similar species.

AB REC: Buffalo Lake Conservation Area, 52.53°N 112.70°W, aspen parkland, 24 September 2001, UV LT [BIRD]. Rochon Sands Provincial Park, 52.463°N 112.895°W, 720 m, aspen parkland, 14 September 2001,

UV LT [BIRD].

DIST: Previously known from Oregon and the Chilcotin Plateau in British Columbia. (Wright et al. 1997).

BIO: Unknown.

Zeiraphera hesperiana Mutuura & Freeman, 1966

ID: A medium-sized (14 to 18 mm WS) moth with a mottled brown and white pattern on the FW. Mutuura & Freeman (1966) provide a description and illustrations. It is somewhat variable and extremely similar to other *Zeiraphera* species; it can be identified with certainty only via examination of the genitalia, or host plant association (see below).

AB REC: Porcupine Hills, ex. Douglas-fir, reared, emerged 7 August 1951 [NFRC].

DIST: Previously known from southern British Columbia, from Vancouver Island to the Kootenay district (Mutuura & Freeman 1966).

BIO: Larvae feed on Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco (Pinaceae)). It is the only *Zeiraphera* species that is known to feed on Douglas-fir (Mutuura & Freeman 1966).

Gretchena semialba McDunnough, 1925

ID: A small (12 to 13 mm WS) moth with distinctive maculation consisting of mottled brown and grey FW with a metallic tornal spot, and glossy white HW with a brown fringe (Fig. 8). McDunnough (1925) provides a description, but no published illustrations are known.

AB REC: 16 miles N of Wandering River, ex. *Alnus* sp., reared, larvae coll. 15 July 1966, adults emerged 16-23 January 1967 [in lab], Layton [NFRC] (5 specimens).

DIST: This species was described from specimens collected in Ontario and Manitoba, and has not been reported elsewhere since.

BIO: The rearing information accompanying these specimens comprise the only known information on the biology of this species.

Rhopobota naevana (Hübner, [1817])

ID: A small (11 to 12 mm WS) moth with a mottled dark brown and white pattern on the FW, including a dark basal patch with an angulate margin, and a prominent diagonal dark bar at two-thirds to three-quarters distance from the base. Parenti (2000: Plate 115) provides an excellent color photograph; Miller (1987) provides a photograph and genitalia illustrations. It is quite similar externally to species of *Gypsonoma* and *Ancylis*, and is best separated via examination of the genitalia.

AB REC: Vicinity of Barrhead, black spruce bog, 24 July 2000, MV light, D. Macaulay [NFRC]. Fidler-Greywillow Provincial Wildland Park, 63 km NE of Ft.

Chipewyan, Fidler Point, 59.107°N 110.426°W, 210 m, mixed birch/jack pine, 23 July 2001, UV trap, D. Lawrie [NFRC].

DIST: This is a holarctic species known from eastern North America as far W as Michigan (Miller 1987), and in the West in Washington and British Columbia (Heinrich 1923). The NFRC also has specimens from Northwest Territories.

BIO: This species is a common pest of *Vaccinium* species (Ericaceae). Larvae feed on the leaves, flowers, and fruit. They also feed on other Ericaceae, Rosaceae, and *Rhamnus* species (Rhamnaceae) (Brown 1983).

COM: This species is known as the Black-headed Fireworm. Many publications and collections refer to it as *R. unipunctana* (Haworth), which is an invalid homonym (Poole 1996).

Epinotia albicapitana (Kearfott, 1907)

ID: A medium-sized (20 mm WS) moth with a striking and distinctive FW pattern; the black costal half of the wing adjoins the white caudal half with a zigzag margin (Fig. 9). Heinrich (1923) provides a description and genitalia illustrations. It is similar externally to *E. lindana* (Fernald) and *E. crenana* (Hübner), but in the latter two species the caudal half of the FW is mottled light grey rather than white. It is also similar to *Chimoptesis pennsylvaniana* (Kearfott), which does not occur in northwestern North America.

AB REC: Milk River Ridge, vicinity of Cardston, 10 km N of junction of Highway 820 and Highway 501, 1310 m, 24 August 1998, houselight [POHL]. Rochon Sands Provincial Park, 52.46°N 112.88°W, 720 m, aspen parkland, 14 September 2001, 25 September 2001, UV LT [BIRD] (4 specimens).

DIST: Previously known from California, Colorado, and Utah (Heinrich 1923). The senior author has seen specimens from southern British Columbia, although it has not previously been reported from Canada.

BIO: Nothing has been published on the biology of this species. However, a specimen in the CNC from Oliver, British Columia was reared from *Prunus virginiana* L. (Rosaceae) by FIDS. The Rochon Sands locality contains numerous *Prunus virginiana* plants.

URODIDAE

Wockia asperipunctella (Bruand, [1851])

ID: A medium-sized (16 to 18 mm WS) grey moth with a black transverse fascia of raised scales on the FW. Landry (1998a) provides a description and illustrations.

AB REC: 8 km NW of Winfield, 53.01°N 114.50°W, 1000 m, 25 May 2001, 16 Jun 2001, 8 Jun 2002, 15 Jun 2002, UV LT [BIRD] (4 specimens).

DIST: This holarctic species was reported for the

first time in North America by Heppner (1997), and was subsequently reported from Alberta and other provinces by Landry (1998a). The latter reported the species from central British Columbia to Maine, and from Touchwood Lake in east-central Alberta. Here we report a second locality for Alberta.

BIO: Larvae feed on *Populus tremuloides* Michx. (Salicaceae); in Europe they have been reared from *Betula* (Betulaceae) and *Salix* species (Salicaceae) (Landry (1998a).

COM: As Landry (1998a) discussed, this species is probably more common than the rarity of records suggests. It is crepuscular, and does not often come to lights.

SCHRECKENSTEINIIDAE

Schreckensteinia festaliella (Hübner, [1819])

ID: A small (10 to 12 mm WS) narrow-winged moth with a greenish-copper tinge to the wings, and a dark line on the FW (Fig. 10). Forbes (1923) provides a brief description, including characters for separation from other species of *Schreckensteinia*.

AB REC: Caribou Mountains Wildland Provincial Park, Wentzel Lake, marsh near mouth of Wentzel River, 59.075°N 114.450°W, dry peat bog over permafrost, 10 June 2003, G.R. Pohl [NFRC]. 8 km E-SE of Sherwood Park, wet meadow, 30 April 1999, at dusk, G.R. Pohl [NFRC]. 8 km SE of Sherwood Park, 53.47792°N 113.22912°W, aspen forest, 18 May 2002, diurnal [POHL]. 8 km NW of Winfield, 53.01°N 114.50°W, 1000 m, 14 May 2000, UV LT [BIRD].

DIST: This is the first report of this holarctic species in Canada. It was previously known from eastern North America, as far west as Michigan (Forbes 1923). It is also known from California (Powell 2002).

BIO: Larvae skeletonize the underside of leaves of *Rubus* species (Rosaceae) (Emmet 1996). Adults tend to fly during the day or at dusk, and are occasionally attracted to lights.

COM: This is the first published report of the family Schreckensteiniidae in Canada.

EPERMENIIDAE

Epermenia imperialella (Busck 1906)

ID: A small to medium-sized (13 to 18 mm WS) moth with light brown head, thorax and FW, and raised tufts of black scales and a diffuse dark longitudinal mark in the discal cell of the FW (Fig. 11). Covell (1984) provides a color photograph; Gaedike (1977) provides a description (in German) and genitalia illustrations, including characters for separation from other species of *Epermenia*.

AB REC: 8 km SE of Sherwood Park, 53.47792°N
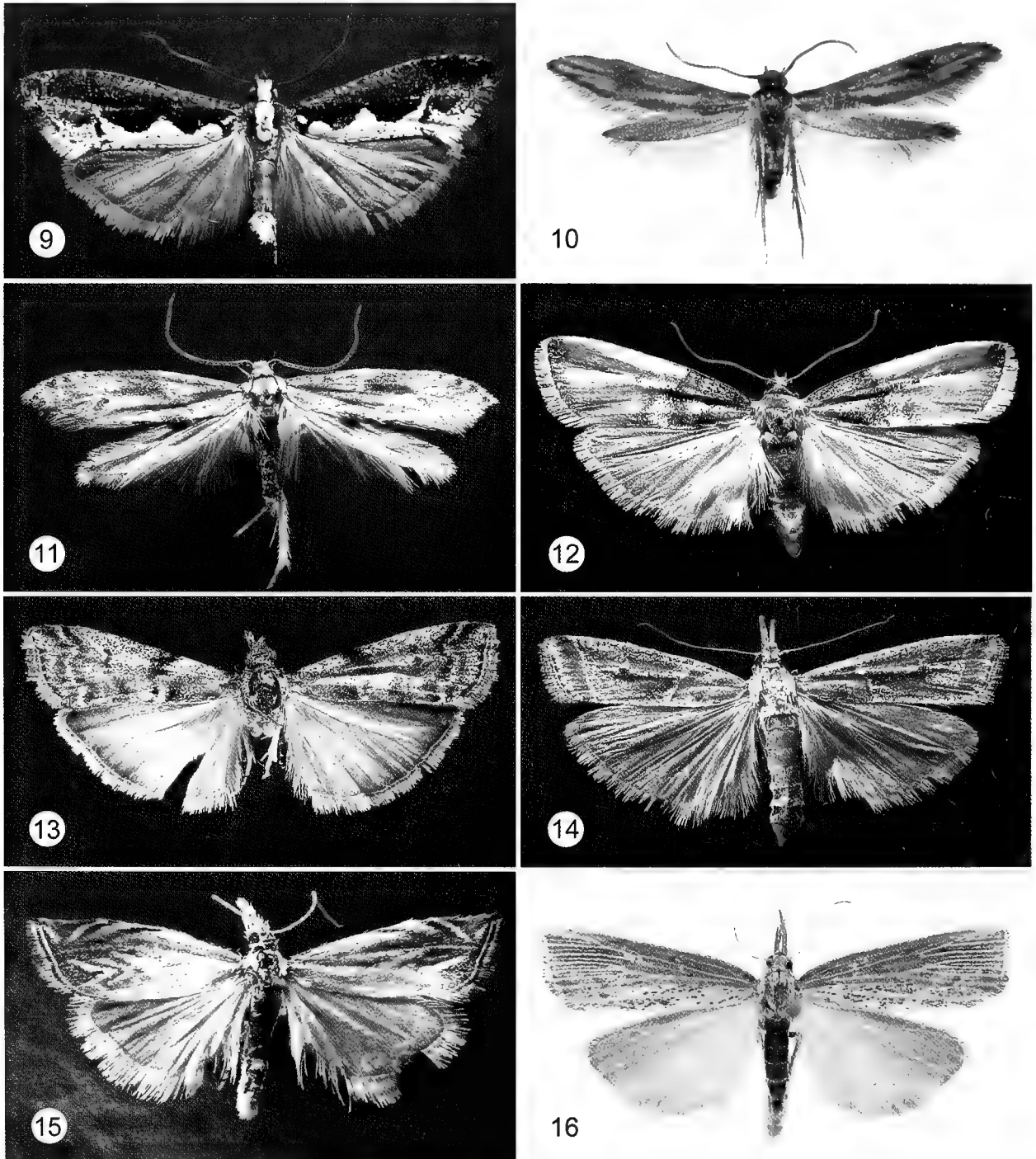
FIGS. 9-16. Microlepidoptera new to Alberta. **9**, *Epinotia albicapitana*, 20.0 mm WS, Milk River Ridge, 24 August 1998 G.R. Pohl; **10**, *Schreckensteinia festaliella*, 11.1 mm WS, Quebec, lac Brûlé near Ste-Agathe, 10 July 1988 J.-F. Landry; **11**, *Epermenia imperialella*, 14.4 mm WS, 8 km SE of Sherwood Park, 13 July 2002 G.R. Pohl; **12**, *Dasypyga alternosquamella*, 20.9 mm WS, Gogo Lake, 16 June 2000 G.R. Pohl; **13**, *Pyla aenigmatica*, 20 mm WS, 5 km S of Nevis, 7 July 2002 C.D. Bird; **14**, *Lipographis fenestrella*, 23 mm, WS, Big Knife Provincial Park, 22 August 2003 C.D. Bird; **15**, *Platytes vobisne*, 12 mm WS, Dry Island Buffalo Jump Provincial Park, 27 June 2002 C.D. Bird; **16**, *Pediasia abnaki*, Cooking Lake, Franck Farm, T50 R21 W4, 29 July 1997 D. Lawrie.
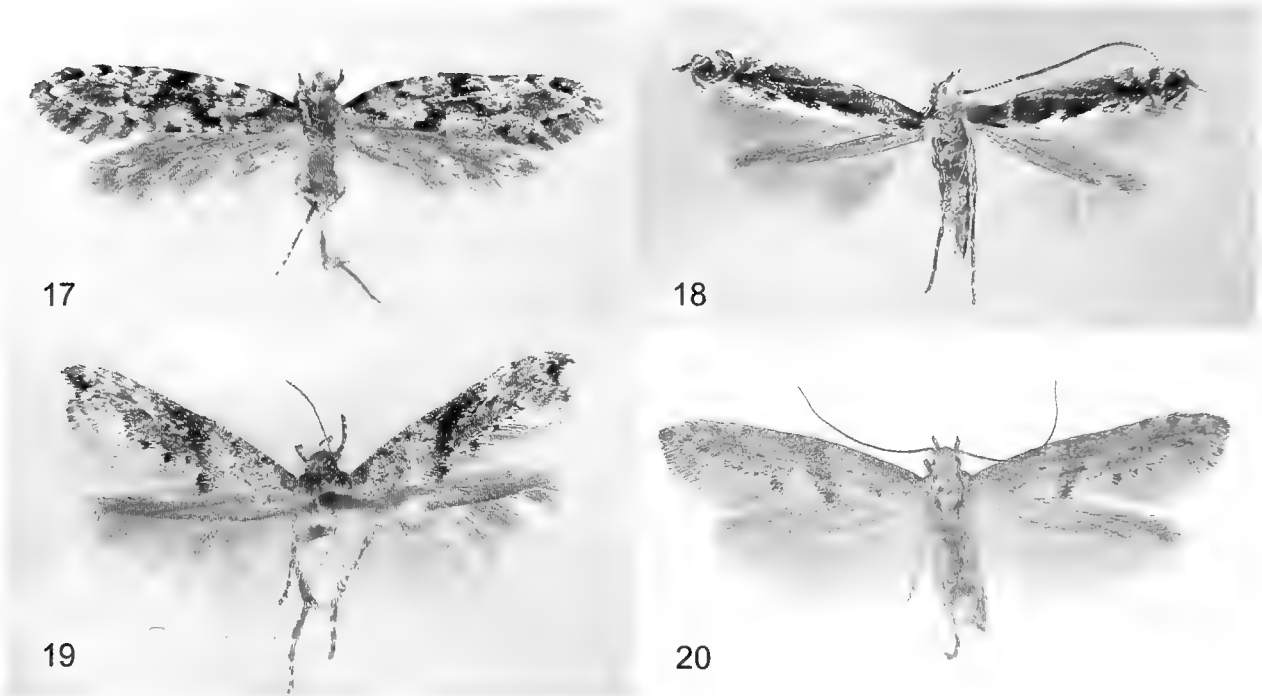
FIGS. 17-20. Microlepidoptera new to Alberta. **17**, *Nemapogon acapnopennella*, 14.4 mm WS, Edmonton, 21 July 2001 G.G. Anweiler; **18**, *Micrurapteryx salicifoliella*, 10.6 mm WS, Steen River, 7 August 1963; **19**, *Epermenia lomatii*, 12.1 mm WS, Edmonton, 16 June 1947 K. Bowman; **20**, *Ochromolopis ramapoella*, 13.7 mm WS, Kleskun Hills, 20 July 2003 J.-F. Landry.

113.22912°W, aspen forest, 13 July 2002, MV light, G.R. Pohl [NFRC].

DIST: Previously known from Pennsylvania and Manitoba (Gaedike 1977).

BIO: Unknown.

Epermenia lomatii Gaedike 1977

ID: A small (12 to 16 mm WS) brown and grey moth, with raised tufts of black scales and a dark reddish brown diagonal mark across the FW (Fig. 19). Gaedike (1977) provides a description (in German) and genitalia illustrations, including characters for separation from other species of *Epermenia*.

AB REC: Edmonton, 16 June 1947, K. Bowman [UASM].

DIST: This is the first report of this species from Canada. It was previously known from California, Oregon, and Washington (Gaedike 1977).

BIO: This species has been reared from *Lomatium* and *Velaea* species (Gaedike 1977).

Ochromolopis ramapoella (**Kearfott, 1903**)

ID: A small (13 to 15 mm WS) moth with narrow grey wings, with two patches of raised black scales on the caudal margin of the FW (Fig. 20). The raised scales are easily rubbed off, and are often indistinct in worn specimens. Gaedike (1977) provides a description (in German) and genitalia illustrations.

AB REC: Big Knife Provincial Park, 52.486°N 112.206°W, 692 m, meadow with aspen/buckbrush, 17

June 2003, UV LT [BIRD]. Breed Creek, 3 km S of Aden, 49.07°N 111.27°W, cottonwoods, creek bottom, 14 June 1996, UV trap [POHL]. Cypress Hills, Elkwater Lake, 17 June 1996, at light [POHL] (2 specimens). Dry Island Buffalo Jump Provincial Park, 51.93°N 112.97°W, 27 June 2002 [BIRD]. Dunvegan, 19 July 2003, MV light [POHL]. Kleskun Hills, 55°15'38"N 118°30'35"W, 20 July 2003, sweeping low prairie forbs at 21:30H, J.-F. Landry [CNC] (2 specimens). 3 km S of Nevis, Allen Hall acreage, 52.31°N 113.05°W, 815 m, aspen parkland, 25 June 2002, 7 July 2002, UV LT [BIRD] (2 specimens). Pinhorn Grazing Reserve, 49.10°N 110.82°W, prairie coulee on Milk River, 14 June 1996, UV trap [POHL]. 18.5 km N of Stettler, 52.48°N 112.70°W, aspen parkland, 23 June 2002, UV trap [BIRD]. Tolman Bridge Recreation Area, 51.8325°N 113.0106°W, *Populus* scrub and *Artemisia*, 15 June 2002, UV trap, G.G. Anweiler [NFRC] (3 specimens).

DIST: Previously known from eastern North America, as far W as Manitoba, North Dakota, Utah, and Colorado (Gaedike 1977).

BIO: Larvae feed on *Comandra umbellata* (L.) Nutt. (Santalaceae) (Gaedike 1977).

PYRALIDAE

Hypsopygia costalis (**Fabricius, 1775**)

ID: A medium-sized (20 mm WS) purple moth with deep yellow costal marks and wing fringes on FW and

HW. It is superficially similar to *Herculia thymetusalis* (Walker), but is easily distinguished by the wider yellow wing fringes. Parenti (2000: Plate 132) provides a color photograph.

AB REC: Olds, 24 July 1998, UV LT, E. Mengersen [OLDS] (2 specimens).

DIST: This is an extension of the known range of this introduced palearctic species. It has previously been reported in the published literature only as far W as Kentucky and Texas (Covell 1984). J.A. Powell (pers. comm.) reports specimens from Utah (1950s), Oregon (1966), and California (1968). The OLDS collection also has a specimen from British Columbia.

BIO: Larvae feed in stored hay, and are sometimes pests.

COM: This species is known as the Clover Hayworm in North America, and as the Gold Triangle Moth in Europe. The Olds records may represent a very recent and localized introduction of this moth in Alberta. Olds is the home of the Olds College, which specializes in agriculture. It is perhaps significant that no further specimens have been encountered since the 1998 collections, even though the collector has trapped at the same location frequently since that time.

Acrobasis betulella **Hulst, 1890**

ID: A medium-sized to large (17 to 25 mm WS) grey and brown moth. The FW has a wide, diffuse antemedial line, and a narrow zigzag postmedial line. Between the two bands are two small black spots on a background of grey scales. Neunzig (1986) provides a description and illustrations, including maculation characters for separation from other species of *Acrobasis*. There are no consistent differences in the genitalia to distinguish this species. Identification is easiest by food plant association; it is the only *Acrobasis* species in Canada which feeds on *Betula* species (Betulaceae).

