A COMPARISON OF THE MOTH COMMUNITIES OF FORESTED, GLADE, AND URBAN HABITATS IN BIBB AND JEFFERSON COUNTIES, ALABAMA

BY

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INTRODUCTION

To those unfamiliar with the state, Alabama is surprising in its biological diversity. Alabama ranks 5th in the U.S. for overall biological diversity, and 1st east of the Mississippi River (Stein, 2002). The state also ranks high (#7 in the U.S.) in the number of endemic species, with 144 species that occur nowhere else in the world. Much of this biodiversity is due to high numbers of aquatic species, but the diversity of terrestrial organisms is also very rich. In addition, terrestrial plants show considerable biodiversity, placing Alabama as #9 in the US, and #3 of eastern states (Stein, 2002).

One particularly diverse part of the state is in Bibb County, which is the home of the Bibb County Glades Preserve (hereafter referred to as the Glades). The Glades are a series about 40 rocky openings that total approximately 250 acres. These treeless areas are surrounded by a matrix of dry upland forest, for a total of 480 acres of habitat protected by The Nature Conservancy of Alabama (http://www.nature.org/wherewework/northamerica/states/alabama/preserves/art902.html). Because Glades often exhibit very stressful abiotic conditions such as thin, nutrient-poor soils, high irradiance, and extremes in temperature, these habitats limit plant productivity (Baskin and Baskin, 2000; Garland, 2008). Glades typically contain endemic or relict species typical of hotter and drier conditions of deserts or dry prairies (Baskin and Baskin, 2000), and the Bibb Co. Glades are no exception. They are home to eight endemic species and subspecies of vascular plants that have been recently described as well as 44 rare vascular plants, the latter as formally recognized by the Alabama Natural Heritage Program (Allison and Stephens, 2001). It is likely that no other area of the U.S. has had more new taxa of plants described from a single habitat of such restricted area in the last century.

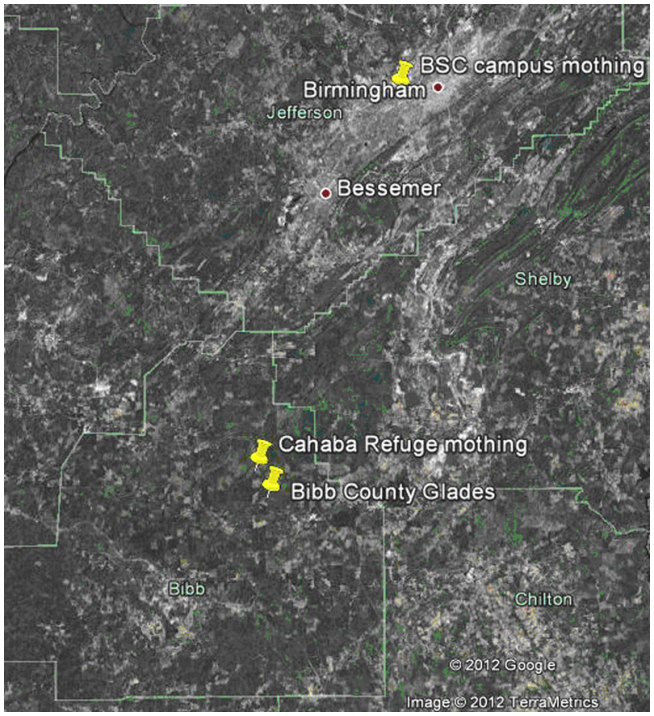


Fig. 1. Sampling locations for this study.

The Cahaba River National Wildlife Refuge (hereafter referred to as the Refuge) is only 3.5 km from the Bibb Co. Glades (Fig. 1), but is very different in many respects. At over 3,414 acres, the refuge contains 12 different natural plant associations within several different plant community types including river habitats, dry upland forests, and bottomland hardwood forests (Schotz, 2007). The Refuge has 12 rare species of terrestrial plants (Schotz, 2007) and a total diversity of plants that has yet to be determined. The diversity of both of these preserved areas is at least partially due to their location at the boundary between the Southern Ridge and Valley and East Gulf Coastal Plain physiographic regions. Although these sites have historically experienced substantial disturbance through logging and mining activities, the variety of habitats have made Bibb County a biodiversity hotspot for plants as well as other terrestrial and aquatic taxa. Together, the Glades and Refuge help preserve what is thought of as the most species rich portion of a very diverse state (Stein, 2002; Schotz, 2007; Garland, 2008).

