

NORTHWARD EXPANSION OF TWO MINT-FEEDING SPECIES OF *PYRAUSTA* IN CALIFORNIA (LEPIDOPTERA: PYRALOIDEA: CRAMBIDAE)

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ABSTRACT.—*Pyrausta laticlavata* (G. & R.), which may have been a native species as far north as Monterey County, expanded its range northward into the San Francisco Bay area (1990) and Sacramento Valley (1993), after at least a century of residency in southern California. *P. volupialis* (Grote), colonized Los Angeles County from Arizona by 1991 and spread into the San Francisco Bay area by 1997. Both have been reared from larvae feeding on Rosemary (*Rosmarinus officinalis* L.; Lamiaceae). Movement of nursery stock may account for the rapid spread of *P. volupialis*, but global warming may be a factor in recent adaptation to more northern climes by these and several other Lepidoptera reviewed here.

KEY WORDS: Arizona, distribution, global warming, hostplants, introduced insects, Lamiaceae, life history, Mexico, Nearctic, Pyraustinae, urban insect survey.

The establishment and spread of introduced insects in North America often have been difficult to document retrospectively owing to paucity of records (e.g., Powell and Burns, 1971; Langston and Powell, 1975; Powell, 1964a, 1981, 1988). In recent decades there has been a growing interest in long-term monitoring of local moth diversity at a number of urban and rural sites in California (Powell, 1995). As a result we have been able to document the occurrence and persistence of introduced moths (Powell, 1992; Powell and Passoa, 1991).

In recent years, two additional moth species have colonized northward into central California: *Pyrausta laticlavata* (Grote & Robinson) and *P. volupialis* (Grote). The former evidently was a native species in southern California (or adventive in the 19th century), while *P. volupialis* colonized from Arizona or Mexico. Both are brightly colored, predominantly pink moths not likely to be ignored by collectors nor easily confused with any other Californian species, so their presence was not overlooked until recently.

METHODS

We monitored moths attracted to lights most nights when in residence: J. A. Powell (JAP) at two sites in Walnut Creek, Contra Costa Co., by black light (BL) trap 1961-69 and two in north Berkeley, Alameda Co., 1978-99 (incandescent light, with BL sporadically until October 1986, then BL continuously); Paul Russell (PR) and Sandra Russell (SR) at Malibu, Los Angeles Co., 1988-98 and Santa Barbara, Santa Barbara Co., 1998-1999 (BL or MV continuously); F. A. H. Sperling (FAHS) in central Berkeley (3.25 km S of JAP site), 1995-99 (BL continuously). After current records were compiled, JAP searched the curated collections and unsorted accessions for historical records of these species at the California Academy of Sciences (CAS), Essig Museum of Entomology, University of California, Berkeley (EME), Los Angeles County Museum of Natural History (LACM), San Diego Natural History Museum (SDNHM), and University of California, Davis (UCD). Specimen vouchers from all of these sources were identified by JAP. In addition, John Brown provided records from the U.S. National Museum of Natural History (USNM), as did Tom Eichlin from the California State Collection of Arthropods, California Department of Food and Agriculture, Sacramento (CDFA).

Pyrausta laticlavata (Grote & Robinson)

Botys laticlavata Grote & Robinson, 1867, Trans. Amer. Ent. Soc., 1:17.

Botys cinerosa Grote & Robinson, 1867, *ibid.*:18.

This species, which was described originally from Pennsylvania, is widespread in the eastern United States: from New Jersey to southern Florida, west to Missouri, Texas, Arizona, and southern California (Munroe, 1976). Adults are about the size of a small butterfly (FW length 9.1-11.3 mm). Summer individuals of this moth typically have bright pink forewings with poorly defined yellowish bands (Fig. 1-2). Many of those flying in spring (Jan-Apr in Berkeley) and fall (Sep-Nov) are much darker, with the colors subdued by infuscation, almost unicolorous dark gray-brown in the extreme [form *cinerosa* (G. & R.)]. Intermediate individuals (Fig. 3) and both forms occur together in late spring and through the fall months.