AB REC: Empress, reared, ex. *Betula occidentalis*, collected as larvae 29 May 1962, adults emerged 4-12 July 1962, Gautreau [NFRC] (4 specimens).

DIST: According to Neunzig (1986), this species is more common in the East, but it occurs across Canada as far W as southeastern British Columbia. Although it has been collected in Saskatchewan and British Columbia, there are no previously published records for Alberta.

BIO: Larvae of this species feed on several species of *Betula* (Betulaceae). After hatching, they feed briefly, overwinter in hibernacula on branches, and then resume feeding the following spring, constructing a silken tube of new foliage. Adult moths fly in July, and eggs hatch later the same year (Neunzig 1986).

COM: This species is known as the Birch Tubemaker.

Dasypyga alternosquamella **Ragonot, 1887**

ID: A medium-sized (20 to 21 mm WS) moth with distinctive FW, grey on the basal third, and orange streaked with longitudinal white and grey stripes on the distal two-thirds (Fig. 12). Heinrich (1956) provides a description and genitalia illustrations. No other species of moth in northwestern North America has similar maculation.

AB REC: Fidler-Greywillow Wildland Prov. Park, 20 July 2001, UV trap, D. Lawrie [NFRC]. 3 km NE of Redwater, Range Rd. 205, 3 km N of Victoria Trail, 670 m, 20 July 1999, MV light, D. Lawrie [NFRC]. Gogo Lake, 57.8827°N 111.0333°W, 16 June 2000, adult on *Pinus banksiana*, G.R. Pohl et al. [NFRC].

DIST: Previously known from western United States (California, Arizona, Colorado, Washington) and British Columbia (Heinrich 1956). Prentice (1965) reports it from several sites in southeastern British Columbia.

BIO: Mooney (2001) reports the host as mistletoe (*Arceuthobium* species (Loranthaceae)), and provides the following biological information, based on observation in Colorado. Larvae initially feed externally, and later mine into the mistletoe plants. Even a small amount of larval feeding can kill the hosts. The moths overwinter as pupae on the ground in a cocoon of silk, frass, and soil. FIDS surveys report this species from mistletoe on *Larix*, *Tsuga*, *Pseudotsuga*, and *Abies* species (Pinaceae) (Prentice 1965).

COM: Heavy infestations of *Arceuthobium americanum* Nutt. occur on *Pinus banksiana* Lamb. (Pinaceae) at all three Alberta collection sites listed above.

Pyla aenigmatica **Heinrich, 1956**

ID: A medium-sized (18 to 21 mm WS) moth with black and white antemedial and postmedial lines and a dusting of white scales on the FW (Fig. 13). Neunzig (2003) provides a description and habitus illustration; Heinrich (1956) provides genitalia illustrations. It is very similar to several other *Pyla* species, but can be separated via genitalic differences, as detailed by Wilterding & Balogh (2002).

AB REC: Big Knife Provincial Park, near Battle River, 52.486°N 112.206°W, 683 m, meadow with chokecherry, 8 July 2003, UV LT [BIRD]. Big Knife Provincial Park, 52.492°N 112.211°W, 660 m, meadow with chokecherry/aspen, 30 July 2003, UV LT [BIRD]. 3 km S of Nevis, Allen Hall acreage, 52.31°N 113.05°W, 815 m, aspen parkland, 7 July 2002, 1 July 2003, UV LT [BIRD] (3 specimens).

DIST: According to Wilterding & Balogh (2002), this species is distributed across North America, from the

Gaspé region of Quebec to Vancouver Island, British Columbia, and as far S as Utah. However, no previous records are known for Alberta specifically.

BIO: Unknown.

COM: Identity of the 7 July 2002 Nevis specimen reported above was confirmed by G. Balogh.

Lipographis fenestrella (Packard, 1873)

ID: A relatively large (21 to 24 mm WS) moth with FW ranging from ash gray to brownish yellow in color (Fig. 14). The FW has narrow, white, nearly straight antemedial and subterminal lines, and five dark dots outside of the subterminal line. The HW is dull white to pale bownish yellow, darkening toward the termen. Heinrich (1956) provides a description and genitalia illustrations; Neunzig (2003) provides illustrations. No other moth in northwestern North America resembles this species.

AB REC: Big Knife Provincial Park, 52.493°N 112.220°W, 686 m, aspen/chokecherry/saskatoon, 22 August 2003 [BIRD]. Big Knife Provincial Park, 52.492°N 112.211°W, 660 m, meadow with chokecherry, 22 August 2003, UV LT [BIRD] (2 specimens). Lowden Springs Conservation Area, 17 km S of Stettler, 52.09°N 112.425°W, 830 m, prairie, 23 August 2002, 14 August 2003, UV LT [BIRD] (9 specimens).

DIST: Previously known from California, Utah, and Manitoba (Neunzig 2003).

BIO: Unknown.

COM: Heinrich (1956) states that no features separate *Lipographis leoninella* from *L. fenestrella* except wing coloration. However, he felt they should not be synonymized until details of their biology was known. B. Scholtens (Biology Department, College of Charleston, Charleston, South Carolina), who identified the 2002 material, noted that the full color range was present in the Alberta specimens and that in his opinion they are conspecific. (*L. fenestrella* is known only from California).

CRAMBIDAE

Platytes vobisne Dyar, 1920

ID: A small (11 to 12 mm WS) moth with diffuse brown longitudinal lines and a zigzag postmedial line on the FW (Fig. 15). Landry (1995) provides a description and illustrations. This species could be mistaken for a tiny *Chrysoteuchia topiaria* (Zeller), but in the latter the postmedial line has only a single angle rather than two conspicuous angles.

AB REC: Dry Island Buffalo Jump Provincial Park, 51.93°N 112.97°W, mixed grass area with *Symphoricarpos occidentalis*, *Prunus virginiana* and *Amelanchier alnifolia*, 27 June 2002 [BIRD].

DIST: Previously known from Connecticut to western Ontario, S to Oklahoma and W to Colorado (Landry 1995) and South Dakota (Forbes 1923).

BIO: Unknown.

COM: According to Landry (1995), this species is very poorly represented in collections. This specimen was identified by B. Scholtens (Biology Department, College of Charleston, Charleston, South Carolina).

Catoptria maculalis (Zetterstedt, 1840)

ID: A medium-sized (17 mm WS) moth with chocolate brown wings, with two light blotches in the center of the FW, and lacking distinct antemedial, postmedial, and subterminal lines. Landry (1995: Figs. 168, 260, 317) provides illustrations of an adult, and of the male and female genitalia. This species is superficially similar to *Agriphila biarmica* (Tengström), *Catoptria trichostoma* (Christoph) and *Gesneria centuriella* (D. & S.), all of which have a zigzag subterminal line in the FW.

AB REC: 29 km NE of Zama City, 59.33°N 118.43°W, boreal forest, 15 July 1997, G.R. Pohl [NFRC].

DIST: This holarctic species has previously been reported from Quebec/Labrador (Handfield 1997) and from Yukon Territory (Lafontaine & Wood 1997).

BIO: Unknown.

Pediasia abnaki (Klots, 1942)

ID: A large (23 to 27 mm WS) moth with grayish white FW with a dusting of relatively coarse (approximately 1 mm diameter) dark spots dorsally, and with the distal one third of the wing along the costal margin pale bluish gray (Fig. 16). Klots (1942) provides a description and illustrations. It can be separated from other species of *Pediasia* by the bluish grey ground color in the distal third of the FW, and by the coarse rather than fine scattering of dark spots.

AB REC: Vicinity of Cooking Lake, 29 July 1997, UV LT, D. Lawrie [NFRC]. McKenzie Crossing, 13 km W of Big Valley, 16 July 2000, UV LT [BIRD]. Olds, 18 August 1989, 8 July 1984, 6 July 2002, E. Mengersen [OLDS] (3 specimens). Tolman Bridge, 3 July 2000, 8 July 2000, E. Mengersen [OLDS] (3 specimens). 29 km NE of Zama City, 59.33°N 118.43°W, boreal forest, 10 June 1998, UV trap, H.E.J. Hammond et al. [NFRC].

DIST: This species has been reported from Quebec, Ontario, Nova Scotia and New Brunswick by Klots (1942).

BIO: Unknown. In Michigan, it has been found very localized in sedgy wetlands (G. J. Balogh pers. com.).

Acentria ephemerella (Denis & Schiffermüller 1775)

ID: A medium-sized (13 to 18 mm WS) moth with

semitransparent wings; the FW is light grey, and the HW is white. Scholtens & Balogh (1996) provide a brief description; Parenti (2000: Plate 147) provides color photographs. This species resembles no other moth species in western North America, but could easily be mistaken for a caddisfly (see comments below).

AB REC: Big Knife Provincial Park, near Battle River, 52.492°N 112.211°W, 660 m, meadow with chokecherry, 26 August 2002, 11 September 2002, 8 July 2003, 30 July 2003, 22 August 2003, UV LT [BIRD] (11 specimens). Big Knife Provincial Park, near Battle River, 52.486°N 112.206°W, 683 m, meadow with aspen/buckbrush, 22 August 2003, UV LT [BIRD]. Calgary, Edgemont, 28 July 2003, T. Pike [T.M. Pike COLLECTION]. Dry Island Buffalo Jump Provincial Park, near Red Deer River, 51.93°N 112.97°W, 12 July 2002, 10 September 2002, UV LT [BIRD] (2 specimens). Holmes Crossing Staging Area, 7.3 km SE of Fort Assiniboine on Highway 33, 54.29403°N 114.86665°W, pine forest, 22 August 2003, UV trap, D. Macaulay [DAM] (4 specimens); [NFRC]. J. J. Collett Natural Area, 52.552°N 113.640°W, 895 m, aspen woods, 9 August 2003, UV LT [BIRD]. J. J. Collett Natural Area, 52.551°N 113.640°W, 866 m, *Picea glauca* woods, 9 August 2003, UV LT [BIRD]. Lowden Springs Conservation Area, 17 km S of Stettler, 52.09°N 112.425°W, 830 m, 23 July 2002, UV LT [BIRD]. Medicine Lake Recreational Area, 52.749°N 114.744°W, 950 m, aspen/alder woods beside lake, UV LT [BIRD]. Mountainview County, Olds, 28 July 1995, 6 August 1997, 20 August 1998, 6 September 1998, 10 July 1999, 23 July 2002, 24 August 2002, UV trap, E. Mengersen [NFRC] (4 specimens); [OLDS] (8 specimens). 3 km S of Nevis, Allen Hall acreage, 52.31°N 113.05°W, 815 m, aspen parkland, near pond, 7 July 2002, UV LT [BIRD]. Red Deer, Gaetz Lakes Sanctuary, 52.284°N 113.735°W, 841 m, meadow with *Artemisia*, 13 August 2003, UV LT [BIRD]. Red Deer, Gaetz Lakes Sanctuary, 52.285°N 113.791°W, 858 m, balsam poplar/white spruce woods, 13 August 2003, MV light [BIRD]. Tolman Bridge Recreation Area, E side of river, 51.83461N 113.01139W, 706 m, chokecherry/aspen, 24 August 2003, UV LT [BIRD].

DIST: Scholtens & Balogh (1996) report that this European species was introduced to North America, and first reported in Montreal, Quebec, in 1927. By 1996 it was well established in the Great Lakes region, and as far W as the Missouri River in Iowa.

BIO: The aquatic larvae of this species feed on Water Milfoil (*Myriophyllum spicatum* (Haloragaceae)) and other aquatic plants (Scholtens & Balogh 1996). They obtain oxygen from their hostplants, and possibly via diffusion through the skin (Watson & Whalley 1975).

COM: Watson & Whalley (1975) comment that when members of this genus were first discovered, they were described as caddisflies (Trichoptera) rather than moths. This species is listed as *A. nivea*, (Olivier, 1791) in Hodges et al. (1983).

Munroessa icciusalis (Walker, 1859)

ID: A medium-sized (18 to 20 mm WS) straw-colored moth with a unique pattern of white marks and curved black lines on the wings. Munroe (1972) provides a description and illustrations.

AB REC: Athabasca Sand Dunes Provincial Park, lake 3 km E of dunes, 58.165°N 110.844°W, pitcher plant bog, 1050 m, 24 August 2000, D. Macaulay and D. Lawrie [NFRC]. 10 km NE of Bearberry, 15 July 2002, E. Mengersen [OLDS]. 8 km NW of Winfield, 53.01°N 114.50°W, mixed woods near East Poplar Creek, 1000 m, 22 July 2000, UV LT [BIRD].

DIST: Munroe (1972) reports this species from Newfoundland and W to Nebraska, and in British Columbia in the Fraser and Okanagan valleys. Besides the Alberta specimens, the NFRC has specimens from Saskatchewan and Manitoba.

BIO: The larvae of this species are aquatic, and feed primarily on *Potamogeton* species (Potamogetonaceae), and also on other aquatic plants (Munroe 1972). They construct oblong biconvex cases of parts of their host plants.

COM: Munroe (1972) thought this species may have been introduced in British Columbia, as there was no evidence at that time that the range was continuous. It is clearly transcontinental.

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NEW ADDITIONS TO THE BUTTERFLY FAUNA OF BELIZE

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ABSTRACT: We present records for 85 butterfly species new to Belize and discuss an additional seven species that were previously known from vague literature records. These records represent a 19% increase in the number of butterflies (excluding Hesperiidae) known from the country. New records include 10 new Nymphalidae, and 75 new Lycaenidae (including Riodininea). A total of 521 species of true butterflies are now known from Belize. Using the nonparametric estimator Chao 2 in conjunction with our comprehensive database of Belize butterfly records, we estimate total species richness to be 633.

Faunal lists of invertebrate groups from tropical regions are potentially valuable to workers pursuing a wide variety of biological studies including biogeography analysis and community ecology. Although Belize has earned a growing reputation as a favored destination for such investigations, much remains to be learned about the composition and distribution of the Belize butterfly fauna. Older literature, such as Davis (1928), is either badly dated, or else represents the results of rather limited field efforts. Davis' (1928) account of the fauna, while providing interesting reading, reflected an era when transportation through the country was extremely limited, and butterfly taxonomy was badly confused. Although far from a comprehensive faunal review, his accounts of some 200+ species are still intriguing and provide valuable insights into the ecology of Belize 100 years ago. Ross (1961) provided a significant contribution by publishing an annotated list of species collected during a month stay in the country. More recently, Meerman (1999) produced the most complete summary of butterfly records to date based on field work throughout the country, making a significant contribution to butterfly faunal studies in the region. Meerman reported a total of 436 species of true butterflies from Belize and includes a thorough treatment of historical records as well.

Over the past 10 years, we have sampled butterflies extensively throughout Belize and have documented the occurrence of numerous species not previously reported for the country. Although we have tried to distribute our sampling effort as widely as possible across habitats and geographic areas, the bulk of our most recent field work has been concentrated at a few key representative sites located primarily in the northern half of the country. Table 1 summarizes the most important ecosystems types (Meerman and Sabido 2001) present at each of these sites.

Rio Bravo Conservation and Management Area, Orange Walk District. Hill Bank Camp, located on the New River Lagoon, provides access to northern Belize limestone-substrate broadleaf forests, bajo forests (see Austin et. al., 1996), lake edge marsh, and pine-ridge savanna habitats. La Milpa Camp, located in extreme north-west Belize, provides access to vast swaths of broadleaf forest and bajo forest.

Maya Mountains, Cayo District. Guacamallo Bridge area at the Macal River - located on the road to Carocol Ruins. Due to an abrupt change in geologic substrates, this river defines the boundary between two important habitat types in the Maya Mountains. Broadleaf forest (limestone substrates) dominate the south side of the river, while pine/oak scrub on granite substrates dominates the north.

Chiquibul Forest Reserve, Cayo District. The Las Cuevas Research Station, at an altitude of

approximately 500m, is nestled in second-growth pre-montane, limestone-substrate broadleaf forest.

Succotz, Cayo District. Located in extreme west central Belize, this is a densely populated area. Habitats around the town and adjacent Xunantunich Ruins are highly disturbed and range from pasture and recently abandoned milpa, to young second-growth broadleaf forest.

Mayflower Valley in Mayflower-Bocawina National Park, Stann Creek District. Located at the foot of the Maya Mountains, this site provides access to second-growth granite-substrate broadleaf forest habitats.

Cockscomb Basin Wildlife Sanctuary, Stann Creek District. Located at the foot of the Maya Mountains, this site provides access to second-growth and mature granite-substrate broadleaf forest habitats.

Blue Creek Cave and Village, Toledo District. Although not well sampled, this site provides access to extreme southern Belize forests. Both second growth and primary forest are accessible at the site.

During the period of 1995 to the present we spent at total of approximately 29 person/months collecting a total of over 7000 records from Belize. These records represent over half of the data managed in a comprehensive database of Belize butterflies. In addition to opportunistic capture with hand nets, we trapped butterflies using fruit bated traps (Shuey, 1997). The extensive "photographic collections" of Belizean butterflies of James Young and Jane Ruffin were also reviewed and incorporated into this analysis. All identifications of photographic records incorporated into the database are made by the senior author.

In this paper, we present a list of 85 species not recorded from Belize by Meerman (in bold), a 19% increase in the number of species known for the country. We also provide specimen-based records for an additional seven species for which Meerman (1999) had only non-specific literature records available for Belize. All records based solely on photographs are noted in the text. Nomenclature follows Lamas (2004).

These new additions to the fauna substantiate

TABLE 1. Primary habitat types present in the sample areas. Ecosystem types are defined and mapped in Meerman & Sabido (2001).

Rio Bravo Conservation and Management Area
  Tropical evergreen seasonal broad-leaved lowland forest on calcareous soils
  Evergreen broad-leaved lowland shrubland (=bajo)
  Tropical evergreen seasonal broad-leaved alluvial forest
  Tropical evergreen seasonal broad-leaved lowland swamp forest
  Tropical lowland tall herbaceous swamp
  Short-grass savanna with shrubs
  Short-grass savanna with needle-leaved trees
  Caribbean mangrove forest; freshwater mangrove scrub

Guacamallo Bridge area on the Macal: Southside
  Tropical evergreen seasonal broad-leaved lowland hill forest on steep karstic terrain
  Tropical evergreen seasonal broad-leaved submontane forest on steep karstic terrain

Guacamallo Bridge area on the Macal: Northside
  Tropical evergreen seasonal needle-leaved lowland hill forest
  Tropical evergreen seasonal needle-leaved submontane forest
  Tropical evergreen seasonal mixed submontae forest

Las Quevas
  Tropical evergreen seasonal broad-leaved submontane forest on steep karstic terrain
  Tropical evergreen seasonal broad-leaved submontane forest on rolling karstic terrain

Succotz/Xunatunich
  Agriculture (milpa), secondary growth and remnants of:
  Tropical evergreen seasonal broad-leaved lowland hill forest, on rolling karstic terrain

Mayflower Bocawina National Park:
  Tropical evergreen seasonal broad-leaved lowland hill forest, Simarouba-Terminalia variant

Cockscomb Basin
  Tropical evergreen seasonal broad-leaved lowland hill forest, Simarouba-Terminalia variant
  Tropical evergreen seasonal broad-leaved lowland forest on poor or sandy soils

Blue Creek
  Tropical evergreen broad-leaved lowland hill forest on steep karstic terrain

Meerman's assessment of his annotated checklist. He felt that the "big three" families, Papilionidae, Pieridae, and Nymphalidae were very well sampled. We strongly concur, and add only 10 additional species to the country, all Nymphalidae. Meerman felt less sure that the Lycaenidae (including Riodininea) had been as well sampled, noting that only 9.9% of the data in his database pertained to this family. We add 75 species of Lycaenidae to the country, a 54% increase in the known fauna. Based on our recent field experience, we expect to add a substantial number of additional species of Lycaenidae to the fauna of Belize as we increase our sampling efforts in southern Belize over the next few years. A total of 521 species of true butterflies are now known from Belize: Papilionidae - 37 species; Pieridae - 39 species; Nymphalidae - 233 species; and, Lycaenidae - 212 species. Using the nonparametric estimator Chao 2 (Young, et. al 2004) in conjunction with the comprehensive database, we estimate total species richness to be 633 for Belize.

