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Source: Bulletin of the Biological Society of Washington, 15(1):75-79.
Published By: Biological Society of Washington
DOI: http://dx.doi.org/10.2988/0097-0298(2008)15[75:CPRRFP]2.0.CO;2
URL: http://www.bioone.org/doi/full/10.2988/0097-0298%282008%2915%5B75%3ACPRRFP%5D2.0.CO%3B2

Caterpillar-Host Plant Relationships Recorded from Plummers Island, Maryland (Insecta: Lepidoptera)

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Abstract.—During the summers of 2004 and 2005 host plant associations of larvae of Lepidoptera were studied on Plummers Island, Maryland, with an emphasis on the family Limacodidae (slug caterpillars). A total of 37 species from 12 families was recorded, representing 79 caterpillar-host plant combinations. Eleven species of Limacodidae were collected and reared from six target host plants—box elder (*Acer negundo* L.), sugar maple (*Acer saccharum* Marshall), pawpaw [*Asimina triloba* (L.) Dunal], pignut hickory [*Carya glabra* (Mill.) Sweet], spicebush [*Lindera benzoin* (L.) Blume], and red oak (*Quercus rubra* L.).

Key words.—Larvae, food plants, slug caterpillars, Limacodidae, inventory, *Acer negundo, Acer saccharum, Asimina triloba, Carya glabra, Lindera benzoin, Quercus rubra.*

While our collective knowledge of the morphology and systematics of moths and butterflies of North America is fairly well developed (e.g., Pyle 1981, Covell 1984, Scott 1986), our understanding of their primary feeding stages (caterpillars) is much less complete (e.g., Stamp & Casey 1983, Wagner 2005). Because the host plant and habitat associations of larval Lepidoptera are important determinants of both their geographic range and local population dynamics (Haukioja 1993, Roland 1993), documentation of larval host plant associations provides important information for scientists investigating issues in pest management, insect evolutionary ecology, and insect conservation. Moreover, population-level studies of plant-herbivore interactions have been increasingly approached from a geographical perspective, requiring detailed observations of host plant use from multiple sites in order to determine the importance of local adaptation in shaping patterns of host plant selection, colonization, and use (Thompson 2005 and references therein). These efforts are aided by ongoing compilations of caterpillar-host plant associations such as the online HOSTS database assembled by Robinson et al. (2006) at The Natural History Museum, London. Compiled data on host plant use by caterpillars can be used to address fundamental questions regarding the proximate effects of variable host ranges on insect population dynamics (and resulting plant damage) and to trace the evolutionary trajectories of clades of Lepidoptera with regard to diet breadth and host plant affiliations (e.g., Janz & Nylin 1998, Ward et al. 2003, Weiblen et al. 2006). Moreover, the collective biodiversity encompassed by insect herbivores and their host plants (approximately 50% of all recorded species; Strong et al. 1984) suggests that developing our understanding of these interactions should be a high priority for modern biology. This paper reports the results of ongoing efforts to identify woody plant-caterpillar relationships on Plummers Island, Montgomery County, Maryland, U.S.A., and adds an 'interaction component' to the inventory work described in this volume.

Materials and Methods

During the summers of 2004 and 2005, host plant associations of larvae of a number of different species of Lepidoptera were observed on Plummers Island and the nearby mainland. In both years, the foliage of understory woody vegetation was inspected visually, and larvae of interest were collected and reared in the laboratory. The focus of collecting and rearing efforts was the family Limacodidae (slug caterpillars). In addition, leaf-tying Microlepidoptera (mainly Gelechiidae, Oecophoridae, and Pyralidae) and various other incidentally encountered (and easily recognized) larvae were collected and/or recorded from common trees and shrubs. Documenting local host plant relationships for generalist herbivores (e.g., many temperate forest Lepidoptera) provides important natural history information, because host ranges of many of these insects are poorly known and can vary significantly over their range (Wagner 2005).

In the summer of 2005, a more formal census of six common woody plant species was undertaken on

Plummers Island in an effort to document the host-use patterns of slug caterpillars. Slug caterpillars are notable for their unusual morphology, with all species having a high degree of ventral contact with the leaf surface during locomotion (Epstein 1995). A number of species are physically defended with urticating spines [e.g., *Sibine* (=*Acharia*) *stimulea* (Clemens) and *Euclea delphinii* (Boisduval)] and have bright, contrasting coloration suggesting aposematism (Dyar & Morton 1895, Epstein 1996). All of the eastern temperate Limacodidae are thought to be generalists, feeding on an array of woody trees and shrubs over their range (Wagner 2005), but detailed patterns of host use for any one location currently are lacking. Epstein (1988) hypothesized that host plant selection in Limacodidae is guided more by leaf texture than other plant traits, since they are most commonly reported from plants bearing glabrous leaves. However, this ''glabrous host'' hypothesis only recently has been tested (Lill et al. 2006) and requires further investigation. From adult light-trapping records on the Island (Brown et al. 2008), fifteen species occur locally, but none of the local host associations of the species on the Island have been reported previously.