Larval host plant and life cycle

Larvae were found on Rosemary (*Rosmarinus officinalis*; Lamiaceae) at Santa Maria in October 1998 and reared to adults by Santa Barbara County Entomologist Jerry Davidson (CDFA). No larval host records were known to Munroe (1976), and the native plants used are unknown. In coastal California, *P. laticlavata* probably is multivoltine. We have observed the adults in every month except December, and their flight is continuous from July into November at Berkeley.

Occurrence in California

Historical collection records are insufficient to document conclusively whether *P. laticlavata* was a native insect in southern California or became an adventive colonist during the 19th century. There is one specimen from the Koebele collection labelled "Los Angeles Co. Sept." that presumably was collected in the 1880s by Coquillett or Koebele (CAS) when the earliest entomological investigations in southern California were made. There are many records from G. H. Field and W. S. Wright in San Diego between 1908-12, which evidently was several years after they began collecting moths there (Essig, 1931, 1934). Hence, this species may have colonized urban San Diego about 1906-08. Moreover, except for the Koebele specimen, we did not find any records for the Los Angeles region prior to 1910. *P. laticlavata* was collected at Loma

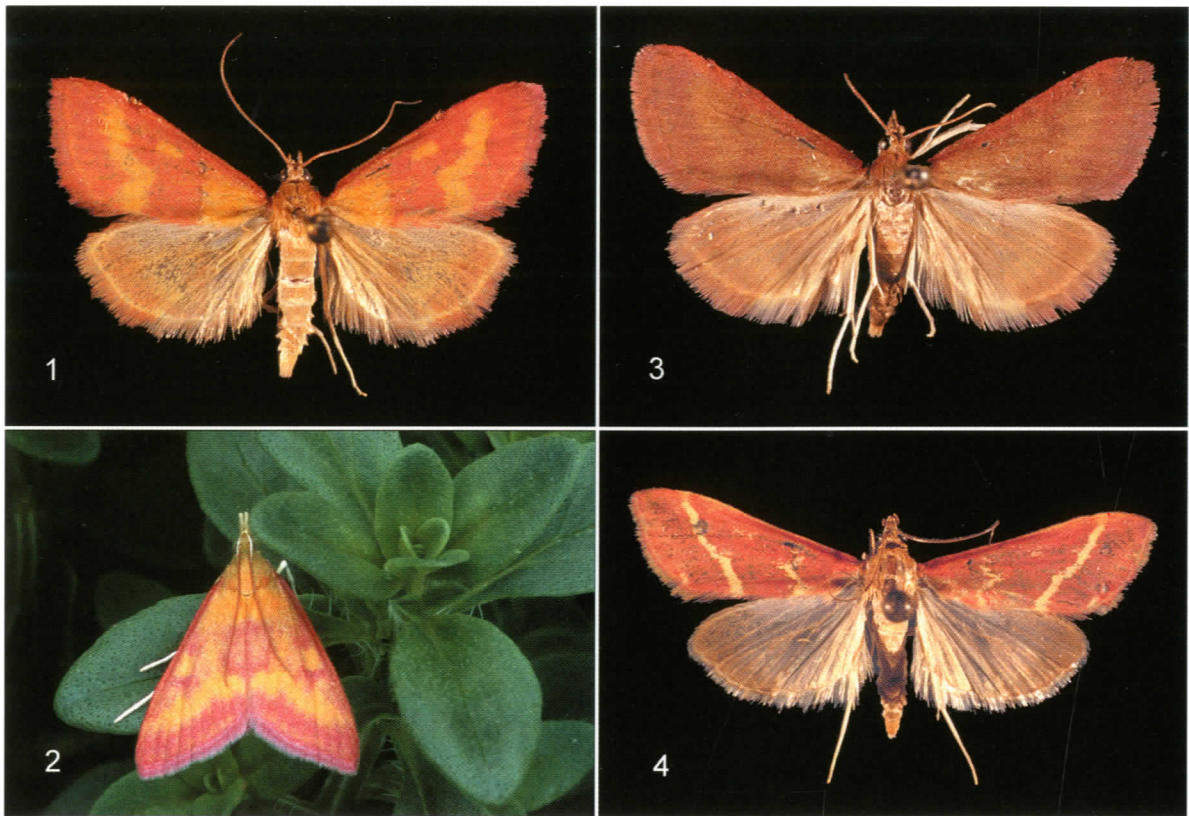


Fig. 1-4. Mint-feeding *Pyrausta* in California: 1-2) *Pyrausta laticlavata* (G. & R.), summer form; Berkeley, CA and San Marino, CA perched on thyme (*Thymus*, Lamiaceae) (© 2003 G. Rothschild). 3) *P. laticlavata*, intermediate to suffused winter form, Berkeley. 4) *P. volupialis* (Grote), Berkeley.

Linda, San Bernardino Co. in 1911-12 (USNM), and LACM specimens document its widespread occurrence in urban places by the 1920s: Glendale, Los Angeles Co. (1921); Palm Springs, Riverside Co. (1927); Upland, San Bernardino Co. (1928); Roscoe [now Sun Valley] and Beverly Hills in Los Angeles (1930); and Avalon, Santa Catalina Island (1932).

Alternatively, speculation that *P. laticlavata* may have been a native species or may have colonized native plants is reinforced by several collections in non-urban habitats: Telegraph Canyon, Chula Vista, San Diego Co. in 1918; Devils Canyon, San Bernardino Mts. in 1931; Bixby Canyon, Monterey Co. in 1948 (CAS); 3 mi. E of Refugio Beach, Santa Barbara Co. and 7 mi. NE of Morro Bay, S.L.O. Co. in 1965 (EME, UCD); and Big Creek Reserve, Monterey Co., 1987-92 (EME).