LYCAENIDAE - RIODININAE

Apodemia hypoglauca wellingi Ferris. Known from two specimens collected from Consejo, Corozal District. (Jul 1988)

Apodemia walkeri Godman and Salvin. Known from scattered localities in Stann Creek and Cayo Districts. (May, Jun and Oct)

Argyrogrammana holosticta (Godman and Salvin). We have numerous records of this species, centered around Hill Bank, Orange Walk District and Succotz, Cayo District. (Feb, Mar, and Nov)

Baeotis barce Hewitson. A single photographic record from Jane Ruffin taken at Crooked Tree Reserve, Belize District. (Feb 2003)

Calospila cilissa (Hewitson). Known only from Mayflower Valley, Stann Creek District, where it is seasonally common. (May and Oct)

Calephelis browni McAlpine. We have numerous records from Orange Walk and Cayo districts. (Apr, June, July and Sept)

Calephelis clenchi McAlpine. Common in Toledo, Stann Creek, Belize and Orange Walk districts. (May, June and Sept)

Calephelis maya Clench. We have numerous records from Toledo, Orange Walk and Cayo districts. (July and Sept)

Calephelis stallinsgi McAlpine. Reported without details in Meerman 1999 based on McAlpine's (1971) revision. We have many records from Cayo, Corozal and Orange Walk districts. (July and Sept)

Calephelis tikal Austin. Known from scattered sites in Cayo, Orange Walk and Corozal districts. Otherwise, this species is known only from two specimens from Tikal, Guatemala (Austin, 1991). (July and Sept)

Calephelis wellingi wellingi McAlpine. Reported without details in Meerman 1999 based on McAlpine's (1971) revision. We have numerous records from Cayo, Stann Creek, Toledo and Orange Walk districts. (May, July, Sept, Nov and Dec)

Caria ino Godman and Salvin. Known from a single specimen collected by Ron King at Succotz, Cayo District. (Sept 2002)

Caria rhacotis (Godman and Salvin). Known from two records from Las Cuevas, Cayo District. (July and Sept)

Emesis ocypore (Geyer). One record from Lubantun Ruins, Toledo District. (July 1988)

Eusalasia eubule (Felder). A single specimen collected at Succotz, Cayo District. (Sept 2002)

Eusalasia hieronymi (Salvin and Godman). Ron King collected a specimen at Shipstern, Corozal District. We have an additional records from Blue Creek Cave, Toledo District and Las Cuevas, Cayo District. (May and Sept)

Eusalasia procula (Godman and Salvin). Known from four specimens collected at Hill Bank, Orange Walk District, and an additional specimen from the Macal River, Cayo District. (Jan, Mar and Sept)

Eusalasia pusilla (Felder). Reported from Corozal by Godman and Salvin (1879-1901), we found it to be locally common in and around Succotz and Xunantunich Ruins, Cayo District (Sept and Nov 2003.)

Pheles melanchroia (Felder and Felder). Known from a single record from Blue Creek Village, Toledo District. (May 1999)

Menander menander purpurata (Godman and Salvin). Known from specimens collected at Las Cuevas and Mollejon, Cayo District, and a photograph taken by James Young at Cockscomb Basin Stann Creek District. (July and Dec)

Notheme erota (Cramer). Known from three records, all from Las Cuevas, Cayo District. (July and Sept)

Periplacis glaucoma Geyer. Known from a lone hindwing collected at Hill Bank, Orange Walk District. (Feb 1996)

Rhetus periander (Cramer). Reported by Meerman (1999) based on records by Godman and Salvin (1879-1901). We have encountered this species at sites near Las Cuevas, Cayo District. (Sept 2002)

Sarota craspediodonta (Dyar). Known from Las Cuevas and the oak - pine habitat at the Macal River, Cayo District. (Sept)

Sarota myrtea Godman and Salvin. Known from a specimen collected at Las Cuevas, Cayo District and a

photographic record taken by Jane Ruffin at Blue Hole National Park, Cayo District. (Sept and Dec)

Pirascca sagaris (Cramer). A single record collected at Rio On Falls, Cayo District. (June 1988)

Symmachia accusatrix Westwood. Known from a single record from Mayflower-Bocawina Valley, Stann Creek District. (May 1999)

Symmachia rubina Bates. Known from two records taken in oak-pine scrub near the Macal River, Cayo District. (July and Sept)

Theope eupolis Schaus. Numerous records from Cayo, Corozal and Stann Creek districts. (May, July and Sept)

Theope pedias Herrich-Schaffer. Known from Succotz and Las Cuevas, Cayo District. (July and Sept)

LYCAENIDAE - LYCAENINAE

Arawacuss hypocrita (Schaus). A single record collected by Mike McInnis from San Ignacio, Cayo District. (Mar 1994)

Arawacus jada (Hewitson). Known from scattered localities in Cayo, Toledo and Corozal districts. (July and Sept)

Arcas cypria (Geyer). Known from Las Cuevas, Green Hills and the Macal River, Cayo District, and La Milpa, Orange Walk District. (July, Sept and Oct)

Atlites carpasia (Hewitson). A single record from Succotz, Cayo District. (Sept 2002)

Atlites gaumeri (Godman) Known from 2 females collected from a tree-lined ditch in savanna east of Belmopan, Cayo District. (Sept 2002)

Atlites inachus (Cramer). A single photographic record from Jane Ruffin taken at Crooked Tree Reserve, Belize District. (Feb 2003)

Aubergina paetus (Godman and Salvin). Known from Gren Hills and Xinantunich Ruins, Cayo District and Consejo, Corozal District. (June and July)

Calycopis atnius (Herrich-Schaffer). Known from Blue Creek Cave, Toledo District, and Mayflower Valley, Stann Creek District. (Apr and May)

Calycopis cerata (Hewitson). Known from two specimens from Mayflower Valley, Stann Creek District and Blue Creek Cave, Toledo District. (Sept and Oct)

Calycopis drusilla Field. Known from five records, all from Hill Bank, Orange Walk District. (Mar and Apr)

Calycopis pisis (Godman and Salvin). A single record from Hill Bank, Orange Walk District. (Mar 1995)

Calycopis quintana Johnson. Known from Consejo, Corozal District and La Milpa, Orange Walk District. The type locality is Consejo, Corozal District. (July) This taxon is synonomised under *Calycopis isobeon* (Butler and Druce) in Lamas (2004), but

ecologically behaves as a distinct entity in northern Belize and much of the Yucatan Peninsula.

Camissecla vespasianus (Butler and Druce). Known from a single record from Hill Bank, Orange Walk District. (Apr 1994)

Celmia conoveria (Schaus). Known from numerous records from scattered localities within the Rio Bravo Conservation Area, Orange Walk District. (Apr and July)

Chlorostrymon simaethis (Drury). A single record collected by Mike McInnis from San Ignacio, Cayo District. (Mar 1994)

Contrafacia imma (Prittwitz). Known from a single record from Mayflower Valley, Stann Creek District. (May 1999)

Dicya carnica (Hewitson). Known from La Milpa, Orange Walk District and Blue Creek Cave, Toledo District. (June and July)

Electrostrymon joya (Dognin). Known from Succotz, Rio On Falls and Douglas de Silva, all in northern Cayo District. (Sept 2002)

Electrostrymon mathewi (Hewitson). Known from a single record from Xunantunich Ruins, Cayo District. (July 2003)

Electrostrymon sangala (Hewitson). Known from numerous records from Toledo, Cayo, Corozal and Orange Walk districts. (Mar, Apr, May, June, July and Sept)

Enos nr. ***falerina*** (Hewitson). Locally common at La Milpa, Rio Bravo Conservation Area, Orange Walk District in July 1996.

Erora gabina (Godman and Salvin). Known from Las Cuevas, Cayo District and Mayflower Valley, Stann Creek District. (May and July)

Eumaeus childrenae (Gray). Jan Meerman discovered a population of this species at a site near the Raspaculo River, along the west side of the Maya Mountains, Cayo District, which will soon be flooded by a hydroelectric reservoir. We have additional records from Las Cuevas, Cayo District. (Sept)

Gargina thoria (Hewitson). Known from Las Cuevas and the Macal River, Cayo District. (July 2002)

Iaspis nr. ***castitas*** (Druce). A single record from Blue Creek Village, Toledo District. (Apr 1996)

Ignata gadira (Hewitson). Known from a single record from Mayflower Valley, Stann Creek District. (May 1999)

Ignata norax (Godman and Salvin). A single specimen collected from Chaa Creek, Cayo District. (June 1994)

Janthecla janthina (Hewitson). Known from a single record from Las Cuevas, Cayo District. (Sept 2002)

Lamprospilus nr. *arza* (Hewitson). Known from a single record from Las Cuevas, Cayo District. (July 2003)

Lamprospilus collucia (Hewitson). Known primarily from Hill Bank, Orange Walk District, with an additional record from Las Cuevas, Cayo District. (Feb, Mar, Apr and Sept)

Ministrymon arola (Hewitson). A single record collected by Mike McInnis from San Ignacio, Cayo District. (Mar 1994)

Ministrymon zilda (Hewitson). A single photographic record taken by James Young at the Belize Botanical Gardens, Cayo District. (Apr 2003)

Nicolaea heraldica (Dyar). Known from a single record from Mayflower Valley, Stann Creek District. (May 1999)

Ocaria ocrisia (Hewitson). Known from Rio On Falls, San Ignacio and Las Cuevas, Cayo District. (Mar, June and July)

Ocaria thales (Fabricius). Known from Las Cuevas, Cayo District and Hill Bank, Orange Walk District. (Feb, July and Sept)

Ostrinotes keila (Hewitson). Known from scattered localities in Cayo, Corozal, Stann Creek and Belize districts. (April and Sept)

Paiwarria antinous (Felder and Felder). First reported by Owen (2000) from Las Cuevas, Cayo District, as collected in bait traps. We have additional Cayo records from Las Cuevas, northern Pine Ridge and Succotz. (July, Sept, Oct and Nov)

Panthiades phaleros (Linnaeus). Originally reported without specific data by Nicolay (1976). We have records from Succotz, Cayo District and La Milpa, Orange Walk District. (Sep and Dec)

Semonina semones (Godman and Salvin). Known from a single record from the Macal River, Maya Mountains, Cayo District. (July 2003)

Siderus philinna (Hewitson). Known from six records from the area around Succotz, Cayo District as well as a single record from Rio Frio Cave, Cayo District. (Jan and Sept)

Strephonota sphinx (Fabricius). Known from Succotz, Cayo District, Mayflower Valley, Stann Creek District and Blue Creek Cave, Toledo District. (May and Sept)

Strephonota syedra (Hewitson). Known from a single record from Blue Creek Cave, Toledo District. (May 1999)

Strymon rufofusca (Hewitson). Known from numerous records from Cayo, Corozal and Toledo districts. (June, July Sept, Oct and Nov)

Theclopsis demea (Hewitson). Known from a single record from Mayflower Valley, Stann Creek District. (May 1999)

Theclopsis mycon (Godman and Salvin). Known from two records from Mayflower Valley, Stann Creek District. (May 1999)

Thereus citonius cambes (Godman and Salvin). Known from a single record from Consejo, Corozal District. (July 1988)

Thereus lausus (Cramer).Known from a single record from Consejo, Corozal District. (July 1988)

Thereus oppia (Godman and Salvin). Known from the Macal River, Maya Mountains, Cayo District and Sarteneja, Corozal Distrct. (July and Sept)

Thestius nr. *lycabas* (Cramer). A single record from oak-pine forest along the Macal River, Cayo District. (July 2003)

Tmolus mutina (Hewitson). Known from a single record from Blue Creek Cave, Toledo District. (May 1999)

Ziegleria syllis Druce. Known from numerous localities in Belize, Orange Walk and Cayo districts. (Feb, Mar, July and Sept)

NYMPHALIDAE - LIMENITIDINAE

Adelpha boeotia oberthurii (Boisduval). Known from a single record from Las Cuevas, Cayo District. (July 2003)

Adelpha paraena massilia (Felder and Felder). Initially attributed to Belize by Willmont (2003) based on his miss-interpretation of literature records (Meerman 1999) of *Adelpha nea sentia* Godman and Salvin. Despite this, we have three specimen-based records of *A. paraena massilia* from Las Cuevas, Cayo District and Blue Creek, Toledo District. (May and Sept)

Adelpha leuceria (Druce). Locally common at Doyle's Delight (elev. 1124m), located on the Toledo and Cayo districts border. (August 2004)

NYMPHALIDAE - CHARAXINAE

Agrias amydon Hewitson. Based on a single sight record at Las Cuevas, Cayo District. A male of this species landed on a bait trap as we were setting bait inside the trap. Unfortunately, it flew off without entering the trap. (Sept 2002)

Agrias aedon rodriguezi Shaus. A single record from Cockscomb Basin, Stann Creek District. (Mar 2004).

Memphis proserpina (Salvin) . Locally common around the base camp at Cockscomb Basin, Stann Creek District and from Doyle's Delight (elev. 1124m), located on the Toledo and Cayo districts border. (Feb, Mar, Aug and Sept)

NYMPHALIDAE - BRASSOLINAE

Opoptera staudingeri (Godman & Salvin) Locally common at Doyle's Delight (elev. 1124m), located on the Toledo and Cayo districts border. (August 2004)

NYMPHALIDAE - ACREIINAE

Actinote anteas (Doubleday). One specimen was caught (Meerman) near Placencia, Stann Creek Distict on (February 2000).

NYMPHALIDAE - SATYRINAE

Cissia labe (Butler). Although Meerman (1999) includes the species based on Davis' (1928) report, he had no personal experience with it in Belize. Meerman notes the historical confusion associated with the identification of this species relative to *Cissia confusa* (Staudinger) and *Cissia pseudoconfusa* DeVries and Ehrlich and the high probability that Davis was in fact, referring to one of these two common species. We have a single specimen-based record of *C. labe* from Las Cuevas, Cayo District. (Sept 2002)

Cissia terrestris (Butler). Initially reported by Owen (2000) from Las Cuevas, we believe that this is also the "*Cissia* with distinctive orange lines on the hindwings" referred to as *Cissia* sp. by Meerman (1999) from Slate Creek Preserve (Cayo Dist). We have three additional records from Hill Bank, Orange Walk District. (Feb, Mar and Oct)

Euptychia mollis Staudinger. Known from Mayflower Valley and Cockscomb Basin, Stann Creek District. (Mar and May)

Megeuptychia antonoe (Cramer). Known from Mayflower Valley, Stann Creek District and Green Hills, Cayo District.(May, Oct and Dec)

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BIODIVERSITY PATTERNS OF SPRING-ASSOCIATED BUTTERFLIES IN A MOJAVE DESERT MOUNTAIN RANGE

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ABSTRACT: We examined whether species richness (number of species), abundance, and species composition (identity) of butterflies at 23 springs in the Spring Mountains, an isolated mountain range in the eastern Mojave Desert (Nevada, USA), had a predictable response to presence of riparian vegetation. The Spring Mountains are the focus of regional conservation planning, and managers are charged with prioritizing its springs for conservation and rehabilitation. We therefore used butterflies to help provide information on faunal responses to potential changes in land cover. Species richness and abundance of butterflies in locations with riparian vegetation consistently was higher than in locations with non-riparian vegetation across several levels of spatial resolution. Similarity of species composition of butterflies decreased as the linear distance between springs increased. Neither local presence of larval hostplants nor vegetation association (riparian or non-riparian) of larval hostplants had a significant effect on occurrence rate or abundance of individual species of butterflies. Nestedness analyses demonstrated that species present in locations with few species of butterflies tended to be subsets of the species present in locations that were richer in species, but that pattern did not appear to be driven by the availability of riparian habitat. The species that were present at the greatest number of springs tended to be geographically widespread taxa that can exploit human and natural disturbances. Our results suggest that reduction in water availability and the extent of riparian vegetation at montane springs in the Mojave Desert is likely to reduce local species richness and abundance of butterflies. The ability of broad categories of vegetation to serve as a predictor of species richness and composition of butterflies, however, may be relatively low.

ADDITIONAL KEY WORDS. conservation, isolation, nestedness, riparian, Spring Mountains.

Springs and spring-fed aquatic systems support a substantial proportion of aquatic and riparian species in the arid western United States (Williams & Koenig 1980, Gubanich & Panik 1986, Myers & Resh 1999). Not only do several hundred endemic species and subspecies of aquatic vertebrates, invertebrates, and plants depend on springs, but springs provide resources for as many as 80% of terrestrial species (Hubbs & Miller 1948, Thomas et al. 1979, Hershler et al. 2002).

Because springs are the only reliable source of water across much of the western United States, human land uses also have tended to concentrate around springs. These uses include diversion of water for domestic and municipal use, livestock grazing, and recreation (Shepard 1993). Moreover, both intentionally and inadvertently, humans have introduced numerous non-native species of animals and plants to springs (Hendrickson & Minckley 1984, Sada & Vinyard 2002), leading to changes in biodiversity patterns and ecological processes (Mills et al. 1993, Kinzig et al. 2001, Soulé et al. 2003). Rates of extinction in the western United States currently are higher for native species that occur at springs and spring-fed aquatic systems than for species associated with any other category of landscape features (Sada & Vinyard 2002). As a result, restoration and rehabilitation of aquatic and

riparian areas, often with a focus on vegetation communities, has become a top management priority.

Understanding how native faunal assemblages respond to availability of water and composition of vegetation in spring-fed riparian systems is critical to development of effective, practical strategies for ecological restoration and maintenance. The Clark County Multiple Species Habitat Conservation Plan (MSHCP), issued by the U.S. Fish and Wildlife Service in 2001, illustrates why this information has become so important. Thanks to explosive growth of the Las Vegas metropolitan area, Clark County is the most rapidly urbanizing municipality in the United States. The MSHCP, which covers 79 species, is intended to mitigate the cumulative effects of urbanization while giving participants greater security about future regulatory restrictions. Among the requirements of the 30-year MSHCP is development of a Conservation Management Plan for springs in the permit area. The Spring Mountains, an isolated mountain range in the eastern Mojave Desert, cover about 4000 km^2, contain approximately 300 springs, and are largely public land. They have become a principal focus of these planning efforts.

Few standardized biological surveys have been conducted at springs in the Spring Mountains. Among

invertebrates, several well-known taxonomic groups, including tiger beetles and butterflies, are thought to be associated strongly with changes in land cover (Kremen et al. 1993, New et al. 1995, Carroll & Pearson 1998, Rodrigues et al. 1998). Because invertebrates have relatively short generation times, they may be useful for exploring how expansion or contraction of riparian cover affects native fauna. In this paper, we present the early results from an ongoing study that uses butterflies as a case-study group to infer how changes in water availability and land cover at springs may affect native fauna. As a first step, we have examined patterns of species richness and abundance of butterflies associated with broadly categorized riparian and non-riparian vegetation. We are in the process of collecting detailed data on vegetation composition and structure to increase understanding of potential mechanisms driving the patterns reported here and to help guide regional conservation and restoration efforts.

METHODS

Study system. The Spring Mountains are ca 125 km in length and span an elevational gradient from 1500 m in Las Vegas Valley to 3632 m on Charleston Peak. As elevation increases, annual precipitation increases from less than three cm to more than 55 cm. Summer temperatures may reach 46° C at the lower end of the elevational gradient, decreasing to -9° C at higher elevations during the winter (Hidy & Klieforth 1990).

Most of the springs in the Spring Mountains are small and isolated, and many have been excavated or otherwise developed. Diversion structures, such as spring boxes to collect water and pipes to transport water to nearby troughs or tanks, are common. Numerous non-native species (mostly plants and fishes) have colonized these springs, and many springs are impacted by stochastic environmental phenomena such as fire, avalanche, and flood. Nonetheless, some springs appear to be in good condition and have been minimally affected by either natural or anthropogenic disturbance.

The butterfly fauna of the Spring Mountains is particularly well known and has been subject to intensive sampling for more than four decades (Austin & Austin 1980, Austin 1981).

Field Methods. Between April and August 2003, we conducted surveys of butterflies at 23 springs that collectively span major environmental and land-use gradients in the Spring Mountains. Visits were conducted once per month for a total of five visits per spring. Phenologies of butterflies and plants were similar among springs. Surveys were conducted when weather conditions were most conducive to flight (e.g., mostly sunny, light winds, warm temperatures).

Although stronger inferences could be drawn if more than one year of data were available, weather conditions in 2003 were representative–neither particularly dry nor particularly wet. Annual precipitation for 2003 at Red Rock Canyon State Park in the Spring Mountains was 24.2 cm; the mean for the 17-year period of record is 29.4 cm (± 13.6 SD) (Western Regional Climate Center 2004).