Although considerable information is known of the diversity of plants, vertebrates, mussels, and crayfish of Bibb County, very little is known about the diversity of moths. Indeed, the moths of the southeastern U.S. are poorly studied overall (Brown, 2003), but the Lepidoptera of Alabama are especially understudied, even in comparison to other southeastern states (*e.g.*, Schweitzer *et al.*, 2011). However, this lack of knowledge of moths belies their vital roles in

communities. Here and elsewhere, they serve important roles as selective herbivores, detritus feeders, and pollinators (Scoble, 1992; Summerville and Crist, 2004). Moths are also important sources of food for predators such as songbirds, which can consume over half of the caterpillars in a forest during nestling and fledgling periods (Holmes *et al.*, 1979). Moths can also be useful indicators of overall insect biodiversity, forest disturbance, and habitat quality (Summerville *et al.*, 2004; Summerville *et al.*, 2005).

While many caterpillars are generalist herbivores, a majority are much more specialized and feed on selected species in a single genera or family of plant (Scoble, 1992; Wagner, 2005; Scholtens and Wagner, 2007). Therefore, given the high amount of plant diversity and endemism of these areas, moths should show a pattern of high diversity and rare species similar to the highly diverse groups mentioned above. Moreover, because many species have specific host or habitat requirements, one might expect that the community of moths associated with the Glades should be considerably different than the nearby forested habitat of the Refuge. If forested sites have differing plant species, then one would expect that the communities of moths in these sites should be relatively unique. Alternatively, the moth communities in adjacent sites could be fairly similar, given that many moths are vagile and widespread.

We evaluated these two hypotheses by comparing the moth diversity and community identity of each of the rural sites in Bibb County to each other and to the community of moths in a 16 acre urban woodlot on Birmingham-Southern College's campus. At approximately 16 acres, the Birmingham-Southern College Ecoscape forest (hereafter referred to as the Campus site) is considerably smaller than both of the Bibb Co. sites. The Campus habitat is isolated and surrounded by urban developments, including a college campus and residential neighborhoods, although the forest itself has been undisturbed for over 100 years. This moist upland forest is relatively diverse for its size, containing at least 100 species of plants. Comparing these rural plots in Bibb Co. to this urban site is important because our knowledge of urban woodlots for maintaining moth diversity in North America is scarce (Summerville and Crist, 2008).

METHODS

Collection

We sampled moths using black light bucket traps, which consisted of a 15-watt black light powered by a motorcycle battery. We placed one trap per site in all three locations on the same night, which allowed us to minimize confounding effects of variable weather and moon phases across nights. Sampling trips were conducted approximately every 10-20 days at all three sites from May 7th to October 27th, 2011. We sampled only on rain-free, low-wind nights without a bright moon to maximize capture of the most species (Butler *et al.*, 1999). Equipment and time constraints prevented us from sampling more extensively from these sites. Each trap was collected the following morning, and all individuals were frozen for later sorting, identification, and curation.

Family	Species
Bombycidae	2
Cossidae	1
Erebidae	103
Euteliidae	2
Geometridae	64
Lasiocampidae	3
Limacodidae	11
Megalopygidae	3
Noctuidae	71
Nolidae	2
Notodontidae	21
Saturniidae	8
Sesiidae	1
Sphingidae	10
Yponomeutidae	3
Zygaenidae	1
Total	**306**

Table 1. The families of moths examined in this study, along with the number of species per family that were observed during 10 weeks of sampling.

For this study, we focused on 16 families, comprised mostly of macrolepidoptera, but including some of the larger microlepidopteran species that could be readily identified without dissection (Table 1). We selected a representative series of individuals from each known species or unique, unidentified species (*i.e.*, morphotype) for pinning, spreading, and labeling for preservation and later identification. These samples were compared to the synoptic collection at Birmingham-Southern College and the collection of the Mississippi Entomological Museum (MEM) at Mississippi State University for identification.