In the early summer of 2005, ten plants (entire saplings or branches from larger trees) of each of six plant species, including box elder (*Acer negundo* L.), sugar maple (*Acer saccharum* Marshall), pawpaw [*Asimina triloba* (L.) Dunal], pignut hickory [*Carya glabra* (Mill.) Sweet], spicebush [*Lindera benzoin* (L.) Blume], and red oak (*Quercus rubra* L.), were individually marked and the leaves were counted in early June (following leaf expansion). Each of these plant species is mostly to entirely glabrous, is common on the Island, and has been observed to be a host of at least one species of Limacodidae. Pignut hickory and red oak occur on the Island's two knolls while the other species are found mostly along the floodplain. At the time that the leaves were counted, fifty undamaged leaves of each plant species were randomly collected from ten non-study trees, dried, and scanned to determine the area of each leaf to the nearest 0.01 cm^2. From this subset, an average leaf size was calculated for each tree species. For each of the ten marked census trees, the total number of leaves inspected for larvae was multiplied by the average leaf size to estimate the total leaf area inspected during each census. These values were then used to compute comparable density estimates (larvae/m^2 foliage) for each species of Limacodidae encountered over the summer. Two censuses of each plant were conducted, in late June-early July and again in early September. These dates were chosen to encompass the range of larval development times exhibited by the various species comprising this assemblage. Eastern slug caterpillars are well known for their propensity to feed on old foliage late in the season, and some species [e.g., *Isa textula* (H.-S.) and *Phobetron pithecium* (Smith)] can be found as larvae well into October, just prior to leaf drop (unpublished data).

The goal of this pilot study was to quantify host use patterns for this subset of plants by the assemblage of slug caterpillars and determine if there are any species-level differences in host plant use. Because the abundance of slug caterpillars was low, the density data did not meet the assumptions of a parametric test, so the non-parametric Kruskal-Wallace test (Zar 1999) was used to compare mean rank densities among host plants for the entire assemblage (all slug caterpillar species combined). Post-hoc tests comparing the rank sums of the densities on the different host plants were conducted using the Nemenyi test (Zar 1999). There were insufficient data to test for host plant differences in densities of individual caterpillar species, but qualitative patterns are noted below.

Results and Discussion

General collecting.—A total of 37 species of Lepidoptera from 12 families was recorded over two years of visiting Plummers Island (Table 1). This represents a total of 79 caterpillar-host plant combinations. Larvae were collected from eleven different plant species, representing eight plant families (Aceraceae, Annonaceae, Ebenaceae, Fagaceae, Juglandaceae, Lauraceae, Rosaceae, and Tiliaceae). All of the caterpillars collected were external-feeders, but included both free-feeding and shelter-building species. This is not an exhaustive list by any account, and focuses exclusively on the summer-feeding fauna. The oak species (*Quercus alba, Q. prinus,* and *Q. rubra*) hosted an assortment of microlepidopterous leaf-tying caterpillar species in relatively high abundance, all of which have been described from oaks in Missouri (Carroll & Kearby 1978, Lill 2004). In addition to the oaks, leaf ties (sandwiches of overlapping leaves) also were observed commonly on box elder (*Acer negundo*) and spicebush (*Lindera benzoin*) but were uncommon on the remaining non-oak hosts surveyed. Further sampling of the shelter-building fauna of Plummers Island is ongoing and will add significantly to this list (particularly with regard to Tortricidae).

Slug caterpillars.—For the six focal plant species that were sampled intensively for Limacodidae, it was evident both from encounters and from leaf damage that red oak and pignut hickory hosted the highest abundance and diversity of slug caterpillars, spicebush and pawpaw the least, and maples (box elder and sugar maple) intermediate.

A total of 11 species of Limacodidae were collected and reared from the six target host plants (Ta-

Table 1.—Host plant associations of caterpillars collected on Plummers Island, Maryland and the nearby mainland. Host plant codes: AB = American basswood, *Tilia americana* L.; BC = black cherry, *Prunus serotina* Ehrh.; BE = boxelder, *Acer negundo* L.; CO = chestnut oak, *Quercus prinus* L.; P = persimmon, *Diospyros virginiana* L.; PH = pignut hickory, *Carya glabra* (P. Mill) Sweet; PP = pawpaw, *Asimina triloba* (L.) Dunal; RO = northern red oak, *Quercus rubra* L.; SB = spicebush, *Lindera benzoin* (L.) Blume; SM = sugar maple, *Acer saccharum* Marsh; WO = white oak, *Quercus alba* L. Feeding guilds: FF = Free-feeder, CF = concealed feeder (shelter-builder).