Because *P. laticlavata* was collected at Bixby Canyon in central coastal Monterey Co. in 1948, long-term resident populations may have existed that far north. However, there are no records north of Monterey prior to 1965, providing ample evidence that this species was not established in the San Francisco Bay area. One specimen was taken at Hastings Natural History Reservation in Upper Carmel Valley, in 1993 (Hastings Museum). This is noteworthy because the only historical moth survey in the central coast counties was made at Hastings, where about 800 specimens of pyraloids of ca. 70 species were collected between 1938 and 1954, but *P. laticlavata* was not among them (OM). This is comparable species richness to that recorded at Big Creek Reserve, Monterey Co., where we believe we

have a nearly complete inventory. J. W. Tilden collected one *P. laticlavata* at Alum Rock Park in San Jose in July 1965 (CAS)¹ and one was taken at Walnut Creek, Contra Costa Co. in October 1965 (EME), after 5 years continuous trapping.

P. laticlavata first appeared at lights in Berkeley in September 1990 (2 dates), followed by 3 records in 1991, 11 in 1992, and 19 dates in 1993. Two specimens were taken at Antioch, Contra Costa Co. in 1991 (EME), and subsequently adults have been observed sporadically in Berkeley by JAP and FAHS, at Kensington, Contra Costa Co. by Langston (CAS). The species appeared in the Sacramento Valley at Rocklin, Placer Co. in 1993; at 2,000' in the foothills of the Sierra Nevada in October 1995; and in Davis, Yolo Co. in 1998 at the onset of inventory there (UCD).

Pyrausta volupialis (Grote)

Botis volupialis Grote, 1877, Bull. U.S. Geol. Geogr. Survey Terr., 3: 799.

Pyrausta volupialis is a distinctive moth, not easily confused with any native species in California. It is nearly as large as *P. laticlavata* (FW length 8.4-10.7mm), with bright rose-pink forewings bearing a two distinct, transverse, white lines, one submedian partially developed zigzag and a subterminal, straight line (Fig. 4). This species was described from the vicinity of Denver, Colorado in 1877 and subsequently has been recorded from widespread areas of the southwestern United States and in Mexico from Coahuila, Nuevo

1. There is a series of *Pyrausta laticlavata* labeled Stevens Creek, Santa Clara Co., with June and July dates in 1966, collected by R. F. Denno (UCD). The coincidence of this data with those for a series of *Uresiphita reversalis* (Guenée) (Pyraustinae), which similarly preceded other records of that species in the San Francisco Bay area by many years (Powell, 1992), aroused suspicion. I contacted Denno at the University of Maryland, who confirmed that he did not collect in Santa Clara County during the summer of 1966. We concluded that specimens with pro tem labels reading Stevens Park in Santa Barbara must have been misread and printed labels for the Santa Clara County locality used after the specimens were donated to the museum at Davis. Hence my report of the "puzzling" record and mapped date for *U. reversalis* in Santa Clara Co. (Powell, 1992) were in error.