Sampling effort was roughly proportional to length of the springbrook (i.e., sampling effort was approximately equal per unit area). We established sampling points at the spring source; 30 m from the source at 0°, 90°, and 270°; and at 100 m intervals downstream from the source along the length of the springbrook. Vegetation at each sampling point was categorized as either riparian or largely non-riparian. Riparian taxa were defined as those that almost always or usually occur in wetlands with permanent water (Reed 1988). Examples of local riparian taxa include *Eleocharis*, *Equisetum*, *Juncus*, and *Muhlenbergia*. Although the existence of non-riparian vegetation at a spring may seem to be a contradiction in terms, many springs are ephemeral, with flow rates that fluctuate seasonally or annually. As a result, plants that do not depend on permanent sources of water (e.g., *Bromus*, *Penstemon*, *Poa*) often become established near the spring source and along the springbrook. As noted above, our vegetation categorizations were intentionally broad; categorizations will be refined and quantified following collection of additional data.

We established a circle with a 10 m radius at the center of each sampling point. During each visit to each spring, using methods that have proven effective in other riparian areas in the Mojave Desert and Great Basin (Fleishman et al. 1999, Mac Nally et al. 2004), an experienced observer identified and recorded all butterflies seen during a 10 min period within the circle. In preliminary "mock" surveys, more than 10 min in a sampling point almost never resulted in the detection of additional species of butterflies. Because sampling effort was approximately equal per unit area of the spring, the risk of sampling error was relatively uniform. Individual butterflies typically did not appear to move among sampling points during each visit to each spring. We calculated species richness (number of species) and abundance (number of individuals) of butterflies over the five-month sampling period for each spring. Where applicable, we also calculated separately species richness and abundance of butterflies associated with riparian and non-riparian vegetation at each spring.

Larval hostplants have been identified for virtually all species of butterflies that inhabit the Spring Mountains (G. T. Austin unpublished data). For each species of butterfly that we recorded, we categorized the

occurrence and vegetation association of its larval hostplant(s) across the suite of springs we surveyed as present, riparian; present, non-riparian; or absent.

Analyses. We used analysis of variance to test whether species richness and abundance of butterflies varied as a function of vegetation association (riparian versus non-riparian) across all springs. We also used paired t-tests to compare species richness and abundance of butterflies associated with riparian versus non-riparian vegetation at the 18 springs with both types of plant communities.

We calculated similarity (Canberra distances) of species composition (i.e., species identity) of butterflies among all springs, among the riparian component of springs, and among the non-riparian component of springs. We used Mantel tests (Mantel 1967, Douglas & Endler 1982) to evaluate whether similarity of species composition of butterflies decreased as linear distance between springs increased. Canberra distances and Mantel tests were calculated using the R Package (Casgrain & Legendre 2001).

We used analysis of variance to examine whether occurrence rate (i.e., the number of springs at which each species was present) or abundance of butterflies varied as a function of the occurrence or the vegetation association of their larval hostplants in the study system.

To test whether predictability of patterns of species richness and composition varied between riparian and non-riparian vegetation, we used nestedness analyses. Nestedness analyses have greatly expanded our capacity to understand biotic patterns across networks of terrestrial or aquatic islands of resources or habitat (Wright et al. 1998). Nestedness analyses test the degree to which species present in relatively species-poor locations are proper subsets of species present in relatively species-rich locations (Patterson & Atmar 1986, Wright et al. 1998). Nestedness is a property of assemblages, not of individual species, and has been interpreted as a measure of biogeographic order in the distribution of species (Atmar & Patterson 1993).

Numerous studies have demonstrated that nested distributional patterns are common across taxonomic groups and ecosystems. The accuracy of predictions of the sequence in which species will be extirpated from or colonize a set of locations occupied by a nested assemblage is positively correlated with the degree of nestedness. Assemblages can be nested by multiple phenomena, including but not limited to species-specific probabilities of extinction, species-specific probabilities of colonization, and nestedness of resources or habitat types (Darlington 1957, Cook & Quinn 1995, Lomolino 1996).

Nestedness analyses are effective tools for management because they can suggest, albeit via correlation, whether virtually any environmental variable of interest is likely to affect distributional patterns in an array of locations (e.g., Kadmon 1995, Fleishman & Mac Nally 2002). Differential nestedness among groups of species (e.g., functional groups or guilds) that vary in sensitivity to the extent of a particular type of land cover, for example, suggests that the processes affecting the occurrence and extent of that land cover type are driving local extinctions or colonizations (Hecnar & M'Closkey 1997, Fleishman & Murphy 1999, Jonsson & Jonsell 1999). It may not always be possible to establish a causal relationship between environmental variables and species occurrence, but strong correlations can, at minimum, help refine process-based hypotheses that can be tested with more intensive experiments or observations. Nestedness analyses have realistic application because they provide information on patterns and suggest mechanisms affecting not only species richness but also species composition. These data can inform decisions about how to maximize richness of native species across a multiple-use landscape (Margules & Pressey 2000).

To test whether assemblages were nested with respect to vegetation type, we computed the relative nestedness index C (Wright et al. 1990, Wright & Reeves 1992). We estimated statistical significance using Cochran's Q statistic (Wright & Reeves 1992). Values of C vary between 0 and 1.0, approaching 1.0 for perfectly nested matrices. Key advantages of this metric are that it allows for statistical comparison of degree of nestedness among matrices or data sets and is not highly sensitive to matrix size (Wright & Reeves 1992, Bird & Boecklen 1998). We used Z scores (standard-Normal variates) to test whether degree of nestedness was significantly different between assemblages of butterflies associated with riparian versus non-riparian vegetation (Wright & Reeves 1992).

RESULTS

Of the 23 springs in the Spring Mountains that we surveyed, 21 included riparian vegetation and 20 included non-riparian vegetation. Eighteen springs included both riparian and non-riparian vegetation.

We observed a total of 55 species of butterflies at plots, at springs, and along springbrooks (Figure 1). All of the species were recorded in association with riparian vegetation; 37 species were recorded in association with non-riparian vegetation. Many of the 18 species that we recorded only in association with riparian vegetation are known to occur in non-riparian vegetation elsewhere in their distributional ranges, including within the Spring Mountains. No species was recorded in association with
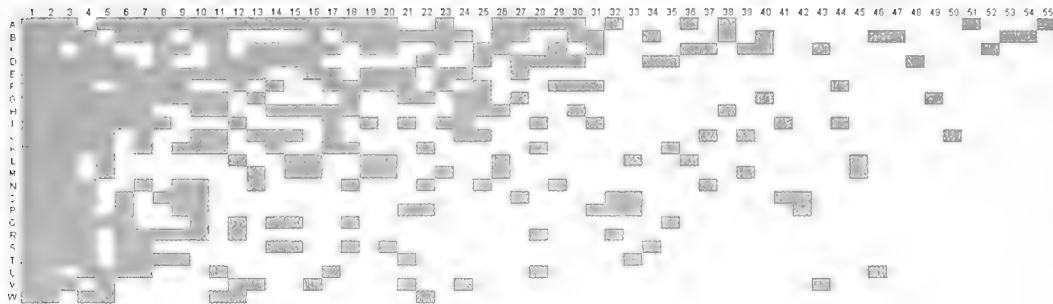
FIG. 1. Species of butterflies present at 23 springs in the Spring Mountains. Springs are listed in decreasing order of species richness; species are listed in decreasing order of number of springs occupied. ° indicates butterflies found only in association with riparian vegetation in this study (may occur in non-riparian vegetation elsewhere). Springs: A, Sawmill Spring; B, Willow Creek; C, Switchback Spring; D, Pine Creek; E, Cold Creek; F, La Madre Spring; G, Ash Creek; H, Lost Creek; I, Mountain Springs; J, Ice Box Canyon; K, Oak Creek; L, Bonanza-f; M, Bonanza-u; N, Calico Spring; O, Mud Spring 1; P, Mud Spring 2; Q, First Creek; R, Red Spring; S, Willow Spring; T, Wheeler Spring; U, White Rock Spring; V, Willow Seep; W, Calico Tanks. Butterflies: 1, *Leptotes marina*; 2, *Vanessa cardui*; 3, *Pontia protodice*; 4, *Danaus gilippus*; 5, *Anthocharis sara*; 6, *Hemiargus isola*; 7, *Eurema nicippe*; 8, *Colias eurytheme*; 9, *Junonia coenia*; 10, *Nathalis iole*; 11, *Pontia sisymbrii*; 12, *Danaus plexippus*; 13, *Vanessa annabella*; 14, *Adelpha bredowii*; 15, *Celastrina ladon*; 16, *Erynnis brizo*; 17, *Incisalia fotis*; 18, *Pyrgus communis*°; 19, *Cercyonis sthenele*; 20, *Limenitis weidemeyerii*; 21, *Papilio polyxenes*; 22, *Chlosyne acastus neumoegeni*; 23, *Colias cesonia*; 24, *Nymphalis antiopa*°; 25, *Papilio indra*; 26, *Nymphalis californica*; 27, *Pontia beckerii*; 28, *Strymon melinus*; 29, *Erynnis meridianus*°; 30, *Heliopetes ericetorum*°; 31, *Megathymus yuccae*; 32, *Brephidium exile*; 33, *Hemiargus ceraunus*; 34, *Atlides halesus*; 35, *Euchloe hyantis*°; 36, *Hesperia comma*°; 37, *Icaricia acmon*°; 38, *Pieris rapae*°; 39, *Speyeria carolae*; 40, *Vanessa virginiensis*°; 41, *Apodemia mormo*; 42, *Apodemia palmerii*; 43, *Euphilotes ancilla*°; 44, *Mitoura siva*°; 45, *Polygonia zephyrus*; 46, *Vanessa atalanta*; 47, *Chosyne acastus robusta*°; 48, *Chlosyne californica*°; 49, *Copaeodes aurantiaca*°; 50, *Erynnis funeralis*°; 51, *Everes amyntula*; 52, *Loranthomitoura spinetorum*°; 53, *Nymphalis milberti*°; 54, *Polygonia satyrus*; 55, *Satyrium behrii*

non-riparian vegetation only. Species richness of butterflies at the spring level ranged from 7 to 30 (16.2 ± 6.2, mean ± SD). Species richness of butterflies in riparian vegetation fell between 6 and 30 (15.6 ± 6.5), and species richness in non-riparian vegetation ranged from 1 to 14 (8.2 ± 3.2).

We recorded a total of 4357 individual butterflies. Abundances of butterflies at the spring level ranged from 40 to 456 (189.0 ± 125.0, mean ± SD). Abundances of butterflies in riparian vegetation fell between 13 and 383 (154.4 ± 115.0), and abundances in non-riparian vegetation ranged from 3 to 136 (55.2 ± 35.2).

Across all springs, species richness of butterflies was significantly higher in riparian vegetation than in non-riparian vegetation ($F_{1,39}$ = 21.1, P < 0.001). Within spring sites that had both riparian and non-riparian vegetation, the effect of vegetation category was significant as well (t = 4.119, df = 17, P < 0.001). Mean abundance of butterflies in riparian vegetation was significantly higher than in non-riparian vegetation, both across all sites ($F_{1,39}$ = 13.7, P < 0.001) and within the 18 spring sites that contained both categories of vegetation (t = 3.788, df = 17, P < 0.01).

At the level of individual sampling points, species richness and abundance of butterflies also were significantly higher in locations with riparian vegetation than in locations with non-riparian vegetation (species richness: $F_{1,145}$ = 40.43, P < 0.001; abundance: $F_{1,145}$ = 41.52, P < 0.001). Thus, although vegetation in a higher proportion of the sampling points (sampled area) was categorized as riparian (0.55) than as non-riparian (0.45), this difference did not appear to explain the discrepancy in species richness and abundance of butterflies between riparian and non-riparian vegetation.

Similarity of species composition of butterflies decreased as the linear distance between springs increased (Table 1). Neither local presence of larval hostplants nor vegetation association of larval hostplants had a statistically significant effect on occurrence rate or abundance of individual species of butterflies.

The distributional pattern of butterflies at all springs, at riparian portions of springs, and at non-riparian portions of springs was significantly nested (Table 2); therefore, the butterfly faunas at relatively depauperate springs were statistically proper subsets of the species present at relatively species-rich springs. Relative nestedness of assemblages associated with riparian versus non-riparian vegetation was not significantly

TABLE 1. Correlations between distance between springs and similarity of species composition of butterflies at all springs, the riparian component of springs, and the non-riparian component of springs. Values are Mantel r statistics. For all values, P ≤ 0.001.

	Mantel's r	P
All springs	0.27	0.01
Riparian vegetation	0.14	0.06
Non-riparian	0.30	0.003

TABLE 2. Size and values of the relative nestedness index C for matrices that included all springs, the riparian component of springs, and the non-riparian component of springs. Degrees of freedom are (number of species - 1). All P-values < 0.0001.

	Sites	Species	C
All springs	23	55	0.366
Riparian	21	55	0.367
Non-riparian	20	37	0.352

different, suggesting that vegetation type as categorized in this study to date does not have an important influence on the ability to predict the order of butterfly colonizations or extirpations (i.e., the order of species associated with riparian vegetation is no more or less predictable than the order of species associated with non-riparian vegetation).

Discussion

Our results suggest that reductions in water availability and the extent of riparian vegetation at montane springs in the Mojave Desert are likely to reduce local species richness and abundance of butterflies. Across several levels of spatial resolution, species richness and abundance of butterflies consistently were higher in riparian vegetation than in non-riparian vegetation. This is not surprising given the importance of water, especially in xeric systems, for sustaining larval hostplants, adult nectar sources, and moist soil from which some species of butterflies draw water and nutrients (Nelson & Andersen 1999, Mac Nally et al. 2004). In semi-arid and arid environments, butterflies, like many other terrestrial taxa, rely heavily on resources provided by springs, spring-fed riparian systems, and other isolated wetlands (Shapiro 1984, Austin 1985, Murphy & Wilcox 1986, Schlicht & Orwig 1998). In addition, the structurally complex vegetation often characteristic of riparian areas creates refugia for many species of butterflies that cannot tolerate relatively hot or dry microclimates (Galiano et al. 1985).

Financial and logistic obstacles make it impossible to inventory terrestrial and aquatic taxonomic groups at each spring in the Spring Mountains. Accordingly, land managers would like to develop a method to predict measures of biodiversity as functions of readily categorized attributes such as land cover. Although species richness and abundance of butterflies appears to benefit from maintenance of riparian vegetation, our results indicate that the ability of broad categories of vegetation to serve as a predictor of species richness and composition of butterflies may be relatively low. In our study system, for example, neither local presence of

larval hostplants nor vegetation association of larval hostplants was an effective predictor of occurrence rate (proportion of locations in which the species was present) or abundance of individual species of butterflies. We suspect that observation at least in part reflects a relatively high degree of polyphagy among the butterfly species encountered in this study, which may serve to reduce effective differences in the suitability of springs that differ substantially in the composition of their vegetation. Nonetheless, species present in relatively depauperate locations tended to be subsets of the species present in locations that are richer in species, but the degree of order in species composition (i.e., the predictability of local extirpations and colonizations) did not appear to be affected by whether riparian habitat was available.

We recognize that conclusions drawn from one year of data on butterfly occurrence and abundance may not be definitive. We also acknowledge that the estimates of resource quantity and quality presented here are relatively coarse; we currently are collecting data on more-detailed measures of vegetation structure and composition that may have greater ability to predict the order of butterfly colonizations or extirpations. Nonetheless, absence of a tight link between occurrence of butterflies and occurrence of larval hostplants is not uncommon (Holl 1996, Waltz & Covington 2004). Although adults that are facultative or obligate nectarivores may be drawn to the high concentrations of flowering plants that can be characteristic of riparian areas, considerable proportions of the distributions of primary larval hostplants in arid environments, as well as entire distributions of potential alternative hosts, may occur beyond riparian boundaries (Galiano et al. 1985).

To some extent, the apparent inability of vegetation type to serve as an effective predictor of biodiversity patterns of butterflies may reflect the tremendous variation in abiotic and biotic attributes of springs in the Spring Mountains, including but not limited to area and morphology of the spring head and springbrook; water volume, chemistry, and seasonal variability; and history

of disturbance from all sources (Wettstein & Shmid 1999). We have observed similarly weak relationships between species richness and composition of aquatic invertebrates in the Spring Mountains and gradients in disturbance intensity and major environmental variables (Sada et al. 2005). The isolation of an individual spring also appears to play a important role in determining its butterfly species composition; springs that are closer together tend to have more similar assemblages of butterflies than springs that are further apart.

One of several useful considerations in establishing location-specific priorities for conservation and rehabilitation is presence of ubiquitous or "weedy" species-in any taxonomic group-that are characteristic of biotic homogenization or are able to exploit specific natural and human disturbances as opposed to species characteristic of less disturbed locations (Noss 1990, Lockwood & McKinney 2001, McKinney 2002). In our study system, individual species of butterflies were present in one to 23 springs, with a median occurrence rate of six springs (6.8 ± 5.6, mean ± SD). The two species of butterflies present at all 23 springs surveyed, *Leptotes marina* and *Vanessa cardui*, are highly vagile as adult individuals, are geographically widespread, and often occur in locations subject to relatively intensive human land uses (Scott 1986). The third and fourth most prevalent species among the springs we surveyed, *Pontia protodice* and *Danaus gilippus*, likewise are fairly opportunistic. Our results, therefore, reinforce the principle that protection of locations that currently support a large number of species, while desirable and necessary for protection of biodiversity, may not be sufficient to meet all conservation goals. Even in a significantly nested system, some species that are absent from relatively species-rich locations are present in locations with equal or lower species richness. Establishment of conservation priorities and strategies requires not only information on species richness and abundance but also complementary measures of ecological condition and function (Kinzig et al. 2002).

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BIOLOGICAL TRAITS OF FRUGIVOROUS BUTTERFLIES IN A FRAGMENTED AND A CONTINUOUS LANDSCAPE IN THE SOUTH BRAZILIAN ATLANTIC FOREST

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ABSTRACT. We test whether five biological traits of frugivorous butterflies (Lepidoptera: Nymphalidae) of the Brazilian Atlantic Forest differ between a continuous forest and an adjoining fragmented landscape. Possible fragmentation effects were detected in sex ratio and age structure, but we found no evidence that recapture rates, wing size, or damage in frugivorous butterflies were related to forest fragmentation. Among the possible explanations for the observed patterns, we suggest that 1) the landscape is sufficiently permeable and suitable for maintaining most general biological patterns in butterflies, 2) non-effects might be statistical artifacts, 3) the traits examined are usually not affected by this level of fragmentation, or 4) the most abundant frugivorous butterflies demonstrate some resistance to habitat fragmentation.

Additional key words: fruit-feeding butterflies, forest fragmentation, population biology.

An inevitable result of the expansion of human activities in forested habitats is the reduction of native vegetation and the creation of mosaics of forest remnants within an anthropic matrix. Consequently, severe ecological outcomes in the landscape may be predicted, and have been observed (Bierregaard et al. 2001). Forest fragmentation is currently one of the processes that most contributes to the increasing rates of species extinction and loss of biodiversity (Saunders et al. 1991, Tscharntke et al. 2002).

To help ensure the success of biological conservation, biologists need to understand patterns and processes of changing landscapes, as well as population responses to these large-scale modifications (Collinge 2001). Although many studies treat habitat fragmentation effects in Neotropical environments (reviews in Saunders et al. 1991, Turner 1996, Debinski & Holt 2000, Laurance et al. 2002, Tscharntke et al., 2002), few data exist for the most rich and abundant group of animals in these environments, the insects. Effects of forest fragmentation on populations of insects are still little understood, and the empirical data are diffuse and contradictory (Didham et al. 1996). Bierregaard et al. (1997) point out that basic natural history information is absent for a majority of the Neotropical fauna and is deficient even for groups considered "charismatic", such as butterflies. This scenario is even worse when focused

on one of the most endangered Neotropical ecosystems, the Brazilian Atlantic Forest, where only few studies on fragmentation effects on insects have been done (eg. Tonhasca et al. 2002, Brown & Freitas 2003).

