

weedy Pieridae including *Pieris rapae* L. and *Pontia protodice* Bdv. & LeC., but it is almost never seen above 1500m and is completely absent in climates comparable to that at Las Lenas. The erect, even bushy growth form of this plant has no analogue in the native brassicaceous flora of the high Andes. It would seem *P. nymphula* has successfully colonized this plant by focusing strictly on small rosettes, whose growth form, with tightly imbricated leaves, is familiar to it as the mature plant is not.

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### SURVIVAL OF FREEZING AND SUBSEQUENT SUMMER ECLOSION BY THREE MIGRATORY MOTHS: *MANDUCA SEXTA* AND *HYLES LINEATA* (SPHINGIDAE), AND *HELICOVERPA ZEA* (NOCTUIDAE).

**Additional key words:** overwintering, *Heliothis virescens*

*Hyles lineata* (Fabricius) and *Helicoverpa zea* (Boddie) are well known migrants whose overwintering limits are apparently poorly known. Winter pupal diapause has been previously discussed (e.g. Johnson, 1995) for *H. zea* in Arkansas, and for other *Helicoverpa* species on other continents (e.g. Gregg *et al.*, 1995). However, while Ferguson (1991) listed *Manduca sexta* (Linnaeus) as a migrant, McNeil *et al.* (1995) repeatedly referred to it as non-migratory. All three species range into the Neotropics. Most southern migrants listed by Ferguson peak in September, October or November in southern New Jersey, but *M. sexta* does not. The latest specimen date found for *M. sexta* for New Jersey, Pennsylvania, or Delaware (collections of Rutgers University, University of Delaware, W.J. Cromartie, the late Joseph Muller, myself) is 12 September and 87% of 30 available specimen and observation dates are from 6 July to 4 September, which includes a partial second brood (my rearings in Connecticut and New Jersey). Jones (1928-1929) reports mid July through August for Delaware, and Smith (1910) and Tietz (1952) report none after September for New Jersey and Pennsylvania. Pupal diapause increases from about 5% in June to 95% in mid August even in northern Florida (Villanueva, 2005). Furthermore, although the related migrants *Agrius cingulatus* (Fabricius) and *M. quinquemaculata* (Haworth) have both been collected several times far to the north in Maine (Brower, 1974), Vermont (Grehan *et*

*al.*, 1995), Nova Scotia (Ferguson, 1955), and Quebec (Handfield, 1999) often in September and October, the generally more common *M. sexta* is unreported by any of those sources. All of these factors suggest northeastern populations of *M. sexta* are not strongly migratory, but occurrence on Bermuda and in the Galapagos Islands (Ferguson, 1991) seems to affirm migratory status elsewhere.

In late November 2001 I unexpectedly found a still living pupae of *Helicoverpa zea* from a caterpillar reared from local (Cumberland County) corn in late summer in a small plastic container with a few cm of peat. I placed it indoors for two weeks and when it did not develop, I moistened the peat, put it in my refrigerator, and returned it to ambient conditions on 15 March. In late November 2002, four small peat-filled containers each containing an *H. zea* pupa from larvae on local corn or bell pepper were packed among dead leaves inside a large Styrofoam box with numerous other pupal containers. I placed the box in a coal bin off my house, which is mostly enclosed, but outside, unheated, and with a floor of natural ground. Three other *H. zea* that had entered the soil as prepupae 30 August to 9 September 2002 eclosed later that month, providing strong evidence that these four, which were also prepupal on or before 10 September, were in diapause. All larvae were reared outdoors.

In October 2002 Robert Barber gave me three small

black form *Hyles lineata* larvae he collected on large, weedy, *Rumex* at Port Norris, New Jersey, where I reared them outdoors on the same hostplant. The first made a pupal cell among paper towel on 22 October and another about a week later. Both pupated in November and were placed in a small, ventilated plastic container also in the Styrofoam box. In late October 2002, Thomas Mullane gave me a *Manduca* pupa he dug from his tomato patch in nearby Cedarville. I left it outside in a ventilated plastic container with no insulation until early December (about -3° to 20°C) before packing it in moist peat and placing it with the *Helicoverpa* and *Hyles*. The winter of 2002–2003 was the coldest in more than fifteen years and the air temperature in the coal bin was below freezing for about half of January and February and twice fell to -5.5° C. Ice crystals were observed in the peat containing these pupae. All containers were returned to shaded ambient conditions in mid March.

An *H. zea* eclosed on 29 June 2002 from the larva prepupal 9 September 2001, and two on 8 and 12 July 2003 from larvae prepupal 10 September 2002. Two pupae died at unknown times. Both *H. lineata* pupae were alive on 1 June 2003 and one produced tachinids later that month and the other a female moth 9 July. A wild adult was seen 25 June that year. A male *M. sexta* eclosed at dusk on 7 July 2003. Despite the small sample sizes, these observations directly demonstrate that overwintering pupae of *M. sexta*, *H. lineata*, and *H. zea* can tolerate slightly sub-freezing temperatures sufficient to freeze their immediate substrate, although *H. zea* and *M. sexta* in insulating icy peat certainly were not exposed to -5.5°C. Furthermore Jeff Fengler (pers. comm., 31 January 2004) reports digging up a pupa in early spring at Shelton, Connecticut (41.3° North), which produced an adult *M. sexta*, directly documenting survival where winters average well below freezing about 250 km west-southwest of the species' range limit near Boston, Massachusetts (42.5° North).