Analysis

Moth species richness was used to represent community biodiversity among our three sites. We used EstimateS (Colwell, 2013) to generate species accumulation curves for our 10 samples and estimate the total species richness in each habitat. We compared total richness for each site using paired t-tests (SPSS, 2010) using species numbers observed per night at each site as paired replicates. We generated Jaccard's index with EstimateS to quantify the faunal similarity of the three sites. We were interested in whether there were more pest species in the urban site,

so we determined pest status by searching literature (Cranshaw, 2004) and web pages (USDA-APHIS, 2000) for species that exhibit unwanted and large damage to stored products, landscaping plants, fruit or nut trees, vegetables, and other cultivated crops. Species whose host plants were largely listed as crops were also categorized as pests for this analysis. Finally, host plants were categorized based on published literature (Wagner, 2005; Wagner *et al.*, 2011) and web pages (Robinson *et al.*, 2010; BugGuide.Net, 2013). We used our 10 sample nights as replicates to compare the three sites in percentage of pest species and percentage of species using different host plant types as categorized above using ANOVA (SPSS, 2010).

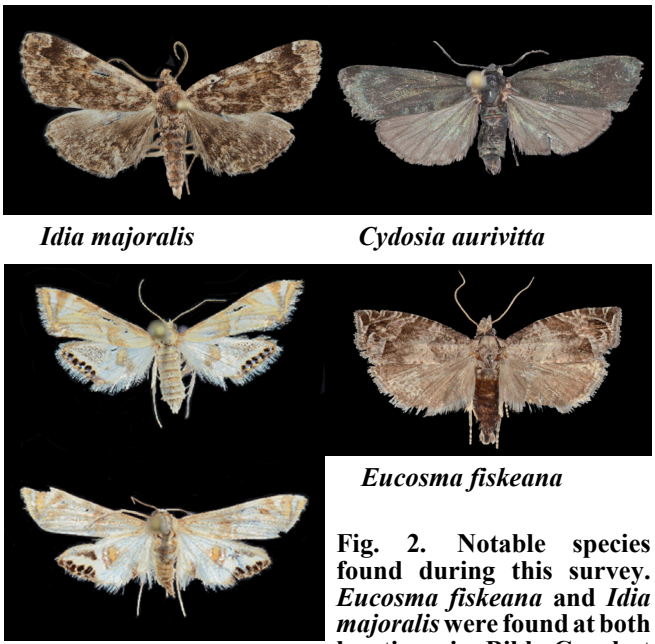
RESULTS AND DISCUSSION

In total, we collected and identified 1856 specimens comprising 306 species in 16 families (Table 1, Appendix 1). The two rural sites had higher numbers of both observed and estimated numbers of species than the urban site (Table 2). Typically, more diverse forest habitats support a greater number of moth species, as do habitats that are less disturbed (Summerville and Crist, 2004, 2008). Therefore, we should expect a considerable number of species in Bibb County due to the high diversity of plant species that occur there. Previous studies have indicated that habitat size can be a good predictor of the number of moth species (Summerville *et al.*, 2005), especially for tree-feeding moth species (Summerville and Crist, 2004). Therefore, it isn't surprising that the total number of moth species was similar between the Glades and Refuge because these sampling locations are surrounded by comparable amounts of forested area. The estimated number of species at all of these locations is likely to be much lower than the actual number of species to be found there. When conducting moth surveys, it may take well more than a hundred sample nights to inventory even 90% of the species in an area (Powell, 1995), which suggests that these results are severe underestimates of the full moth diversity of these habitats. Additional sampling techniques and several years of sampling (*e.g.*, Brown and Bash, 1997; Scholtens and Wagner, 2007) would also lead to better estimates of species numbers at these locations.

Site	Observed species	Estimated species	Unique species (% of total)
Campus	112	200	40 (35%)
Refuge	206	298	73 (35%)
Glade	184	317	50 (27%)

Table 2. Actual and estimated numbers of species occurring at the sites in this study. Estimated species numbers are asymptotes of species accumulation curves based on 10 samplng events at each site. Unique species were those that were only found at one site and neither of the others, and the % total represents the percentage of the number of observed species found at that site that were unique to that site.

There were several species that were unique to each of the sites, and these unique species consistently represented approximately 1/3 of the total species found at each site (Table 2). This finding suggests that sites do have unique combinations of species, even when they are close together. This result is consistent with other studies that find plant identity and diversity to be an important factor in determining lepidopteran diversity (Summerville and Crist, 2002; Shuey *et al.*, 2012). Interestingly, the one location with highest plant endemism (the Glade) had the lowest percentage of unique species. It is worth noting, however, that the unique species in this comparison include common species like *Manduca sexta* (found only at the Campus site) as well as less common species like *Cydosia aurivitta*, which was only found at the Glade sampling location (Fig. 2). Members of the Mississippi Entomological Museum (MEM) sampled for six nights in the Bibb County Glades during 2003 – 2004 (Appendix 1). They found approximately 481 species of moths plus unidentified morphotypes (far higher than even our projections), at least four of which are considered rare or uncommon (*e.g.*, Martinez and Brown, 2007). Researchers from MEM also surveyed Tennessee glade habitats (Brown, 2003) and found 18 species of moths that were regionally rare, uncommon or state record species. All of these results indicate that glade habitats may house many endemic or relict species and should be surveyed more thoroughly.