Leon, and Durango south to Puebla, Vera Cruz and Chiapas (Munroe, 1976; CAS, LACM, EME specimens). Munroe (1976) had not seen specimens of this species from California, and he stated that the early stages were unknown.

Occurrence in California

P. volupialis was discovered at Malibu, Los Angeles Co., in 1991; 8 specimens were collected between September 7 and December 22 by PR and SR, who began a moth inventory at the site in 1988. At the beginning of that survey they were not collecting smaller moths consistently, but this species is so pretty and distinctive that they believe it would have been taken when first observed. By 1991, they were collecting microlepidoptera systematically, and therefore the September 1991 date probably represents an early colonization of the area. Specimens were taken there on many dates in nearly every month of the year during 1992-98, indicating a resident population. They planted Rosemary on the property but not until after 1991.

Subsequently, *P. volupialis* was recorded at Manhattan Beach, L. A. Co., by Leuschner in August 1995, and it began appearing there sporadically. It occurred in Bloomfield's blacklight traps at the Miramar Naval Air Station [now Marine Corps NAS], San Diego Co. beginning in mid December 1995, 6 weeks after systematic inventory began there, and many times through 1996 and 1997 (SDNHM, USNM). The moth made its appearance in the San Francisco Bay area when specimens were collected in Berkeley September 9, 1997 by FAHS and 19 days later by JAP (3 specimens in one trap). Subsequently it has become well established in Berkeley; we recorded *P. volupialis* on more than 20 dates between late August and early November 1998 at the two sites.

Additional collections were made in 1998 by Julian Donahue at Mt. Washington, Los Angeles, in March; by Kelly Richers at Morro Bay, San Luis Obispo Co. in July; by Bob Langston at Kensington, Contra Costa Co. in September; and by U.C. Extension Specialist Frank Laemmlen at Santa Maria, S. L. O. Co., in October.

Search of institutional collections in 1998 yielded only one California specimen of *P. volupialis*, a female labelled "Victoria, Cal X-26-1925 (E. Piazza)" (CAS). This locality is near Riverside, and the identical data is associated with the single specimen of *Ethmia hodgesella* Powell (Gelechioidea) recorded for California (Powell 1973). *Ethmia hodgesella* occurs otherwise from southern Arizona to Texas and is widespread in Mexico; the coincidence suggests an error in labelling a collection of Piazza moths.

Larval host plant and life history

Larvae were found on Rosemary (*Rosmarinus officinalis*; Lamiaceae) at Santa Maria by Laemmlen and reared to adult by Santa Barbara County Entomologist Jerry Davidson (CDFA). This confirmed the suspected larval source in California, garden mints. Related species of *Pyrausta* feed on Lamiaceae, and all the records of *P. volupialis* in California are urban. The adults fly throughout the year but are most prevalent at lights in August, September, and October. Multivoltine populations likely build up in numbers during late spring and summer, and larvae may occur on Rosemary and other garden mints in greater frequency in summer and autumn.

Similar native species

Pyrausta grotei Munroe is widespread in the western U. S. and foothill and mountainous areas of California (Munroe, 1976, EME specimens). It has deep magenta-pink forewings with a sinuate, broken, white subterminal line and lacks the submedian zigzag line of *P. volupialis*. *Pyrausta grotei* is rare in urban areas.