Since pupae can survive slightly subfreezing temperature, *H. zea* should be able to overwinter farther north than southern Arkansas (33.2° North) as reported by Johnson (1995), although no southern migrants he discusses appear to overwinter successfully to the 0°C January isotherm. I collected a worn runty female with malformed wings and impaired flight at Millville, New Jersey (39.4° North, January mean +0.6°C) flying diurnally on 13 July 1994 that virtually had to come from a locally overwintered pupa. Since I am aware of only one record before 9 June for New Jersey (Rutgers collection, 28 May 1974) and none before 15 June from similar latitudes in Delaware (Jones, 1928–1929, University of Delaware collection) or

Ohio (Rings *et al.*, 1992), local eggs by early June would be extremely unlikely, and with cooler conditions and probably suboptimal food, development of this moth from oviposition to eclosion in early July would have required longer than the 35 to 44 days required under optimal conditions (Stewart, 2003, Hardwick, 1996). Observations from Arkansas (Johnson, 1995) suggest the earliest adults (often late June in New Jersey) would probably be migrants and since my eclosion dates were 29 June to 12 July it is quite likely July–early August adults include some from locally overwintered pupae.

Perhaps the most interesting observation is that adults of all three species eclosed in summer, despite the fact that they start in early spring or fly nearly all year much farther south (e.g. Hardwick, 1996, Villanueva, 2005) and that non-diapausing pupae of *H. zea* hatch in about two weeks and *M. sexta* in about three weeks in late summer. The heat requirements to terminate diapause and complete subsequent development for both species appear similar to resident heliothine Noctuidae and many Sphingidae which eclose in June or later in southern New Jersey. Therefore a lack or scarcity of spring adults northward is not valid evidence that pupae of multivoltine migratory moths perish over winter northward, as lepidopterists often assume.

Since overwintering pupae of these three species can survive slightly subfreezing conditions, they probably could survive in moderately cold climates. Furthermore *Manduca sexta* pupae at 10–15 cm deep (Villanueva, 2005) would experience only a few degrees below freezing even at their range limit in southern New England, where I report an instance of overwintering in the field, and would remain above freezing in many southern New Jersey winters. Although the evidence suggests some local overwintering, *Helicoverpa zea* is obviously reinforced by immigrants from the south in New Jersey, as is well documented for much of North America, and may even have some southward return in fall (Johnson, 1995). However, *M. sexta* populations in the northeastern USA probably do not depend on immigrants. Freeze tolerance, diapause, and the brief mid-summer peak flight season seem well adapted to the climate at the northeastern limit of the range. *Hyles lineata* is currently uncommon enough in New Jersey that its status is unclear and the species is essentially absent now farther to the northeast. Finally I note obtaining one eclosion, in late May, after overwintering three local autumn pupae of another heliothine pest migrant, *Heliothis virescens* (Fabricius), in my refrigerator.

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#### NOTES ON ASPECTS OF THE LIFE HISTORY AND BEHAVIOR OF *COLEOTECHNITES ERYNGIELLA* (GELECHIIDAE).

**Additional key words:** *Eryngium*, herbivory, tallgrass prairie, Illinois

The Gelechiidae is one of the largest families of microlepidoptera, with between 4,300–4,600 species estimated worldwide (Hodges 1998, Arnett 2000); 87 genera and 813 species have been recorded from the U.S. and Canada (Arnett 2000). This number may be an understatement as only 30% of the Nearctic species have been described (Hodges 1998). In North America, there are approximately 47–49 species of *Coleotechnites*, of which eight are considered pest species, mostly on coniferous trees and shrubs. These pest species damage plants by eating the foliage and mining through the leaves/needles (Arnett 2000, Mississippi Entomological Museum 2005). Although numerous studies have been done on the pest species in this genus, very few, if any, studies have examined *Coleotechnites eryngiella* (Bottimer, 1926).

It is important to note that members of the family

Apiaceae have a broad chemical diversity, and that the presence of secondary compounds mediates plant-animal interactions. As a result very few insects are capable of feeding on the plant parts of members of Apiaceae, and those insects that are capable of feeding on members of this family are often highly specialized (Berenbaum 2001). Currently only two species of Lepidoptera are recorded as having larvae that feed on the plant parts of *E. yuccifolium*: *C. eryngiella* (Molano-Flores 2001 [moths were originally misidentified as *Aristotelia* sp., but were later determined to be *C. eryngiella* by Terry Harrison], pers. obs.) and *Papaipema eryngii* Bird, 1917 (Noctuidae), an Illinois state-threatened species whose larvae bore into the inflorescence stalks (Panzer and Derkovitz 1992). Here I provide some information regarding the life history and behavior of *C. eryngiella* as well as suggestions for