Idia majoralis ***Cydosia aurivitta***

Eucosma fiskeana

***Petrophila* n. sp. (above)**
***Petrophila bifascialis* (below)**

Fig. 2. Notable species found during this survey. *Eucosma fiskeana* and *Idia majoralis* were found at both locations in Bibb Co., but *Petrophila* n. sp. and *Cydosia aurivitta* were found only at the Glade site.

We were expecting to find a greater number of interesting or uncommon species than we did during our survey. Some of the notable species are microlepidoptera, but they still deserve a brief mention here. *Eucosma fiskeana* (Tortricidae) is uncommonly found, but exhibits a broad range from Illinois to Ohio south to Texas and Florida (Moth Photographers Group, 2014). Most records suggest that this species is associated with open habitats like glades and remnant prairies. *Cydosia aurivitta* (Noctuidae) is generally uncommon outside Texas, but was found on several occasions in the Glades, where only the melanic form was collected. This species is possibly a relict in scattered glades east of Texas in similar arid habitats like glades. However, James Adams (personal communication) reports collecting it from open understory areas in Georgia and Northern Alabama, so it may be associated with habitats other than glades and barrens. *Petrophila* n. sp. (Crambidae) is an undescribed species that is common at Bibb County Glades near the Cahaba River and which is similar to *P. bifascialis*. While little is known about its distribution, the larvae are likely to be aquatic, similar to its sister species. Finally, *Idia majoralis* (Erebidae) is associated with woodrat nests (which are rare over much of their range, especially in NE USA). *Idia majoralis* is not exclusive to woodrats and is found widely throughout its southern range.

	Campus	Refuge	Glade
Campus	-	24.9	26.9
Refuge	11 (4%)	-	45.2
Glade	10 (3%)	67 (22%)	-

Table 3. Similarity comparisons for the sites in this study. Numbers below the diagonal represent the species shared between the two sites listed, and the number in parentheses represents the percentage of the number of observed species found at only those two sites. Numbers above the diagonal are the Jaccard index, or the percentage of faunal similarity between two sites.

According to Schweitzer *et al.* (2011), this is possibly a case of false rarity as it has a widespread distribution, though it is found in small numbers where it occurs.

Overall, the two adjacent sites (Refuge and Glade) shared a higher number of species in common and had a greater faunal similarity than sites with more similar habitats and plant communities (*i.e.*, the Refuge and Campus sites; Table 3). This suggests that proximity of sites is more important for determining the make-up of a moth community than is habitat type. However, our limited number of samples and replicate sites prevents us from being too confident in this conclusion.

One goal of this study was to search for patterns in the commonness of pest species. Our initial conjecture was that the Campus site would have a greater number of herbaceous pest species, given the relatively high level of disturbed and cultivated habitats surrounding this forest site. Consistent with this expectation, we found that there was a higher average percentage of pests found at the Campus location on each trapping event (Fig. 3). This is not merely because there was a lower number of total species at the Campus site, because there was also a greater absolute number of pests per

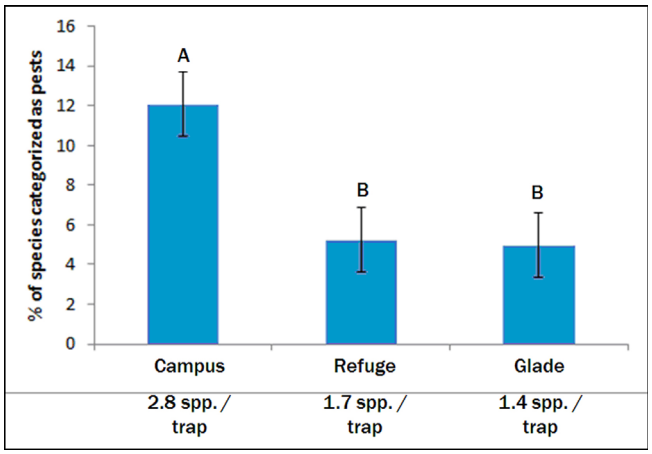


Fig. 3. The average percentage of pest species captured during each trap night. Bars with different letters are statistically different from each other (overall $P = 0.006$, $F_2 = 6.18$). The numbers below the figure repesent the average number of individual pests captured per trap on each night.