DISCUSSION

Geographic expansion northward from southern California has been documented for several Lepidoptera, evidently with increasing

frequency in recent decades. The Gulf Fritillary butterfly (*Agraulis vanillae* (Linnaeus); Nymphalidae), which had been established in southern California dependent upon ornamental *Passiflora* since 1875, abruptly spread northward in 1959-60 (Powell, 1961), colonized, and has been a continuous resident in the San Francisco Bay area for 40 years. The timing of immigration and spread has not been documented as accurately for small moths due to incomplete records of adventive populations while still at low levels. However, the lag time before appearance in the San Francisco Bay area following widespread, long-term residency in southern California was about 40 years for the Omnivorous Leaf Roller, *Platynota stultana* Walsingham (Tortricidae) (Powell, 1981, 1983), and 50-60 years for the Genista Moth, *Uresiphita reversalis* (Guenée) (Crambidae) and *Crociosema plebiana* Zeller (Tortricidae) (Powell, 1992). These moths reached the San Francisco Bay area by 1967, 1980, and 1988, respectively.

The two *Pyrausta* reported here colonized these urban areas in 1990 and 1997, one after about a century of recorded residency in southern California, the other within six years of its detection in Los Angeles County. Two additional moth species became established in southern California and began northward expansion without appreciable delay during naturalization: the lawn moth, *Parapediasia teterrella* (Zincken) (Crambidae) colonized in the Sacramento Valley within 6-13 years after detection in the Los Angeles basin in 1954 (but 21 years passed before establishment in the San Francisco Bay area) (Powell, 1992); *Pyramidobela angelarum* Keifer (Gelechioidea), which causes unsightly leaf crumpling of ornamental *Buddleja* and therefore is quickly recognized by gardeners, was established in Santa Clara and San Mateo counties within seven years after its discovery in Los Angeles (Keifer, 1942; Powell, 1973), possibly aided by movement of nursery stock.

A few species have spread southward after introduction in central California. For example, the Omnivorous Leaf-tier, *Cnephasia longana* (Haworth) (Tortricidae), first colonized the Pacific Northwest, then appeared in the San Francisco Bay area in 1947, where it became widespread within 15 years (Powell, 1964b). Fragmentary records indicate *C. longana* gradually expanded southward along the coast and reached Santa Rosa Island between 1978 and 1995 and San Diego County by 1996 (Powell, 1997; Brown and Bash, 2000).

Powell (1992) postulated that the repeated sequence: introduction-establishment, a long period of naturalization, followed by rapid range extension, was the result of genetic adaptation to environmental conditions to which founder or source populations had not been adapted. One of the two species reported here may have been a native insect, and even if not, it was widely established in southern California for nearly a century before expanding northward. Therefore the underlying causes in such ecogeographical expansion could involve environmental change as well. Global warming may have been a key factor in enabling adaptation to new territories by these Lepidoptera. Poleward shifts in geographic ranges of numerous European butterflies have been documented and attributed to regional warming (Parmesan *et al.* 1999). Nearly all shifts involved extensions at the northern boundaries, with the southern boundary remaining stable, as observed for introduced species in California.

As we enter the 21st century, increasing human population inevitably will lead to greater global warming and shifts in geographic ranges of native species. There will be increasing destruction of native habitats and more abundant travel with greater movement of people and products, which will lead to more frequent introduction of alien insects and competitive exclusion of native species.

We urge renewed efforts to insect inventory on a regular basis in order to document introduction and spread of alien species and geographic shifts by native species. Knowledge of Holarctic Lepidoptera is sufficient that poleward shifting ranges can be

recognized with confidence for most species. Much of this effort can be developed by amateur and avocational collectors. The importance of proper maintenance of private and institutional collections, including timely sorting of new accessions enabling efficient retrieval, cannot be overemphasized. Although some butterfly enthusiasts have created a misleading perception that collecting insect specimens is detrimental to species' existence and no longer necessary, there is no documented evidence that collecting insects results in long term effects on population size. Moreover, butterflies are negligible in terms of biodiversity (fewer than 0.1% of described insect species in North America), and they are wonderfully better known than most other insects. Among most families of small moths (e.g., Gracillariidae, Coleophoridae, Gelechiidae, Tortricidae, each of which outnumbers all butterflies in species richness), at least 10% to more than 50% of Nearctic species have no names. Clearly, increases not decreases in insect inventory should be our mandate.

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