Because butterflies are short-lived organisms whose populations respond rapidly to changes in habitat quality (Brown 1991), our objective is to determine if biological traits of Atlantic Forest frugivorous butterflies (Lepidoptera: Nymphalidae) (sex ratio, recapture rates, size, incidence of damage, and age structure) differ between a continuous forest and an adjoining fragmented landscape (data on abundance distribution as well as community patterns will be reported elsewhere). These traits were chosen because they were reported in other population studies on Neotropical butterflies (e.g. Ehrlich & Gilbert 1973, Ehrlich 1984, Freitas 1993, Ramos & Freitas 1999) and are easily recorded, even if their relations to habitat fragmentation are either ambiguous (e.g. Thomas et al. 1998, Davies et al. 2000) or were not evaluated.

METHODS

Study area. The study area is located in the town of Cotia, São Paulo State, SE Brazil (23°35'S - 23°50'S, 46°45'W - 47°15'W). The altitude in the region varies from 800 to 1,000 m, with climate Cwa (humid subtropical with a dry winter, Köppen 1948). The annual mean temperature is 20.4°C, ranging from 16.5°C in July to 23.6°C in February; mean annual rainfall is 1,339 mm (meteorological data for 1962-1992).

The site was originally covered with Atlantic Forest vegetation, classified as montane rainforest (Ururahy et al. 1997). Field work was done in two landscapes (Fig. 1): a continuous forest block (Morro Grande State

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Reserve) and a mosaic of forest fragments immediately to the west. The Morro Grande State Reserve (23°39'S - 23°50'S, 46°55'W - 47°01'W) is a large block of forest (> 10,000 ha) mostly in advanced stages of succession, containing patches of well-preserved original forest. The fragmented landscape consists of a matrix formed mostly of small farms and orchards, mixed with vegetation in initial stages of regeneration (2 to 8 years) and reforestation of *Eucalyptus* and pine plantations, interspersed with about 35% natural vegetation (data from 1:10,000 aerial photographs from April, 2000).

Frugivorous butterflies. Butterflies can be separated into two main guilds, considering the feeding habits of adults (DeVries 1987): 1) nectar-feeding: Papilionidae, Pieridae, Lycaenidae, Hesperiidae, and some subfamilies of Nymphalidae; 2) "frugivorous" nymphalid butterflies, mostly in the satyroid lineage (*sensu* Freitas & Brown 2004): Satyrinae, Brassolinae, Morphinae, Charaxinae, Biblidinae, and the tribe Coeini (Nymphalinae). The so-called "frugivorous butterflies", besides feeding on fermented fruits, also feed on mammal excrement, plant exudates, and carrion (DeVries 1987).

Sampling frugivorous butterflies presents some practical advantages. They can be easily captured in traps containing rotting fruit, which permits simultaneous sampling with standardized effort at different sites. After identification, the majority of the butterflies can be released unharmed and marked, so that recaptures can be evaluated with minimum handling. Moreover, the attraction of butterflies to a food resource reduces the possibility of chance capture, present in other methods (DeVries & Walla 2001, Freitas et al. 2003).

Several nymphalid species in the nectar-feeding guild (including Apaturinae, Limenitidinae and Ithomiinae) are occasionally captured with fermenting baits (DeVries et al. 1999). Since they belong to another guild and may suffer influence from flowers next to the traps, such species have not been considered in this work. A complete illustrated list of the frugivorous butterflies observed in the study area is presented by Uehara-Prado et al. (2004).

Sampling procedures. This study was carried out at nine sites in the two landscapes: four sites inside the Morro Grande State Reserve (called "control", Fig. 1 A-D) and five forest fragments of approximately 14, 29, 52, 99 and 175 ha (Fig. 1 E-I, respectively). Each site received a sampling unit (hereafter SU) of five portable bait traps. Bait traps consisted of cylinders 110 cm high x 35 cm diameter made with dark netting, with an internal cone (22 cm wide at the opening) to prevent

Fig. 1. Location of the study areas in the Morro Grande Reserve (A-D) and in the fragmented landscape (E-I). Source: Kronka et al. (1993).

butterflies from escaping. The cylinder was attached ca. 4 cm above a plywood base, on which the bait was placed (adapted from Shuey 1997).

The traps were placed linearly along pre-existing trails in the understory of each site, suspended 1.8-2.2 m above the ground, with a distance of at least 20 m between adjacent traps and at least 50 m from the forest edge. Each trap was placed in a small, partly sunny clearing large enough to allow butterflies to circle and enter without exposing the bait and butterflies to extreme heat. The average distance between traps did not differ between SUs (Kruskal-Wallis H = 12.75, p = 0.121, df = 8). The use of five spaced traps per SU aimed to average the effects of trap position and bait attractiveness on the probability of butterfly capture (DeVries & Walla 2001).

A standard mixture of mashed banana and sugar cane juice, fermented for at least 48 hours, was used as attractant. The bait was placed inside the traps in plastic pots with a perforated cover to prevent butterflies from drowning in the liquid, to avoid feeding by other insects, and to reduce evaporation (Hughes et al. 1998). The traps were checked every 48 hours, permitting an increase in the number of sample sites (Hughes et al. 1998). The baits were replaced at each visit. The traps were kept in the field 12-14 days for a total of 36,000 trap/hours, with about 10 hours of effective sampling per day. Six samplings were carried out between November 2001 and May 2002, the period most favorable for the capture of frugivorous butterflies in SE Brazil (Brown 1972).

Sampling was done with minimal collecting events to reduce the effect of individual removal over time. Before release, each butterfly received an individual alphanumeric mark made with a felt-tipped pen on the ventral surface of each hind wing (as in Freitas 1993, 1996). We registered the following data for each captured individual: sex, forewing length, wing damage (present or absent), and wing wear (a measure of age: new, intermediate or old; modified from Freitas 1993).

We used G-tests for comparing proportions and Student's t-tests for comparing wing sizes. Data for males and females of each species were analyzed separately when the sample size of each sex allowed this. When multiple comparisons were made, critical values were corrected using the sequential Bonferroni method (Rice 1989).

RESULTS

Seventy species in six subfamilies of Nymphalidae were included in the 1,810 butterflies captured (Table 1, Appendix I). In 14 species (representing 76.6 % of the sampled individuals), the sample was large enough (N > 30) to describe the chosen population measures (Appendix I). Similar analyses with the remaining species were done only when the data were pooled by subfamily.

TABLE 1 Species richness and abundance (individuals captured) of frugivorous butterflies subfamilies (Nymphalidae) sampled in the Morro Grande Reserve (MG) and in the fragmented landscape (FR) from November 2001 to May 2002.

| Subfamily	Species richness		Individuals captured	
	MG	FR	MG	FR
Satyrinae	17	20	201	309
Biblidinae	14	17	292	583
Charaxinae	10	14	56	172
Brassolinae	10	9	105	62
Morphinae	2	2	6	15
Nymphalinae: Coeini	1	2	1	8
TOTAL	54	64	661	1,149

After Bonferroni's correction the sex ratio was significantly different from 1:1 in three species in the reserve and in one species in the fragments (Fig. 2). In the fragments, only *Hamadryas epinome* (Biblidinae) had a male-biased sex ratio. In the reserve, males were more abundant than females in *H. epinome, H. fornax,* and *Dasyophthalma creusa* (Brassolinae). When compared between landscapes, females were proportionally more abundant in the fragments (16%) than in the reserve (8%) for *H. epinome* (G = 7.31, df = 1, p = 0.007, N = 538) and proportionally more abundant in the reserve (74%) than in the fragments (50%) for *Myscelia orsis* (Biblidinae) (G = 8.07, df = 1, p = 0.005, N = 158) (critical p value = 0.007).

For both sexes of the four most abundant species and for *Dasyophthalma creusa* males, the recapture rate was similar among landscapes (Table 2A), varying from 7.5 to 25.8 % in the fragments and from 0 to 28.2 % in the continuous landscape. When compared between landscapes (excluding *Euptychoides castrensis*, whose males were not captured in the reserve), these rates did not differ significantly (Table 2A). Likewise, there were no differences in recaptures between sexes, when each landscape was analyzed separately (Table 2B). Although individuals of some species were observed flying through the matrix in the fragmented landscape and along large roads of the Morro Grande Reserve, recaptures between SUs were not observed in any species in this study.

There were no differences in wing size between landscapes for any analyzed species (Table 3). When wing size was compared between sexes, females were significantly larger than males in 8 of the 14 analyzed species (pooled data from the two landscapes) (Table 4).

Most species showed a homogeneous age structure in both landscapes; that is, there was no predominance of

FIG. 2. Sex ratio of frugivorous butterflies (Nymphalidae) at the Morro Grande Reserve (MG) and at the fragmented landscape (FR) from November 2001 to May 2002. ° = Sex ratio significantly different from 1:1 (corrected critical P-value = 0.004).
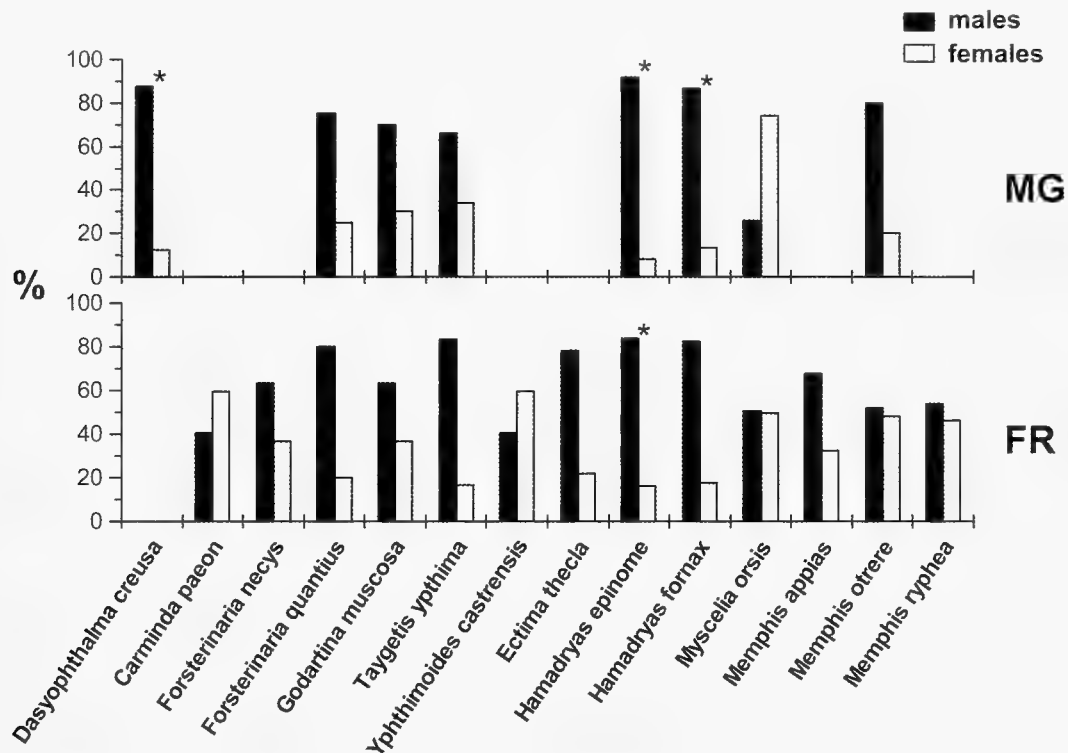
individuals in any age category. The exceptions to this pattern, all "new"-biased, were males of *Hamadryas epinome* and *Taygetis ypthima* in the reserve, and males of *H. epinome*, *Godartiana muscosa*, and *Memphis appias*, and both sexes of *Myscelia orsis* in the fragments (Table 5A). *Godartiana muscosa* (males) was the only species that showed age structure significantly different between landscapes, with more individuals in "intermediate" and "new" categories in the fragments (G = 11.29, p = 0.004, df = 2, N = 58, corrected critical p-value = 0.013). Conversely, when species were grouped by subfamily, the Satyrinae showed a predominance of individuals in "intermediate" and "old" categories in the fragments (Table 5B).

The percentage of individuals with wing damage for the nine most abundant species ranged from 0 to 30.8% in the reserve and from 4.6 to 37.5% in the fragments. Damage frequency was not different between landscapes, either when species were considered separately or grouped by subfamily (Table 6 A, B). The subfamilies showed different damage ratios, both in the reserve (G = 26.61, p < 0.001, df = 3, N = 636) and in the fragments (G = 27.83, p < 0.001, df = 3, N = 1,106), with the highest damage ratios in Brassolinae in both landscapes (corrected critical p-value = 0.013)

DISCUSSION

Population Biology. Contrary to many field studies carried out with butterfly populations (e.g., Gilbert & Singer 1975, Ehrlich 1984, Tyler et al. 1994), the sex ratio observed for most species in this study was not male-biased; recapture rates also did not differ between sexes. In most studies that sampled butterflies with nets, male-biased sex ratios result in part from differences in butterfly behaviors, with males flying in the same places frequented by lepidopterists (open tracks, with elevated light incidence and large space for flight), and females more dispersed in the habitat, searching for host plants (e.g. Ehrlich 1984, Freitas 1996, Ramos & Freitas 1999). The use of traps in the present study may minimize this bias due to the use of a food resource attractive to both sexes and independence from collector efficiency. Nonetheless, more mark-recapture studies are necessary to evaluate if, and by how much, the sex ratio is biased in different butterfly species.

The recapture rates found in this study - always less than 30% in both landscapes - might be attributed to particular characteristics of each species, such as large population size, flight ability, relatively short life span, or

TABLE 2 Recapture of frugivorous butterflies species (Nymphalidae) in the Morro Grande Reserve (MG) and in the fragmented landscape (FR) from November 2001 to May 2002. **A**. Comparisons among landscapes. **B**. Comparisons among sexes. BRA = Brassolinae, SAT = Satyrinae, BIB = Biblidinae, Subf = Subfamily.

A)	Species	Subf.	Sex	Morro Grande Reserve		Fragmented landscape		MG x FR	
				Capture	Recapture (%)	Capture	Recapture (%)	G-test	P
	Dasyophthalma creusa	BRA	♂	33	1 (3.03)	18	3 (16.7)	2.50	0.114
	Godartiana muscosa	SAT	♂	26	6 (23.1)	31	8 (25.8)	0.06	0.815
			♀	9	2 (22.2)	18	2 (11.1)	0.02	0.899
	Hamadryas epinome	BIB	♂	163	46 (28.2)	283	60 (21.2)	2.76	0.097
			♀	15	2 (13.3)	48	8 (16.7)	0.09	0.763
	Myscelia orsis	BIB	♀	28	1 (3.6)	51	4 (7.8)	0.55	0.460

B)	Species	Subf.	Morro Grande Reserve		Fragmented landscape	
			G-test	P	G-test	P
	Godartiana muscosa	SAT	0.00	0.960	1.54	0.215
	Euptychoides castrensis	SAT	-	-	0.02	0.876
	Hamadryas epinome	BIB	1.69	0.194	0.53	0.467
	Myscelia orsis	BIB	-	-	1.39	0.239

TABLE 3 Wing size of frugivorous butterflies (Nymphalidae) sampled in the Morro Grande Reserve and in the fragmented landscape from November 2001 to May 2002: comparisons among landscapes. Abbreviations as in Table 2 legend. CHA = Charaxinae. ° Corrected critical *P*-value = 0.004

Species	Subf.	Sex	Morro Grande Reserve			Fragmented landscape			MG x FR		
			x̄ (mm)	SE	N	x̄ (mm)	SE	N	t-test	df	P°
Dasyophthalma creusa	BRA	♂	45.44	0.24	39	45.44	0.27	25	0.02	55.4	0.991
Forsterinaria necys	SAT	♂	24.00	0.62	7	24.04	0.28	26	0.06	8.6	0.956
Forsterinaria quantius	SAT	♂	25.19	0.22	26	25.13	0.69	8	0.09	8.5	0.95
Godartiana muscosa	SAT	♂	22.33	0.35	30	23.58	0.37	36	2.45	63.9	0.017
		♀	23.91	0.60	11	25.87	0.34	23	2.86	16.8	0.011
Taygetis ypthima	SAT	♂	36.65	0.27	31	35.78	0.28	9	2.23	24.7	0.035
Euptychoides castrensis	SAT	♀	20.20	0.37	5	19.51	0.19	47	1.64	6.3	0.151
Hamadryas epinome	BIB	♂	36.06	0.15	156	35.95	0.09	262	0.62	258.8	0.534
		♀	37.67	0.29	15	36.96	0.20	47	2.03	28.7	0.052
Hamadryas fornax	BIB	♂	36.62	0.26	26	36.46	0.25	28	0.42	51.8	0.680
		♀	37.75	0.48	4	36.80	0.20	5	1.83	4.1	0.140
Myscelia orsis	BIB	♂	24.60	0.65	10	25.58	0.15	57	1.46	9.9	0.178
		♀	27.27	0.29	30	27.13	0.26	53	0.35	58.5	0.730

territoriality. In the present work, it is not possible to identify which of these factors could account for the observed pattern. Recapture rates may also be a result of the capture method employed, which may have been "traumatic" for certain species. Morton (1982) found that handling changed recapture rates in four of the five species studied, all captured with nets. Mallet et al. (1987) demonstrated that capture and handling reduce the tendency of *Heliconius* butterflies to return to the capture site in the days following marking, while maintaining their presence in another part of their living area. However, Hughes et al. (1998) found no evidence for either 'trap-happiness' or 'trap-recognition' for frugivorous butterflies in Costa Rica. In the present

TABLE 4. Wing size of frugivorous butterflies (Nymphalidae) sampled in the Morro Grande Reserve and in the fragmented landscape from November 2001 to May 2002: comparisons among sexes (both landscapes pooled). Bold numbers represent significant p values (after Bonferroni's correction). Abbreviations as in Table 2 legend. CHA = Charaxinae. °Corrected critical P-value = 0.004

Species	Subf	♂			♀			♂ x ♀		
		x (mm)	SE	N	x (mm)	SE	N	t-test	df	P°
Dasyophthalma creusa	BRA	45.44	0.17	64	52.25	0.47	8	14.01	9.3	**< 0.001**
Moneuptychia paeon	SAT	19.89	0.36	12	18.79	0.18	19	0.32	16.65	0.378
Forsterinaria necys	SAT	24.03	0.25	33	25.47	0.31	15	3.62	32.7	**0.001**
Forsterinaria quantius	SAT	25.09	0.26	34	26.55	0.37	11	3.25	20.9	**0.004**
Godartiana muscosa	SAT	23.02	0.27	66	25.24	0.34	34	5.18	73.3	**< 0.001**
Taygetis ypthima	SAT	36.70	0.38	40	37.89	0.34	18	2.32	51.22	0.012
Euptychoides castrensis	SAT	18.63	0.26	27	19.58	0.18	52	3.04	50.6	**0.004**
Ectima thecla	BIB	21.68	0.24	25	21.56	0.34	9	0.30	16.41	0.383
Hamadryas epinome	BIB	35.99	0.08	418	37.13	0.17	62	6.08	90.7	**< 0.001**
Hamadryas fornax	BIB	36.54	0.18	54	37.22	0.28	9	2.07	15.8	0.055
Myscelia orsis	BIB	25.43	0.16	67	27.30	0.23	83	6.57	139.8	**< 0.001**
Memphis appias	CHA	29.95	0.47	19	31.40	1.06	10	1.26	12.64	0.116
Memphis otrere	CHA	30.00	0.81	16	32.27	0.53	15	2.34	25.5	0.027
Memphis ryphea	CHA	29.82	0.62	22	31.88	0.28	17	3.03	29.02	**0.003**

study, the long time between visits to the traps (48 hours) along with butterfly handling might have contributed to many individuals acquiring aversion to the trap ('trap shyness').

In many cases, we observed frugivorous butterflies flying through the matrix and along the main open roads in the Reserve. Thus, the lack of recaptures between SUs could be a result of large numbers of butterflies present in the study area together with the small probability of recaptures of the individuals, not a result of the impermeability of the matrix or low mobility of these butterflies.

The regularity of age structure probably reflects continuous reproduction with overlapping generations in the majority of the analyzed species (unpublished data). As new individuals are continuously being added to the population, the presence of all ages, from 'new' to 'old' is expected. For species in which individuals are added at a greater rate, the accumulation of individuals of the 'new' category would be proportionally greater than the others, as observed in some cases (Table 5; see also Freitas 1993).