trap night at this location (Fig. 3). Similarly, there were also higher total counts of pest species (17 from Campus, 12 from the Refuge, and 10 from the Glade summed over all 10 trapping events). The Birmingham area is largely developed, with only a few urban farm lots, so these results are also not due to a spillover effect from surrounding agricultural areas. Because these pests are not just herbaceous species, but also comprise a number of generalist tree feeding species as well (*e.g.*, Fig. 4), it appears that a higher abundance of pests in the urban site is not merely because of a higher abundance of disturbed and cultivated habitats. Given the consistent pattern for herbaceous and woody feeders, there could be more than one causative factor, including higher plant diversity because of cultivation and higher import rates due to commerce (McKinney, 2008).

We were also interested in trying to find trends in the moth communities based on associations with their food sources. When comparing host associations across the three sites, we can see some interesting trends (Fig. 5). The Refuge site has a lower percentage of grass and herbaceous plant feeding caterpillars, which makes sense
because the Glade and Campus sites have fewer trees near the collection locations. Because the Glades are open habitats filled with grasses and herbs, it is understandable that they have the lowest percentage of woody feeding moths. There was a significantly higher proportion of species that consume both herbaceous and

Feltia subterranea

Amphipyra pyramidoides

Malacosoma americana

Helicoverpa zea

Spodoptera ornithogalli

Malacosoma dissria

Fig. 4. Representative examples of pest species most commonly collected during this study. *Feltia, Helicoverpa*, and *Spodoptera* are all herbaceous feeders (mostly crop pests), but *Amphipyra* and the two species of *Malacosoma* are tree feeders.

woody hosts at the Campus site (Fig. 5). This may partially explain the previous patterns, since a higher number of generalist herbivores could lead to higher numbers of pests. Finally, the urban Campus site had a smaller proportion of species that fed from the "other" category, which consisted of lichen, fungus, and detritus feeders. The loss of these guilds may be indicative of degraded urban environments, but further sampling will be necessary to confirm that this pattern is robust.

As biodiversity hotspots, the Bibb county Glades and the Cahaba River NWR are still vastly understudied, and a greater knowledge of the species present in these regions is desperately needed. Additional surveys have the potential to bring additional attention to species of concern of these areas and to help Refuge or Nature Conservancy managers with decisions such as increasing the preservation of additional important habitats.