Family	Caterpillar species[1]	Guild	Host plant species[2]
Arctiidae	*Hyphantria cunea* (Drury)	FF	BE
Gelechiidae	*Chionodes fuscomaculella* (Cham.)	CF	RO, WO
	Pseudotelphusa nov. sp.	CF	CO, RO, WO
Geometridae	*Epimecis hortaria* (F.)	FF	SB
Limacodidae	*Adoneta spinuloides* (H.-S.)	FF	CO, P, **PH**, **PP**, **RO**, WO
	Euclea delphinii (Bdv.)	FF	P, **PH**, **RO**
	Isa textula (H.-S.)	FF	BC, CO, **PH**, **RO**, **SM**, WO
	Isochaetes beutenmuelleri (Hy. Edw.)	FF	**RO**, WO
	Lithacodes fasciola (H.-S.)	FF	**BE**, **PH**, **RO**, **SM**
	Natada nasoni (Grt.)	FF	**PH**, **RO**
	Parasa chloris (H.-S.)	FF	**PH**, **RO**, **SB**
	Prolimacodes badia (Hbn.)	FF	**PH**, **RO**
	Sibine stimulea (Clem.)	FF	**BE**, **PH**, **PP**, **RO**, **SB**
	Tortricidia pallida (H.-S.)	FF	**RO**
	Tortricidia testacea Pack.	FF	**RO**
Lymantriidae	*Dasychira tephra* Hbn.	FF	RO
	Orgyia leucostigma (J. E. Smith)	FF	BE, PH, RO
Noctuidae	*Acronicta haesitata* (Grt.)	FF	WO
	Acronicta increta Morr.	FF	RO
	Acronicta lobeliae Gn.	FF	RO
	Crocigrapha normani (Grt.)	FF	RO
	Hyperstrotia sp.	FF	WO, RO
	Morrisonia confusa (Hbn.)	CF	BC, PH, RO, SB, WO
	Panopoda rufimargo (Hbn.)	FF	PH, RO
	Zale galbanata Morr.	FF	BE
Nolidae	*Meganola phylla* (Dyar)	FF	RO
Notodontidae	*Ellida caniplaga* (Wlk.)	FF	AB
	Heterocampa guttivitta (Wlk.)	FF	PH, RO, WO
Oecophoridae	*Antaeotricha osseella* (Wlsm.)	CF	WO
	Machimia tentoriferella Clem.	CF	BE, RO
	Psilocorsis cryptolechiella (Cham.)	CF	CO, RO, WO
	Psilocorsis quercicella Clem.	CF	CO, RO
Pyralidae	*Oneida lunulalis* (Hulst)	CF	CO
	Tetralopha expandens (Wlk.)	CF	CO, RO
	Salebriaria engeli (Dyar)	CF	RO
Saturniidae	*Antheraea polyphemus* (Cram.)	FF	SB, SM
Sphingidae	*Amorpha juglandis* (J. E. Smith)	FF	PH

[1] Nomenclature and author abbreviations follow Hodges (1983).
[2] Plant abbreviations in bold indicate the focal taxa recorded as hosts for slug caterpillars in the quantitative sampling.

ble 1). This is very likely an underestimate of the total number of species present on the Island, since adult moths of four additional species, *Adoneta bicaudata* Dyar, *Apoda biguttata* (Packard), *A. y-inversum* (Packard), and *Phobetron pithecium* (Smith), have been recorded over the years from light trapping conducted on the Island (Brown et al. 2008). Because I observed considerable variation in the color patterns among larvae of *A. spinuloide*s, the listing of a single species of *Adoneta* should be interpreted with caution (it is possible that both *A. spinuloides* and *A. bicaudata* have been collected; M. Epstein, pers. comm.); adult identification is in progress and should help resolve this issue. As expected, most of the slug caterpillars were shown to have rather broad host ranges, feeding on multiple plant species and/or families. Exceptions include the two species of *Tortricidia* (*T. testacea* and *T. pallida*) and *Isochaetes beutenmuelleri*; however, I have collected each of these species from beech (*Fagus grandifolia* Ehrh.) elsewhere in Maryland, and beech does not occur on Plummers Island (Shelter et al. 2006).