The higher wing damage rates of the subfamily Brassolinae may reflect only their large size, characteristic of many species of this subfamily. A simple explanation would be that these individuals are more damaged because they collide more often with the vegetation. The same trait may make them both conspicuous targets for predators and more likely to escape a predator attack. Another explanation for the large damage rates would be the aggressiveness of some

species (Brown 1992, Freitas et al. 1997, Srygley & Penz 1999).

Fragmentation effects. The sex ratio of the two most abundant species in both landscapes, *Hamadryas epinome* and *Myscelia orsis*, showed different patterns between the landscapes; *H. epinome* showed a higher proportion of females in the fragments, whereas in *M. orsis* more females were recorded in the reserve. Some studies have shown that density of males, quantity of host plant, and reduction or increase of competitors and predators can result in biased sex ratios (Shapiro 1970, Blau 1980, Peterson 1997).

The large number of Satyrinae in 'intermediate' and 'old' age categories in the fragments indicates some fragmentation effect on the wing wear in this subfamily. Possible explanations could be that individuals in the fragments age faster, live longer, or both. Another explanation could be the increase in individual activity in fragmented landscapes. This increase may be related to a higher light incidence and consequently higher temperature in the fragments, a well-known fragmentation effect (see Turton & Freiburger 1997). Because most satyrines in the study sites fly in the lower forest strata, an increase in temperature and light level associated with fragmentation could be more important for the individuals of this subfamily. The pattern observed in *G. muscosa*, with individuals tending to 'new' in the fragments is divergent in the subfamily Satyrinae, and should be studied in more detail.

We detected possible effects of forest fragmentation only in sex ratio and age structure; we found no

TABLE 5. Age structure of frugivorous butterflies (Nymphalidae) sampled in the Morro Grande Reserve and in the fragmented landscape from November 2001 to May 2002. A. Males vs. females. B. Comparison among landscapes, pooled by subfamilies. Bold numbers represent significant p values (after Bonferroni's correction). Abbreviations as in Tab. 2 legend. Int = Intermediate, CHA = Charaxinae. ° Corrected critical P-value: Fragments = 0.01; Reserve = 0.005; °° Corrected critical P-value = 0.013

A) Species	Subf.	Sex	Morro Grande Reserve					Fragmented landscape				
			New	Int	Old	G-test	$P°$	New	Int	Old	G-test	$P°$
Dasyophthalma creusa	BRA	♂	8	22	9	4.27	0.118	7	13	7	1.23	0.540
		♀	6	0	0	-	-	-	-	-	-	-
Moneuptychia paeon	SAT	♂	1	0	0	-	-	2	4	7	1.53	0.466
		♀	-	-	-	-	-	10	8	1	5.35	0.069
Forsterinaria necys	SAT	♂	4	2	2	-	-	9	13	4	2.64	0.267
		♀	-	-	-	-	-	10	5	0	-	-
Forsterinaria quantius	SAT	♂	19	6	2	9.07	0.011	2	5	1	-	-
		♀	1	6	2	-	-	2	0	0	-	-
Godartiana muscosa	SAT	♂	4	13	5	2.78	0.249	20	15	1	13.33	**0.001**
		♀	4	7	0	-	-	7	12	3	3.02	0.221
Taygetis ypthima	SAT	♂	27	2	6	15.67	**<0.001**	7	3	0	-	-
		♀	13	4	1	7.01	0.030	0	0	0	-	-
Euptychoides castrensis	SAT	♂	-	-	-	-	-	7	11	15	1.51	0.469
		♀	2	2	1	-	-	13	26	0	35.44	**< 0.001**
Memphis appias	CHA	♂	0	0	1	-	-	18	2	1	13.01	**0.002**
		♀	-	-	-	-	-	3	5	2	-	-
Memphis otrere	CHA	♂	1	0	3	-	-	7	7	1	3.58	0.167
		♀	1	0	0	-	-	9	3	2	2.86	0.239
Memphis ryphea	CHA	♂	-	-	-	-	-	15	4	3	5.56	0.062
		♀	1	0	0	-	-	14	3	1	8.27	0.016
Ectima thecla	BIB	♂	0	0	0	-	-	23	2	0	-	-
		♀	2	0	0	-	-	7	0	0	-	-
Hamadryas epinome	BIB	♂	99	46	28	22.84	**< 0.001**	197	61	36	72.38	**< 0.001**
		♀	14	1	0	-	-	46	2	0	-	-
Hamadryas fornax	BIB	♂	23	3	0	-	-	17	11	0	-	-
		♀	0	0	0	-	-	3	3	0	-	-
Myscelia orsis	BIB	♂	8	1	1	-	-	43	12	2	27.04	**< 0.001**
		♀	16	12	4	4.30	0.117	30	21	4	12.99	**< 0.001**

B) Subfamily	Morro Grande Reserve			Fragmented landscape			MG x FR	
	New	Int	Old	New	Int	Old	G-test	$P°°$
Brassolinae	39	39	18	15	25	17	4.11	0.128
Satyrinae	114	57	26	116	137	48	18.77	**< 0.001**
Charaxinae	39	5	9	103	40	24	5.93	0.052
Biblidinae	180	70	35	403	125	47	5.27	0.072

TABLE 6 Wing damage in frugivorous butterflies (Nymphalidae) in the Morro Grande Reserve and in the fragmented landscape sampled from November 2001 to May 2002. A. Most abundant species. B. Data pooled by subfamily. Abbreviations as in Tab. 2 legend. ° Corrected critical P-value = 0.004. °° Corrected critical P-value = 0.013

A) Species	Subf	Sex	% damaged (n)		MG x FR	
			MG	FR	G-test	$P°$
Dasyophthalma creusa	BRA	♂	5.9 (39)	5.9 (27)	0.00	0.982
Forsterinaria necys	SAT	♂	25.0 (8)	7.7 (26)	1.53	0.216
Forsterinaria quantius	SAT	♂	11.1 (27)	37.5 (8)	2.65	0.104
Godartiana muscosa	SAT	♂	18.2 (33)	13.9 (36)	0.24	0.627
		♀	10.0 (11)	4.6 (22)	0.25	0.616
Taygetis ypthima	SAT	♂	5.7 (35)	30.0 (10)	3.85	0.500
Euptychoides castrensis	SAT	♀	20.0 (5)	12.5 (48)	0.20	0.655
Hamadryas epinome	BIB	♂	28.0 (175)	21.0 (296)	2.99	0.084
		♀	13.3 (15)	8.3 (48)	0.31	0.580
Hamadryas fornax	BIB	♂	30.8 (26)	25.0 (28)	0.22	0.636
Myscelia orsis	BIB	♂	0.0 (10)	13.8 (58)	2.72	0.099
		♀	21.9 (32)	19.3 (57)	0.08	0.772

B) Subfamily	% damaged (n)		MG x FR	
	MG	FR	G-test	$P°°$
Brassolinae	41.7 (96)	45.6 (57)	0.23	0.634
Satyrinae	14.2 (197)	14.4 (306)	0.00	0.959
Charaxinae	19.0 (58)	24.0 (167)	0.63	0.428
Biblidinae	23.5 (285)	18.4 (576)	3.04	0.081

evidence that recapture rates, wing size, or damage in frugivorous butterflies are related to fragmentation. Among the possible explanations for the observed pattern, we suggest that 1) even though the environment was modified more than 100 years ago, due to land-use rules of the region the landscape continues to be sufficiently permeable and suitable for maintaining most general biological patterns for long periods of time in butterflies; 2) many of the non-effects found in this study could be statistical artifacts, due to the conservative analyses we used; 3) most of the traits chosen in this study are usually not affected by this level of fragmentation, or 4) the commonest frugivorous butterflies could be in some degree resistant to habitat fragmentation (at least for the traits used in this study).

Frugivorous butterflies are easy (and inexpensive) to sample and identify, are potentially 'charismatic' to nonscientists and could be used in monitoring programs by nonspecialists. However, basic natural history studies on this group are virtually absent for the Brazilian Atlantic Forest species. The data presented here should serve as a guideline for future work, either with population biology or with fragmentation effects in this butterfly group.

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APPENDIX I. Frugivorous butterfly (Nymphalidae) sampled in the Morro Grande Reserve and in the fragmented landscape from November 2001 to May 2002. MOR = Morphinae, BRA = Brassolinae, SAT = Satyrinae, BIB = Biblidinae, CHA = Charaxinae, COE = Nymphalinae, Coeini. nd = individuals whose sex could not be determined (abdomen missing due to predation in traps).

Species	Subf.	Morro Grande Reserve				Fragmented landscape			
		♂	♀	nd	Total	♂	♀	nd	Total
Morpho achilles	MOR	0	0	1	1	0	5	0	5
Morpho catenarius	MOR	3	1	1	5	7	1	2	10
Caligo arisbe	BRA	1	4	1	6	3	0	0	3
Caligo beltrao	BRA	3	0	0	3	1	0	0	1
Caligo eurilochus	BRA	1	0	0	1	4	0	0	4
Caligo illioneus	BRA	1	0	0	1	0	0	0	0
Dasyophthalma creusa	BRA	42	8	0	50	29	0	2	31
Dasyophthalma rusina	BRA	0	0	1	1	0	0	0	0
Eriphanes reevesi	BRA	12	7	1	20	2	3	0	5
Narope cyllarus	BRA	0	0	0	0	1	0	0	1
Opoptera aorsa	BRA	1	2	0	3	2	1	0	3
Opoptera syme	BRA	10	0	1	11	10	2	1	13
Opsiphanes invirae	BRA	7	0	2	9	1	0	0	1
Archeuptychia cluena	SAT	11	2	1	14	5	2	1	8
Moneuptychia griseldis	SAT	0	0	0	0	0	2	0	2
Moneuptychia paeon	SAT	1	0	0	1	13	19	3	35
Eteona tisiphone	SAT	1	1	0	2	1	5	0	6
"Euptychia" pronophila	SAT	0	0	0	0	0	1	0	1
Forsterinaria necys	SAT	8	0	0	8	26	15	3	44
Forsterinaria quantius	SAT	27	9	2	38	8	2	0	10
Godartiana muscosa	SAT	31	11	2	44	23	36	1	60
Hermeuptychia hermes	SAT	1	0	0	1	6	0	1	7
Moneuptychia soter	SAT	0	1	0	1	6	2	2	10
Pareuptychia ocirrhoe	SAT	0	0	0	0	1	0	0	1
Paryphthimoides phronius	SAT	0	1	0	1	1	0	0	1
Splendeuptychia ambra	SAT	6	1	0	7	0	0	0	0
Splendeuptychia doxes	SAT	2	1	0	3	11	7	2	20
Splendeuptychia hygina	SAT	6	0	0	6	0	0	0	0
Taygetis acuta	SAT	8	1	0	9	1	0	0	1
Taygetis ypthima	SAT	35	19	2	56	10	2	1	13
Taygetis laches	SAT	3	0	1	4	1	0	0	1
Taygetis virgilia	SAT	0	1	0	1	1	0	0	1
Yphthimoides angularis	SAT	0	0	0	0	1	0	0	1
Euptychoides castrensis	SAT	0	5	0	5	33	48	5	86
Callicore sorana	BIB	0	0	0	0	1	0	0	1
Catonephele acontius	BIB	0	1	0	1	0	0	0	0
Catonephele numilia	BIB	3	3	0	6	6	1	0	7

APPENDIX 1. continued

Species	Subf.	Morro Grande Reserve				Fragmented landscape			
		♂	♀	nd	Total	♂	♀	nd	Total
Diaethria candrena	BIB	0	1	0	1	0	1	0	1
Diaethria clymena	BIB	0	0	0	0	1	1	1	3
Ectima thecla	BIB	0	2	0	2	25	7	1	33
Epiphile huebneri	BIB	0	0	0	0	4	0	0	4
Epiphile orea	BIB	0	4	0	4	4	4	0	8
Eunica eburnea	BIB	1	0	0	1	0	0	0	0
Hamadryas amphinome	BIB	3	0	0	3	10	2	0	12
Hamadryas arete	BIB	1	0	0	1	3	2	0	5
Hamadryas epinome	BIB	174	15	5	194	294	48	4	346
Hamadryas februa	BIB	3	0	0	3	4	1	0	5
Hamadryas feronia	BIB	0	0	0	0	2	1	0	3
Hamadryas fornax	BIB	26	4	0	30	28	6	0	34
Hamadryas iphthima	BIB	2	0	0	2	3	0	0	3
Myscelia orsis	BIB	11	32	0	43	58	55	2	115
Paulogramma pyracmon	BIB	0	0	0	0	1	1	0	2
Temenis laothoe	BIB	1	0	0	1	1	0	0	1
Consul fabius	CHA	0	0	0	0	1	1	0	2
Hypna clytemnestra	CHA	3	5	1	9	8	9	0	17
Memphis appias	CHA	1	0	0	1	21	10	0	31
Memphis arginussa	CHA	3	0	0	3	4	3	0	7
Memphis morvus	CHA	0	0	0	0	3	0	1	4
Memphis otrere	CHA	4	1	0	5	15	14	0	29
Memphis philumena	CHA	0	1	0	1	1	0	0	1
Memphis ryphea	CHA	0	1	0	1	22	19	1	42
Prepona amphimachus	CHA	14	2	0	16	5	0	1	6
Prepona chalciope	CHA	1	1	1	3	7	8	0	15
Prepona demophon	CHA	5	1	0	6	6	2	0	8
Prepona demophoon	CHA	0	0	0	0	3	0	0	3
Prepona pylene	CHA	0	0	0	0	1	0	0	1
Zaretis itys	CHA	3	7	1	11	1	5	0	6

IDENTIFICATION OF THE LARVAE DESCRIBED BY CRUMB AS CUCULLIA "SPECIES N^O 8" AND *CUCULLIA SPEYERI* RACE *DORSALIS* (NOCTUIDAE, CUCULLIINAE)

Additional key words: life cycle, host plant, purpule aster, *Machaeranthera*.

The identities of the larvae of *Cucullia dorsalis* Smith and *Cucullia speyeri* Linter have remained in question for some time. In his cuculliine monograph, Poole (1995) stated that "the larva of *dorsalis* has not been described" even though he considered the possibility that Crumb's (1956:61) "Cucullia #8" may be this species. The uncertainty concerning the identity of this larva is complicated up by the description made by Crumb of another larva, under the name of *C. speyeri* race *dorsalis*. The unique adult obtained from this larva was a female preventing identification by genitalic examination. Concerning *C. speyeri*, Poole (1995) stated: "the larva has not been unequivocally described…. There are larvae from Illinois that have been reared from *Conyza canadensis* (L.) Cronq. (Asteraceae)". Poole then offered a short description of these larvae. However, Poole's description is not completely consistent with that given by Crumb under the name *C. speyeri* race *dorsalis*. Handfield (1995), citing Crumb, states the food-plant of *C. speyeri* is *C. canadensis*, implicitly recognizing, that the species described as *C. speyeri* race *dorsalis* is *C. speyeri*. Here we present rearing data to help clarify this situation.

In August 1992, near Cedar City, Utah, we found four brightly colored mature cuculliine larvae on a flowering blue-violet aster which we later identified as *Machaeranthera canescens* (Pursh) Gray (Asteraceae). Our larvae strongly differed from those described by Crumb (1956) as *C. speyeri* race *dorsalis*, and more closely resembled larvae of the three taxa "*Cucullia* sp. No. 8," *C. laetifica* (Linter) and *C. alfarata* (Strecker). These latter three taxa all have a last instar with red/orange (sometimes yellow) middorsal and subventral stripes, and variable black markings on a white or green ground color. The subventral stripes appear continuous in all three taxa. The middorsal stripe is continuous only in *C. alfarata*, being broken into separate spots by black transverse stripes in "*Cucullia* sp. No 8," and *C. laetifica*, as well as in our Cedar City larvae (a photo of a *C. alfarata* larva is available at http://troyb.com/photo/gallery/). We exclude *C. alfarata* as a possibility for our larvae because that species is south-eastern in distribution (Poole1995). We felt our larvae were not *C. laetifica* because they had a white rather than green ground color, a different shape of the black markings surrounding the middorsal stripe, and

fed mainly on *M. canescens* (the foodplant reported by Crumb for his *Cucullia* No. 8 collected near Tieton, central Washington) rather than on *C. laetifica* food plants. *C. laetifica* is recorded, according to Crumb 1956, on *Chrysothamnus* (Asteraceae), *Boherhavia* (Verbenaceae), and *Hedera* (Araliaceae) and according to Poole 1995 on *Baccharis neglecta* Britton (Asteraceae). We obtained two adults in late August and early September 1992 from the four larvae, showing that our species was double brooded. However, at the time, we were unable to identify the adult moths with certainty using the figures in Hampson (1906) and Seitz (1919-1944).

We returned in August 1993 to search again for more larvae. We found them in abundance in four north-western states, including: Utah (Brighton; Cedar City; Dixie National Forest; Rte. 211 nr. fork leading to Canyon Land National Park), Colorado (Dove Creek; Clear Creek River nr. Idaho Springs; Estes Park), Wyoming (Rte. 187 N of Rock Springs; Landers; Roverton), and Montana (20 km. SW of Missoula). At low elevation the larvae were feeding on *M. canescens* and similar asters. At higher elevations (2500–3000 m) in Utah they were feeding on low growing plants tentatively determined by us as *Erigeron asperugineus* (D. C. Eat.) Gray (Asteraceae) (the online USDA Plants Database at http://plants.usda.gov only reports *E. asperugineus* from Nevada, Idaho, and Montana). Similarly, *M. canescens* is not reported from Washington in this database but is cited by Crumb (1956) as occurring at Tieton, Washington. It is interesting to note that Poole (1995) lists the following food plants for *C. dorsalis*: *Helianthus* sp.(Asteraceae) and *M. shastensis* Gray, a synonym of *M. canescens* according to the USDA plants database. All these food plants are similar in the sticky properties of their flower buds. In Colorado, Wyoming, and Montana, the only other lepidopteran species we found on *M. canescens* included a species of *Cucullia* in the *asteris* group and an unidentified heliothine, neither of which were common.

DESCRIPTION OF *C. DORSALIS* AND *C. SPEYERI* LARVAE

Cucullia dorsalis: Using information provided by J. D. Lafontaine and later confirmed in Poole's monograph, we were subsequently able to identify our
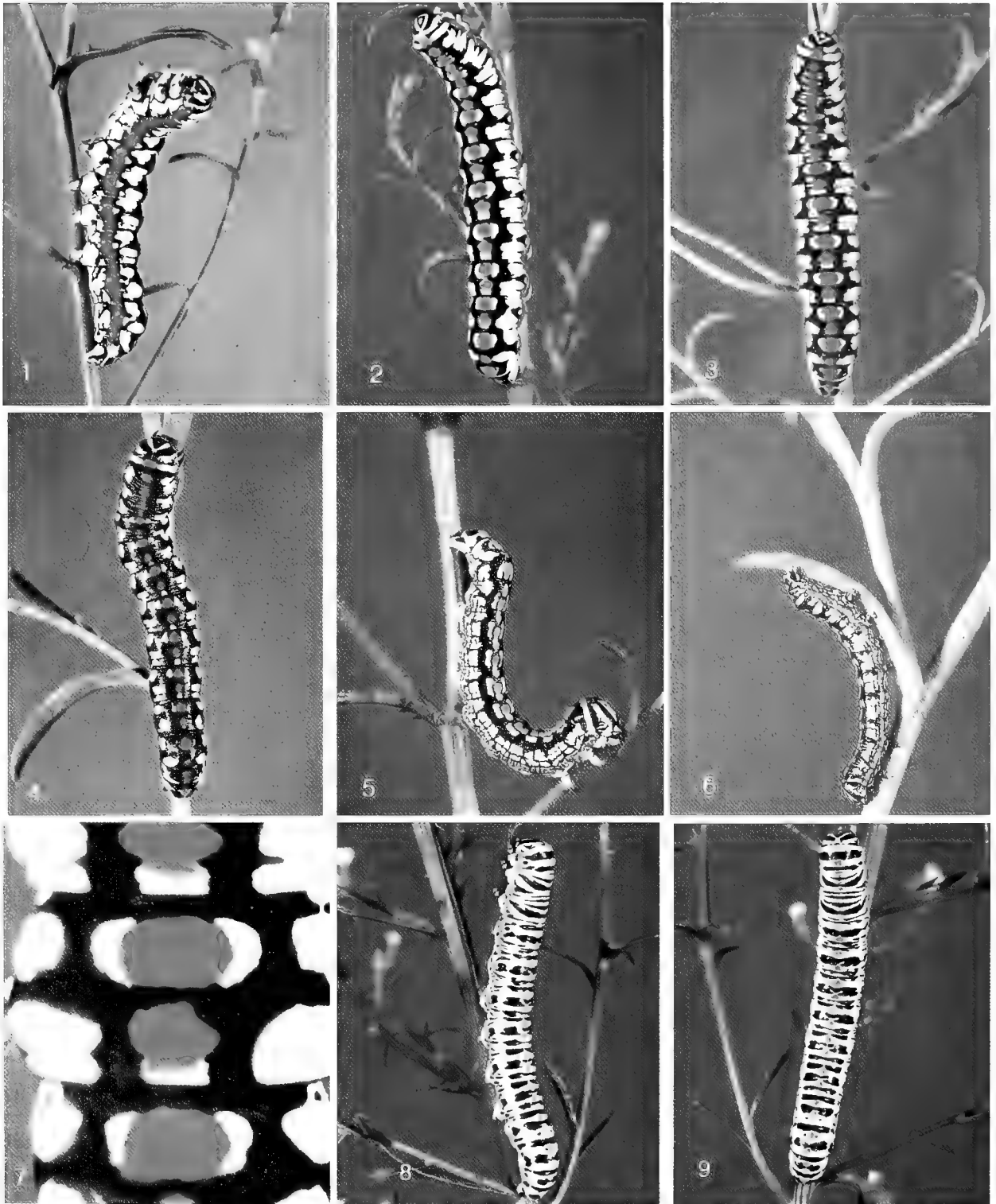
FIGS 1–9. Larvae of *Cucullia* species ordered sequentially from left to right, top to bottom: **1**, *C. dorsalis* (lateral view), last instar, on *M. canescens* Cedar City (Utah, VIII-93). **2**, *C. dorsalis* (dorsal view), last instar, Cedar City (Utah, VIII-93). **3**, *C. dorsalis* (dorsal view), last instar, on *M. canescens*, (Central Washington, IX-02). **4**, *C. dorsalis* (dorsal view), penultimate instar, 20 Km South West of Missoula, (Montana, IX-02). **5**, *C. dorsalis* (lateral view), third instar, Cedar City (Utah, VIII-93). **6**, *C. dorsalis* (lateral view), second instar, Cedar City (Utah,VIII-93). **7**, *C. dorsalis* (enlarged dorsal view), last instar, Cedar City (Utah, VIII-93). **8**, *C. speyeri* (lateral view), penultimate instar on *C. canadensis*, 10 Km West of Clarkston (Eastern Washington, VIII-93). **9**, *C. speyeri* (dorsal view), penultimate instar on *C. canadensis*, 10 Km West of Clarkston (Eastern Washington, VIII-93).

August 1992 reared adults as C. *dorsalis*. Although we failed to locate larvae in 1993 at Crumb's original Tieton, Washington locality, we were successful on a subsequent trip in September 2002 along the Yakima River between Yakima and Ellensburg. Our work therefore confirms that Crumb's (1956) description of "*Cucullia* sp. No. 8" is in fact *Cucullia dorsalis*.

The ground color of the larva is white, with intricate black, red, and orange patterning, giving the larva a harlequin-like appearance. The typical form (Figs.1, 3) of the last instar has a prominent dorsal stripe consisting of a succession of two orange-red spots on each abdominal segment followed by a smaller spot of the ground color partially invaded with yellow (Fig. 7); all the orange-red spots are separated from each other and from the previous segments by black markings which are wider on the sides creating an angled, sinuous longitudinal stripe. The result is a distinctive red/orange/yellow middorsal stripe. In the area between the black subdorsal stripe and the red subventral stripe (margined with black) there are two transverse black stripes on each segment, the second one including the spiracles, which are black. Generally, due to the absence of yellow shading, the subventral stripe is a more intense red/orange color than the middorsal one. Color variants occur in which the dorsal stripe is either yellow (Fig. 2) or red (Fig. 4) with the latter appearing in our Washington samples. In the first instars, the stripes are yellow/ochre (instead of red/orange) and two or three additional thin longitudinal black lines combine with the vertical lines to create a conspicuous reticulation (Figs. 5, 6), a feature that is absent in the last instar. The subdorsal black line is not as prominent as in the last instar.

Cucullia speyeri: We also offer additional information on the identity of the larva of *C. speyeri*. In 1993, we collected fourth instar cuculliine larvae (Fig.8, 9) in eastern Washington (10 Km W of Clarkston) on *Conyza canadensis*. The appearance of these larvae is consistent with the description Crumb (1956) gave of a fifth instar larva from Puyallup, in Western Washington, under the name *C. speyeri* race *dorsalis*.

There are two lemon-yellow longitudinal stripes on a white ground color: the first is middorsal and discontinuous, consisting of two yellow spots on each segment separated by two irregular transversal black lines; the second, located under the black spiracles, is continuous and sinuous. We did not obtain adults from these 1993 rearings, so it was not possible to positively identify the larvae as *C. speyeri*. However, now that the larva of *C. dorsalis* is known, it becomes clear that the species described by Crumb (1956) as *C. speyeri* race *dorsalis* is true *C. speyeri* and not *C. dorsalis*, which was

formerly treated as the western subspecies of *C. speyeri* (see Forbes 1954).

At first glance the description of the larva given by Crumb does not seem completely consistent with that of Poole (1995) who describes USNM specimens of *C. speyeri* collected in Illinois and reared on *C. canadensis* with the statement "the general larva pattern is a complicated series of yellow markings on a *black background*" (our italics). Our Figures 8 and 9 show clearly (for the fourth instar) a white ground color in agreement with Crumb's description of the fifth instar. We think that a "*lapsus calami*" may be the origin of this difference since in the same text Poole says "The dorsal (yellow) triangles are extensively connected and the *black occurs as isolated patches* running in a dorsoventral direction" (our italics). However, this may also suggest that the larvae collected in Illinois had heavier black markings than those collected in Washington. There is also another difference quoted by Poole concerning the color of the prolegs which are black according to Crumb but "black with large yellow patch on the apex of leg" according to Poole. Additional material of *C. speyeri* will be needed to determine if there is any geographical variation in the larvae, or if individual variation is greater than we observed in our material.

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AN INLAND POPULATION OF *POANES VIATOR* (HESPERIIDAE) ASSOCIATED WITH *PHRAGMITES AUSTRALIS*, THE COMMON REED

Additional Key Words: Host plant switching, invasive plants, evolution, *Ancyloxypha numitor*

Shapiro (1971a) showed that "inland" and "coastal" populations of *Poanes viator* (Edwards) differ not only in the range of larval host plants but also in superficial adult characters to warrant separate subspecific status, i.e., inland *P. viator viator* (Edwards), a *Carex* (Cyperaceae)-feeder and coastal *P. viator zizaniae* Shapiro, a *Zizania/Phragmites* (Poaceae)-feeder, respectively. Shapiro suggested (1971b) that inland populations in the Great Lakes region were derived from coastal refugia following glacial retreat, and that they were subsequently cut off from the coastal populations when the opening of St. Lawrence River disrupted the wetland system that connected both populations until that time. The possibility was later raised that the northward expansion may have occurred along the Mississippi valley as well (Shapiro 1977). A potentially important issue not addressed in his thesis is the role of host plant switching that must have taken place at some point. For example, isolation of the inland populations might not have occurred without host plant switching from Poaceae to *Carex*, or vice versa in the coastal populations. Regardless of the exact cause and history of current status, an ability to shift host plants is likely to have played a significant role in the evolutionary success of this skipper.

This note describes two inland populations of *P. viator* in Western New York State (WNY). One uses *Phragmites australis* (Cav.) Trin. in the absence of appropriate *Carex*, and the other is suspected to do so in spite of accessibility to *Carex*. Implications of the finding will be discussed in the light of our current understanding of the plant *P. australis* (henceforth referred to as *Phragmites*).

Poanes viator is a highly localized, but not necessarily rare species in WNY. More than a dozen widely separated colonies are known to us in this area; but, with the exception of at least one described below, all are associated with broad-leaved sedges, such as *Carex lacustris* Willd., which often form chest-high monocultures in partially wooded swamps. The first *Phragmites*-associated colony is located in the Town of Porter, Niagara County, and occupies a portion of a 21-acre open area with artificial ponds. Dense secondary woods surround the open area. The open space and the ponds were created in early 1980s by clearing the woods and are currently maintained by the Niagara River Anglers Association (NRAA) as its preserve. *Phragmites* was not present initially, and may have been introduced by bulldozers used for pond excavation. *Poanes viator* was discovered in this location by one of us in 2001 when a small number of adults was found nectaring on Pickerelweed (*Pontederia cordata* L.). In July 2003, after failing to find broad-leaved sedges in the open area or surrounding woods, we by chance came across several adult males flitting among *Phragmites*, just as one often sees them on the Atlantic coast. The stands of *Phragmites* were small but expanding, occupying an area of about an acre. A short series of specimens of both sexes was collected and compared with longer series from other WNY colonies as well as a series from the Atlantic coast. They were indistinguishable from the former in terms of wing markings and the average size (forewing length ± s.d. in ♂ [n=7], 17.29 ± 0.34mm; ♀ [n =3], 19.60 ± 0.53mm, vs. other WNY ♂ [n=35], 16.94 ± 0.64mm; ♀ [n=7], 19.96 ± 0.68mm; p < 0.25 and p < 0.50 for same sex comparisons by Student's t-test in ♂ and ♀, respectively; the null hypothesis is not rejected in either). John M. Burns kindly confirmed the identification. He was asked to identify the series in a blind fashion, i.e., with the data labels replaced by code numbers and without prior knowledge why he was being asked to do so. Therefore the obvious possibility, that the population simply represents an accidentally transplanted colony of the coastal subspecies, could be ruled out. A single larva was found on *Phragmites* in this colony in late May 2004, but it unfortunately died of an unknown cause. However, its identity was affirmed by a comparison with several *P. viator* larvae obtained in early June 2004 at two Rhode Island colonies, where they fed on *Phragmites*, as previously reported (Tewksbury et al. 2002). We believe that the founders of this small population in WNY switched their host plant from *Carex* to *Phragmites*.

In July 2004, another colony of *P. viator* was located in the Town of Lewiston, Niagara County, about 6 miles (9.6 km) southeast of the Town of Porter locality. In

contrast to the first, this colony is associated with a large *Typha* marsh of at least two thousand acres, and the sedges occur mostly as undergrowth of the taller *Typha*. Stands of *Phragmites* occur in disturbed sections of the marsh, i.e., along a high voltage power line, with impoverished *Typha* and broad-leaved sedges still present as undergrowth. *Poanes viator* was observed flying in and out of dense *Phragmites* to visit flowers of Swamp Milkweed (*Asclepias incarnata* L.) in a small opening in the middle of a stand. Portions of the marsh are bordered by woods in which the broad-leaved *Carex* grew in the absence of *Typha* or *Phragmites*. *Poanes viator* could be found among those sedges within the woods as well, at least a quarter of a mile (400 m) away from the nearest stands of *Phragmites*. This colony is of interest as an example of circumstances that may encourage *Carex* to *Phragmites* shifting. Indeed, shifting may have already taken place in a part of the population. The colony nearest to the above is located on Grand Island in the Niagara River, Erie County, 6 miles (9.6 km) further south, where the skipper seems to be restricted to sedge meadows. However, it is possible, perhaps likely, that other *Phragmites*-associated colonies of the inland subspecies have been overlooked in WNY and elsewhere in the Great Lakes region.

We do not know what causes host plant shifting in *P. viator* from *Carex* to *Phragmites*. Possibly, the choice between these host plants in *P. viator* has always been relatively unrestricted, but lack of opportunities prevented it from happening until recently. Another possibility, which is not mutually exclusive with the one above, is that the exotic variant of *Phragmites* is more palatable to *P. viator* than the native varieties which are being replaced by the former, as we discuss below.

Phragmites australis is an invasive plant rapidly expanding in inland as well as coastal wetlands. It has been a part of the native flora at least since the late Pleistocene in southwestern North America (Hansen 1978). Holocene records are available from both the Pacific and Atlantic coasts (Orson 1999; Goman and Wells 2000). However, the plant was apparently uncommon until an aggressive genetic variant was introduced, probably from Europe, sometime in early 1800s on the Atlantic seaboard and began to expand in the late 19th century and replace less aggressive native genotypes (Saltonstall 2002, 2003). Interestingly, only 5 native herbivores of *Phragmites* have been identified in North America, in contrast to over 150 in Europe, according to Tewksbury et al. (2002). Yet, chloroplast DNA sequences indicate that historical North American specimens from herbaria as well as existing stands of native plants form an isolated cluster of unique genotypes. They are not closely related to those found elsewhere in the world (Saltonstall 2002), suggesting a long period of isolation on this continent. To what extent the present day coastal populations of *P. viator* had been affected by this botanical event is not obvious. Nevertheless, it is generally acknowledged that the coastal *P. viator* is spreading along with the expanding *Phragmites* (e.g., Gochfeld & Burger 1997; Tewksbury et al. 2002). In coastal New England, most if not all *P. viator* populations are now associated with the exotic plant, even though the larvae readily accept the native ones in the laboratory (A. Lambert, L. Tewksbury and R. Casagrande, pers. com.).

It remains unclear whether the genetic variations in *Phragmites*, with potential differences in plant chemistry, are a factor in host plant selection by the herbivorous arthropods, including *P. viator*. Host plant shifting in *P. viator* could have been facilitated if the spreading exotic *Phragmites* is more palatable than a native plant. It turns out, however, that the *Phragmites* associated with the Town of Porter population is a native plant (A. Lambert, pers. com.), presumably of the widespread haplotype E. Thus, native *Phragmites* does serve as a natural host plant for the inland *P. viator*. However, the possibility remains open that the exotic genotype made it easier to shift initially and that, once the shift had taken place, native as well as exotic plants could be used. Aside from palatability, invasiveness itself is relevant for creating situations favorable for host plant shifting. In fact, some populations of the native haplotype E seem to be invasive (Saltonstall 2003).

To conclude, we may be witnessing another landmark event in the evolution of this species: Given opportunities and time, the inland *P. viator* with the newly acquired adaptability may one day become a common species of disturbed wetlands and roadside ditches. This is good news for the inland populations, since their native habitat is disappearing from many areas. Indeed, diminishing native habitats and concurrent spreading of *Phragmites* would be a potent selective pressure favoring *Phragmites* as a host plant. A recent precedent for range expansion in Eastern North America as a direct consequence of host plant adaptation to a spreading alien plant is the skipper *Erynnis baptisiae* (Forbes), as initially reported by Shapiro (1979).

During the course of our observation, another skipper, *Ancyloxypha numitor* (Fabricius), was found to be using *Phragmites australis* as a larval host plant at the Town of Porter locality. Several larvae were found in 2003 and 2004 in typical shelters of folded leaf, with feeding damage above and below the folded portion; they were reared to adults. Thus, at least three native

North American skippers use *Phragmites* as a larval host, i.e., the above two and *Ochlodes yuma* (Edwards).

Note: The NRAA preserve in the Town of Porter is not open to public. Those who wish to observe the colony are welcome to contact the Association or one of the authors. The colony is small and should be protected. The NRAA has a web site (www.niagariveranglers.com) that includes a brief description of the preserve, an aerial photograph, directions and contact information.

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LIFE HISTORY AND MYRMECOPHILY OF *NEOMYRINA NIVEA PERICULOSA* (LYCAENIDAE: THECLINAE)

Additional key words: *Crematogaster*, Dipterocarpaceae, Malaysia, *Tapinoma*, White Imperial.

The life histories of many species of Lycaenidae have been described and of these, a large percentage are commonly associated with ants (Ballmer and Pratt, 1989; Fiedler, 1991; Eastwood and Fraser, 1999; Pierce et al., 2002). While most descriptions are for temperate species, fauna from the Malaysian tropics are becoming more well-represented in the literature (Fleming, 1975; Fiedler, 1991; Corbet and Pendlebury, 1992; Fiedler et al., 1996). One species that remains poorly known though, is the White Imperial butterfly, *Neomyrina nivea periculosa* Fruhstorfer (Lycaenidae: Theclinae).

The genus *Neomyrina* Distant is represented by only a single species *nivea* with additional described subspecies (Corbet and Pendlebury, 1992). *N. nivea hiemalis* Godman and Salvin occurs in mainland Thailand and Malaysia and is considered rare (Fleming,1975; Pinratana, 1992) . *N. nivea periculosa* has been recorded from southern Burma to Thailand, throughout peninsular Malaysia including Langkawi Island, and into Sumatra. *N. nivea periculosa* is considered more common than *N. nivea hiemalis* (Pinratana, 1992; D'Abrera, 2001). This butterfly is still typically rare, but may be locally common when encountered (Corbet and Pendlebury, 1992). *N. nivea* were observed in Thailand and central Laos by Igarashi and Fukuda (2000) and they have published aspects of the life history of the species.

Eggs and Early Instars (Fig. 1a-b). Eggs of *N. nivea periculosa* (n=7) were found in December 2002 on 2 m tall *Balanocarpus heimii* (King) (Dipterocarpaceae) trees in a shady area of the 1600-ha Forest Research Institute of Malaysia (FRIM) nursery, 15 km northwest of Kuala Lumpur in the southern peninsula of Malaysia. The eggs were deposited in small groups around the stems and leaf buds of the terminal growth. Several *Crematogaster* sp. ants (Formicidae: Myrmicinae) were observed to be in close proximity to the eggs at the time of collection and to the extrafloral nectaries of the hostplant. The eggs, plant material, and approximately 20 ants were transported to
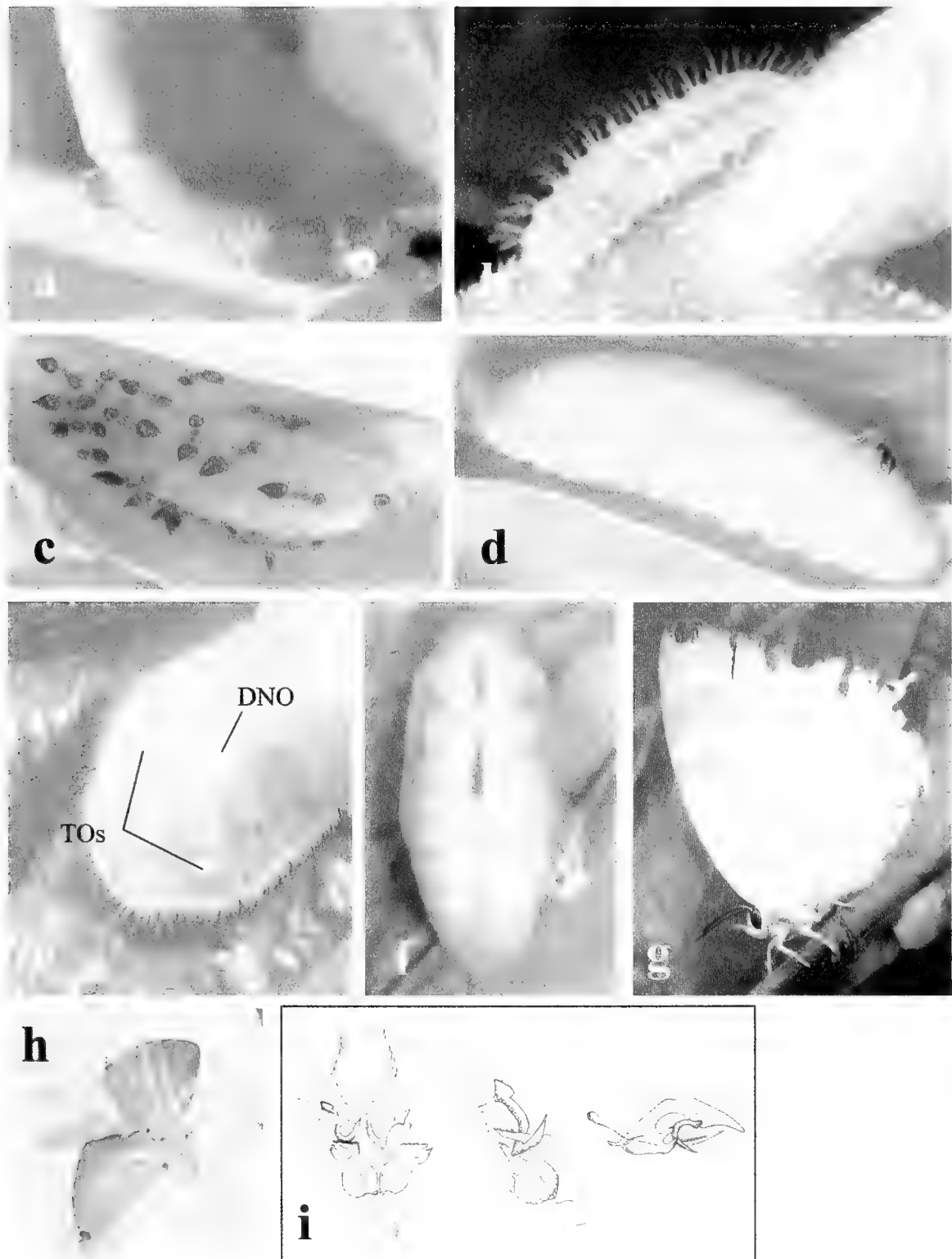
FIG. 1 Life stages of Neomyrina nivea periculosa; a, eggs; b, young instars; c,d, late instars tended by ants; e, late instar with everted TOs and DNO visible; f, pupa and last larval skin; g,h, adults; i, male genitalia. All photos and drawings by E.V. Saarinen.

the FRIM Entomology Laboratory and placed in a clear plastic box. Young flush from *B. heimii* was cut from the FRIM nursery trees where the eggs were initially found. The cut-ends of the plant were wrapped in wet cotton batting and placed in the plastic boxes with the eggs and ants. The eggs hatched within 24 hours and the young larvae began to feed immediately on the young leaves. All containers were cleaned daily and new host material was added.