Of the eleven species of limacodids collected from the marked study plants in 2005 (n = 86), *Sibine stimulea* (Clemens), *Isa textula* (Herrich-Schüffer), *Lithacodes fasciola* (Herrich-Schüffer), and *Adoneta spinuloides* (Herrich-Schüffer) were the most abundant (>10 larvae were collected over the season). Two species, *A. spinuloides* and *Parasa chloris* (Herrich-Schüffer), tended to occur in small clusters of 3–7 individuals, while *S. stimulea* larvae could be found in larger clusters of up to 12 individuals in the same

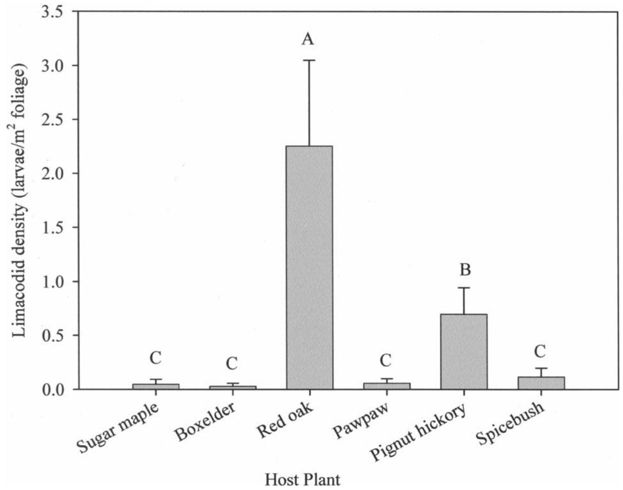

Fig. 1. Densities of Limacodidae larvae (all species) found on six woody plant species on Plummers Island. Values are means + 1 SEM of 10 trees/plant species. Means are presented here to illustrate patterns, but statistical analyses were performed on the ranks (Kruskal-Wallis nonparametric ANOVA). Means with the same letter are not significantly different based on the Nemenyi multiple comparisons test of the rank sums.

stadium feeding gregariously. This species previously has been reported to oviposit in batches of 30–50 eggs (Wagner 2005). *S. stimulea* also fed on the most target species in the sample, occurring on five out of six target host plants (all except sugar maple); however, *I. textula* and *A. spinuloides* each were collected from six different host plant species, including both non-target and target hosts. Red oak and pignut hickory were clearly the superior host plants for Limacodidae, hosting eleven and eight of the eleven species recorded in 2005, respectively. Each of the other four target host plant species censused hosted only two species. Three non-target host plants, white oak (*Quercus alba* L.), chestnut oak (*Q. prinus* L.), and persimmon (*Diospyros virginiana* L.) also each hosted at least two species of slug caterpillars. These incidental collections suggest that future sampling should increase the number of target hosts in order to clearly delimit each species' local host preferences.

The density data (for all Limacodidae combined) reflected the same pattern, with red oak and pignut hickory being the preferred hosts (Kruskal-Wallis test for main effect of host plant: $\chi^2 = 32.71$, $P = 0.0001$; Fig. 1). It should be noted that September 2005, typically the peak of limacodid larval abundance, was an exceptionally dry month, and the pignut hickory trees used in the study suffered from drought stress, causing premature leaf browning, which may have resulted in a decreased abundance of larvae relative to the other target host plant species, which appeared more drought-tolerant.

Further studies focusing on host plant-based collections of larval Lepidoptera on Plummers Island should provide some resolution to the complex plant-herbivore food web existing on the Island. By cataloguing the 'interaction diversity' occurring on the Island, the ecological mechanisms underlying historical patterns of change in both plant and arthropod community composition on the Island (e.g., Shetler et al. 2006, Brown et al. 2008) may become clearer. For example, the disappearance of many species of leafrollers (Tortricidae) on the Island over the last century has been hypothesized to have resulted from secondary succession on the Island and the subsequent loss of several herbaceous plant species that were host to these caterpillars (Brown 2001). However, without identifying the larval-host plant relationships, the ecological mechanisms underlying these changed remain somewhat vague. Inventories of interactions also can provide new host plant records for the growing databases of caterpillar-host plant associations, such as the growing HOSTS database mentioned above.

Moreover, by quantifying local densities of generalist caterpillars (such as the Limacodidae), comparisons of insect preference hierarchies among sites with varying plant community compositions can be made (Kuussaari et al. 2000). Ecological surveys of this type often lay the foundation for more detailed studies of how local selection pressures shape herbivore feeding niches and how these niches vary over space and time (Singer & Stireman 2005). Such studies must necessarily start at the local level and will require a concerted effort on the part of naturalists and caterpillar enthusiasts alike.

Acknowledgments

This research was funded through a grant from the Washington Biologists' Field Club to the author. I thank Brian Juengst and Alison Parker for their assistance with fieldwork and laboratory rearing, and John Brown, Marc Epstein, and an anonymous reviewer for their helpful comments on earlier drafts of this manuscript.

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