First instar larvae were observed elevating their anterior and posterior ends simultaneously, which was followed by the attendance of *Crematogaster* sp. ants. This behavior caused ants in attendance to cease tending in one area of the larva and instead to cover the entire larva by running along the length and over the top of the young larva. Additional ants were summoned to the larva when this behavior was exhibited. After three days, all confined ants had either died or escaped when the boxes were cleaned, but second instar larvae continued the signaling behavior in their absence. Larvae did not continue feeding as much as they had when the ants were present, and no larvae lived past the second instar. Larvae were not observed building any sort of nest, as described in Igarashi and Fukuda (2000).

Eggs are white, dorso-laterally flattened, and uniformly sculpted with ridges of spikes, giving the eggs a rough exterior. Young larvae are pale yellow to pale green, onisciform, and dorso-laterally covered with fine setae that persisted in later instars.

Late instars (Fig. 1c-e). Late instar larvae (1.0-1.5 cm long) of *N. nivea periculosa* (n=6) were found on young shoots of *B. heimii* at the FRIM nursery on four separate occasions throughout October 2002. All individuals were collected with the ants that tended them and were brought to the FRIM Entomology Laboratory. On two occasions late instars were found tended by *Tapinoma* sp. ants and the larvae (n=3) were brought into the lab with the 5-10 attendant ants. In one instance *Crematogaster* sp. ants were tending a larva, and this larva (n=1) was brought into the lab with approximately 40 attendant ants. In one instance, no ants were observed with larvae in the field, and these larvae (n=2) were reared in the lab in the absence of ants. Each time larvae were collected, they were maintained in plastic boxes on young *B. heimii* leaves. All frass was removed and new host material was added on a daily basis and care was taken to keep ants in the boxes. *N. nivea periculosa* larvae exhibited a wide range of colors ranging from pale green to light red, depending on the color of leaf flush upon which they were feeding (Fig. 1d-e).

Ants, when present, congregated at the posterior ends of the larvae (Fig. 1c). Up to 30 *Crematogaster* sp.

ants were found actively and constantly attending a late instar larva. There were at least 10 *Crematogaster* sp. ants in attendance of this larva at all observed times. This behavior persisted until pupation four days later. *Tapinoma* sp. ants exhibited a very different behavior, typically observed walking around the interior of their plastic boxes. On occasion, 1-3 ants were observed tending larvae for up to ten minutes. Individual ants were observed tending larvae for 2-3 minutes at a time before wandering around the box. These larvae were left unattended for up to one hour at a time. A maximum of six *Tapinoma* sp. ants were observed tending the larvae (Fig. 1d).

Older larvae did not display the exaggerated signaling behavior observed in the first two instars. They instead have paired tentacle organs (TOs) on the dorsal surface of the 8th abdominal segment (Fig. 1e). It is unknown when these organs become active, but they are not observed in first and second instars. When these organs are extruded, additional ants are attracted to the larvae and ants already in attendance walk on and over the entirety of the larvae. The TOs are hypothesized to release semiochemicals that mimic ants' own pheromones (Henning, 1983). The TOs are also observed to act independently from one another, with only one extruded at a time in some instances. The TOs only remained everted for a few seconds before being withdrawn. Older larvae also have an active honey secreting gland, or dorsal nectary organ (DNO) on the 7th abdominal segment (Fig. 1e). Ants were observed imbibing secretions from this gland, which likely influenced the concentration of ants at the posterior end.

Pupae (Fig. 1f). Pupae are uniformly light tan in color and may exhibit a reddish tint. Final instars affix to host plant leaves and pupate within loosely assembled leaf shelters. Pupae exhibit a scar on the 7th abdominal segment in place of the DNO. Pupae are not attractive to ants 24 hours after pupation. Pupae were transferred to larger plastic boxes, 25 x 25 x 30-cm in size. Pupation lasted 11.5 days ±1.05 (μ±SD) for all pupae (n=6).

Adults (Fig. 1g-h). A total of four adults successfully emerged, resulting in an even sex ratio (2M:2F). As larvae were field collected at different times, it is unknown which sex typically emerges first. Of the three individuals that pupated at the same time, a male eclosed first. This male was observed to stay in close proximity to the two female pupae. He was observed alighting on the pupae and flapping his wings continuously upon contact with the pupae. Once all the adults had emerged, attempts to induce copulation were carried out by shining a light on the plastic box with butterflies for six hours a day for four days. A cotton ball

with a 50% sugar solution was given as a nutrient source and was replaced daily There were also sprigs of cut host plant in small plastic water bottles placed in the box with the butterflies. All butterflies were observed feeding from the sugar ball but no captive mating was observed despite the light and heat stimulation. Adults lived for 6-19 days in captivity. Following death, the genitalia of the first eclosed male was dissected (Fig. 1i). Only one tattered adult female was ever observed in the field (Fig. 1g).

This report indicates evidence of a facultative symbiotic relationship between the larvae of *N. nivea periculosa* and ants of two genera, *Tapinoma* and *Crematogaster*. Igarashi and Fukuda (2000) also found larvae in Thailand tended by *Lasius* sp. The relationship with ants is clearly unspecific and facultative as now three genera, each belonging to a different subfamily of ants, have been found associating with *N. nivea* larvae to varying degrees of intimacy. The relationship is deemed facultative as larvae were able to pupate and adults successfully eclose in the absence of ants. The ant genera associating with *N. nivea* are very typical ant associates of lycaenid larvae (Eastwood and Fraser, 1999). This loose association supports the idea that non-specific, facultative relationships prevail among Southeast Asian lycaenids (Fiedler, 1997).

Of the three larvae that were maintained with *Tapinoma* sp. ants, only one adult (male) resulted. One larva was maintained with *Crematogaster* sp. ants, and the adult (female) successfully eclosed. The two larvae collected and maintained in the absence of ants successfully eclosed as a small adult male and a normal-sized female. In the plastic boxes, *Crematogaster* sp. ants were always found tending their larva, while *Tapinoma* sp. ants left their larvae unattended while they walked around the interior of the box. Igarashi and Fukuda (2000) noted that *Lasius* sp. were sometimes found with a larva in such great numbers as to hide the larva from view. This indicates that *Crematogaster* sp. and *Lasius* sp. ants would be more effective at protecting larvae from predators and parasitoids in the field than *Tapinoma* sp.

Balanocarpus heimii (Dipterocarpaceae) a resinous, timber tree found in Southeast Asia is noted as a host plant for *N. nivea periculosa*. In Thailand, larvae were observed feeding on *Kurrimia paniculata* (Celastraceae) and were observed ovipositing on *Fissistigma wallichii* (Annonaceae) in Laos (Igarashi and Fukuda, 2000). These host plant records are of importance as they demonstrate *N. nivea* feeding on at least two different and unrelated plant families. It is additionally important as most lycaenid larvae feed on plants in the family Leguminosae or members of the subclass Rosidae. It

should be noted that representatives of the Theclini show a more diverse host plant preference and that polyphagy is pronounced in Southeast Asian lycaenids as a whole (Fiedler, 1995; 1997).

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SALVAGE OF INDIVIDUAL PUPAE AS A MITIGATION MEASURE FOR LOSS OF PALOS VERDES BLUE BUTTERFLY HABITAT

Additional key words: *Glaucopsyche lygdamus palosverdesensis*, Lycaenidae, environmental impact assessment, endangered species

The federally endangered Palos Verdes blue butterfly (*Glaucopsyche lygdamus palosverdesensis*) had been presumed extinct for 10 years when Mattoni (1994) rediscovered it on the Defense Fuel Support Point (DFSP) in San Pedro, California. This single military installation constitutes the only consistently occupied locality for the species. *G. l. lygdamus* is vulnerable to extinction. The population is exceedingly small; we estimate that the brood of adult butterflies each year since 1994 is fewer than 300, with some years fewer than 50 (Longcore and Mattoni 2003).

Surveyors located *Glaucopsyche lygdamus palosverdesensis* on a U.S. Navy-owned housing development adjacent to DFSP while negotiations were under way to dispose the housing property as surplus to allow redevelopment. The recipient of the property (U.S. Department of Housing and Urban Development) and the U.S. Fish and Wildlife Service (USFWS) reached an agreement to protect most of those areas on the housing property occupied by the butterfly ("Biological Opinion on the Formal Section 7 Consultation for the Proposed Disposal and Reuse of the Palos Verdes and San Pedro Navy Housing Areas, Los Angeles County, CA between the Department of Housing and Urban Development (HUD) and the USFWS, September 4, 2002"). Outside of the protected area, however, patches and individuals of deerweed (*Lotus scoparius*), one of the butterfly's larval foodplants, remained. The agreement therefore specified that efforts be made to locate and salvage any pupae under these foodplants before transferring the property. The disposition of the pupae was to a captive rearing program, so the term "salvage" is more appropriate than "translocation," which is defined as "deliberate and mediated movement of wild individuals or populations from one part of their range to another" (IUCN 1998:6, see also Oates 1992, New 1997). This short note documents the logistics and results of locating and salvaging pupae of this sensitive taxon as a mitigation measure, which we implemented at the direction of the U.S. Navy, consistent with the Biological Opinion. We have been unable to locate published reports of the salvage of individual butterfly pupae as a mitigation measure.

Female Palos Verdes blue butterflies oviposit on either *Lotus scoparius* or *Astragalus trichopodus*. Larvae pupate in the duff and soil beneath the plants (Mattoni 1994, Mattoni and George 2002), which is similar to that reported for many other lycaenids (see New 1993, Wagner 1995, Weeks 2003). Earlier we recovered six pupae from a search under foodplants in a 0.5 ha area to be destroyed as part of fuel pipeline repairs at DFSP (Mattoni 1999), and also have recovered hundreds of pupae from the duff and soil in outdoor cages used for captive rearing (Mattoni and George 2002, Mattoni et al. 2003).

At the housing site, we inspected the duff and top 10 cm of soil under all *Lotus scoparius* plants in patches (three or more plants together), all plants within 30 m of recorded observations of adult Palos Verdes blue butterflies, and a random subsample of all remaining plants. If pupae were located under any plant, we searched all other foodplants within 30 m. For each plant, duff was swept gently into a dustpan and inspected by hand. Soil and duff were shaken lightly, which causes lighter items to rise to the surface, and sifted through screens. We removed dead plants, and plants that inhibited access to soil and duff around the base. We recorded the size of all plants, and when pupae were discovered we documented local vegetation.

We searched 1,078 plants, representing 162 m² of vegetative cover, between November 2002 and February 2003. We located only two Palos Verdes blue butterfly pupae during 200+ hours of searching. We found the first adjacent to a dense patch of deerweed where we had seen adult *G. l. palosverdesensis* and the second under a lone deerweed plant. These represented quite different conditions, one with over 50% deerweed cover within 20 m of the plant, the other with less than 5% deerweed cover within the same area. We deduce from this that single plants outside of patches can serve as oviposition sites for Palos Verdes blue butterflies. The first pupa was considered dead (> 50 mg; Mattoni et al. 2003). The second pupa (presumed viable at ~100 mg) was collected for inclusion in the captive rearing program for the species (Mattoni et al. 2003). While only two *G. l. palosverdesensis* pupae were located, we

found hundreds of pupae of other species, predominantly moths. We believe that it is unlikely that pupae were missed, given previous success at locating pupae under plants (Mattoni 1999) and the hundreds of other lepidopterous pupae found, unless pupae were located deeper than 10 cm and far outside the canopy of the larval foodplant. In outdoor tent rearing cages, pupae are found near the plant, not at the edges of the cage as would occur if last instar larvae were dispersing to pupation sites away from the plant.

The effort to locate and recover individual pupae is time-consuming and tedious, with limited long-term benefit. We do not believe that it is an efficient form of mitigation, and propose two alternatives. If endangered sites are within dispersal distance of suitable habitat for a species, one alternative would be to remove the foodplants by hand before the adult flight period, leaving the pupae in the duff and soil. Eclosing adult butterflies would then be forced to disperse to find nectar sources and foodplants. The resources that would have been consumed locating individual pupae could be used to create or enhance more habitat, a strategy that has been demonstrated to be successful for this and other lycaenids (New 1997, Longcore and Mattoni 2003, Mattoni et al. 2001). Because a proportion of pupae may diapause for multiple years in this species (Mattoni et al. 2003) and many others (Scott 1986), a site could be kept clear of foodplants for more than one year to increase the number of adults that emigrate. A second alternative would be to translocate the plants, along with the duff and soil, without searching for pupae, to a site either occupied by the butterfly or targeted for reintroduction. Twelve pupae were sufficient to establish a new population of the lycaenid *Hamearis lucina* (Oates 1992), so such an approach could be successful. In this manner all pupae could be removed from the development site, meeting the goal of the Biological Opinion that "take" be minimized. Salvage of plants from development sites and their translocation to restoration sites would have the additional benefit of stocking newly-created habitats with many epiphytic species that are otherwise slow to colonize restorations (Bowler 2000).

We conclude that the survival and recovery of the Palos Verdes blue butterfly would be better served by another form of mitigation than recovery of individual pupae, even if more pupae were located per unit effort. Ongoing habitat enhancement is essential to the survival of this butterfly. Its microdistribution fluctuates from year to year with the maturation and senescence of patches of foodplant (Longcore and Mattoni 2003). Mitigation should be directed more toward the provision of future habitat, while minimizing loss of individuals at sites allowed to be destroyed either by 1) removing foodplant before the flight season and forcing emigration of eclosing butterflies if suitable habitat is adjacent, or 2) translocating pupae en masse by carefully moving plants, soil, and duff to a new site.

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A NEW PARASITOID OF *DANAUS GILIPPUS THERSIPPUS* (NYMPHALIDAE: DANAINAE) IN SOUTHEASTERN ARIZONA

Additional key words: *Brachymeria*, Chalcididae, Museum Collection, Voucher

The queen butterfly, *Danaus gilippus thersippus* (Bates) (Nymphalidae: Danainae) inhabits open woodland, grassland, and desert in the southwest United States. The larval host-plants in southeast Arizona include many members of Asclepiadaceae, but mostly *Asclepias* spp. and *Sarcostemma* spp. In general, *D. gilippus* is unpalatable to avian predators (Brower 1958) and sequesters cardiac glycosides from its larval host-plants (Cohen 1985), although investigations with the subspecies *thersippus* are lacking. There remains little published information on frequency and types of parasitism in the queen butterfly. *Brachymeria annulata* (Fabricius) (Hymenoptera: Chalcididae) (d'Araújo e Silva et al. 1968) and *Lespesia archippivora* (Riley) (Diptera: Tachinidae) (Arnaud 1978) are the two recorded queen parasitoids. In this study, we reared and identified *Brachymeria ovata* (Say) (Hymenoptera: Chalcididae) from five queen pupae.

Brachymeria ovata is around 5mm long with a black and yellow body. Its hind femora are black with a distal white or yellow spot. This species occurs across North and South America and is a primary parasite of over 100 lepidopteran species (Noyes 2004). *Brachymeria ovata* is commonly characterized as a larval-pupal parasitoid, ovipositing in a late stage larval host and emerging as an adult from the host pupa (Noyes 2004). In certain populations, *B. ovata* parasitizes over 55% of a single lepidopteran host species (Pemberton and Cordo 2001). Many *B. ovata* host species are chemically defended, although parasitism levels in these host species are poorly documented. For example, *B. ovata* parasitizes *Battus philenor* (L.) (Papilionidae: Papilioninae), which sequesters both alkaloids and aristilochic acids (Sims and Shapiro 1983); *Danaus plexippus* (L.) (Nymphalidae: Danainae), which sequesters cardiac glycosides (Halstead 1988); and *Utetheisa ornatrix* (L.) (Arctiidae: Arctiinae), which sequesters alkaloids (Rossini et al. 2000). Given the ability of *B. ovata* to circumvent host chemical defenses and observed high level of host parasitism, future research could investigate the relative tradeoffs of parasitism and predation in chemically defended butterfly species.

Five discolored pupae were collected from a garden of *Asclepias currasavica* (L.) (Asclepiadaceae) on the University of Arizona campus (USA, Arizona, Pima County, Tucson) in September 2003. The unparasitized pupal color of *D. gilippus* is light green; however, these parasitized pupae were dark brown. All five pupae were reared in separate containers in the laboratory exposed to natural daylight. Each pupa yielded a single adult of *B. ovata* within three weeks, killing the host. *Brachymeria ovata* was previously unreported in Arizona, although it is known from New Mexico (Peck 1963). We also searched the University of Arizona Entomology Research Collection for other examples of *B. ovata* parasitism. We found *B. ovata* records for five lepidopteran host species in Arizona:

1) Host: *Danaus gilippus therippus* (Bates) (Nymphalidae: Danainae) USA, Arizona, Pima County, Tucson, Arizona "A" Mountain, Roger Road, July 1969, Collected by R. Staciak (1 specimen associated with *D. gilippus* pupa);

2) Host: *Malacosoma californicum* (Pack) (Lasiocampidae: Lasiocampinae) USA, Arizona, Pima County, Sabino Canyon, April 06, 1957, Collected by Floyd Werner and George Butler, Reared from pupae (16 specimens associated with *M. californicum* pupae, another 56 specimens not associated with pupae);

3) Host: *Phaeostrymon alcestis* (Edwards) (Lycaenidae: Theclinae) USA, Arizona, Pima County, Santa Rita Experimental Range, Florida Canyon, May 1968, Collected by J. Hessel, Reared from pupae found on *Sapindus* (L.) (Sapindaceae), Specimens emerged June 02, 1968 (2 specimens associated with *P. alcestis* pupae);

4) Host: *Pontia protodice* (Boisduval & Leconte) (Pieridae: Pierinae) USA, Arizona, Maricopa County, Goodyear, October 07, 1955, collected by F.F. Bibby, Reared from pupae (5 specimens associated with *P. protodice* pupae);

5) Host: *Simyra henrici* (Grote) (Noctuidae: Acronictinae) USA, Arizona, Cochise County, Saint David, Pond on Apache Powder Road, September 1998, collected by C. Olson, Reared from pupae by M. Singer and J.O. Stireman III (2 specimens associated with *S. henrici* pupae). These specimens are currently housed in J.O. Stireman III's personal collection.

Phaeostrymon alcestis, *P. protodice*, and *S. henrici* are new host species records, and *P. alcestis* is a new host family record (Lycaenidae) for *B. ovata* (Noyes 2004).

This combined approach of field observations, laboratory rearing, and collection research was a simple yet fruitful method for documenting parasitoid host records. It exemplifies the importance not only of maintaining and utilizing museum collections, but also of vouchering parasitoids from butterfly rearing in museum collections (Peigler 1996). Our voucher specimens were deposited in the Entomology Research Collection at the University of Arizona, Tucson, USA.

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CONTENTS