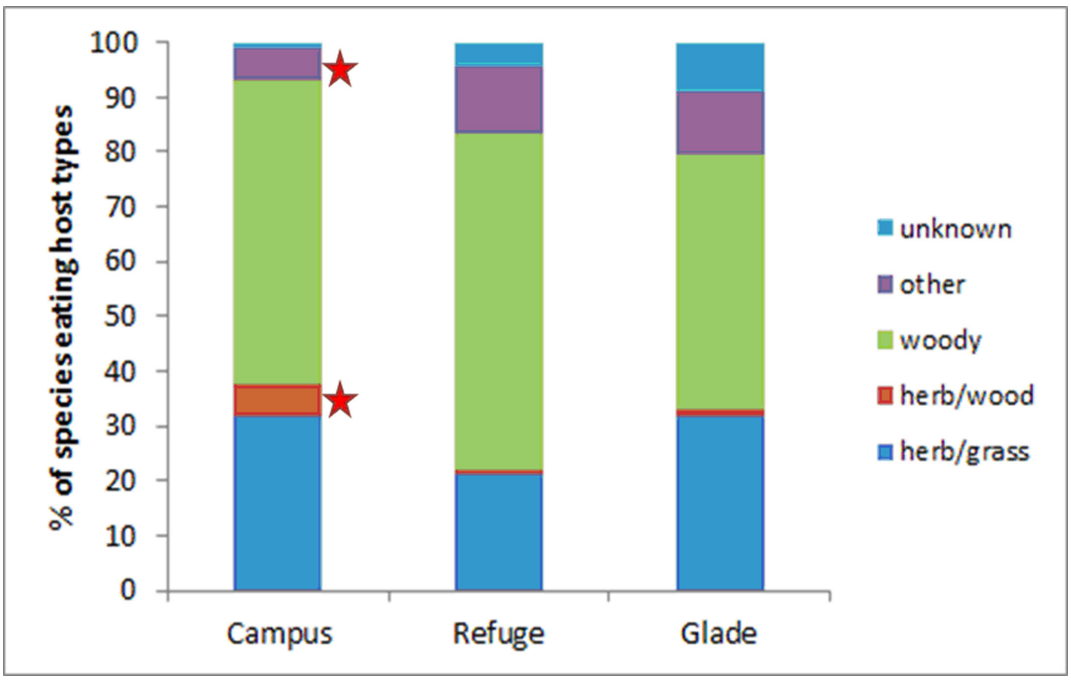


Fig. 5. The percentage of species that are associated with different types of hosts. From the bottom to top in each column, the categtories are: species that consume either herbaceous or grass plants, species that consume either herbaceous or woody plants, specialists on woody plants, species that utilize other hosts not in the previous categories (*e.g.*, lichen, fungi), and species whose host plant associations are unknown. The stars indicate categories that are statistically different among sampling locations (P<0.05).

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Appendix 1. List of species collected in Bibb and Jefferson Counties, Alabama, by Peter Van Zandt (PVZ) and group, including urban woodlot on Birmingham-Southern College campus (C), Cabaha River National Wildlife Refuge (R), and Bibb County Glades Preserve (G). For species collected in Bibb County Glades by Mississippi Entomological Museum (MEM): 1 = 33°03'28"N,87°02'21"W, 2 = 33°03'26"N,87°02'02"W, 3 = 33°03'35"N,87°02'12"W, 4 = 33°03'34"N,87°02'06"W.

Taxa	PVZ	MEM
Apatelodidae		
Apatelodes torrefacta (J.E. Sm.)	R	
Olceclostera angelica (Grt.)	R G	
Argyresthiidae		
Zelleria retiniella Fbs.	R G	
Attevidae		
Atteva aurea aurea (Fitch)	C G	1, 2
Autostichidae		
Glyphidocera juniperella Adamski		3
Glyphidocera lactiflosella (Cham.)		1, 3
Spinitibia hodgesi Lee & Brown		1
Taygete attributella (Wlk.)		2
Blastobasidae		
Blastobasis glandulella (Riley)		3
Calosima spp.		1, 2
Hypatopa spp.		3
Bucculatricidae		
Bucculatrix magnella Cham.		1, 2, 3
Bucculatrix sp.		2, 3
Choreutidae		
Tebenna carduiella (Kft.)		3
Coleophoridae		
Coleophora spp.		1, 2, 3
Cosmopterigidae		
Cosmopterix abdita Hodges		3
Cosmopterix dapifera Hodges		1 ,3
Cosmopterix pulchrimella Cham.		3
Ithome sp.		3
Melanocinclis lineigera Hodges		1, 2, 3
Periploca sp.		1, 2
Teladoma sp.		1
Triclonella determinatella (Zell.)		1, 2, 3
Cossidae		
Cossula magnifica (Stkr.)	R	
Crambidae		
Aethiophysa invisalis (Gn.)		2
Apogeshna stenialis (Gn.)		1
Arequipa turbatella Wlk.		2
Argyria rufisignella (Zell.)		1, 2
Chrysendeton medicinalis (Grt.)		1, 2
Crambus agitatellus Clem.		1
Crambus laqueatellus Clem.		1, 2
Crambus saltuellus Zell.		2
Desmia funeralis (Hbn.)		1, 2
Diacme elealis (Wlk.)		1, 2, 3
Diasemiodes janassialis (Wlk.)		1 ,2, 3, 4
Diatraea evanescens Dyar		2
Dioryctria clarioralis (Wlk.)		1
Elophila icciusalis (Wlk.)		3
Elophila obliteralis (Wlk.)		1, 3
Eoparargyractis irroratalis (Dyar)		4
Eoparargyractis sp.		1, 3
Eudonia strigalis (Dyar)		1, 2, 3
Fissicrambus profanellus (Wlk.)		1
Glaphyria sequistrialis Hbn.		1, 2
Haimbachia placidella B. & McD.)		1
Herpetogramma aeglealis (Wlk.)		1
Herpetogramma fluctuosalis (Led.)		3
Herpetogramma thestealis (Wlk.)		3
Hileithia magualis (Gn.)		1, 2, 3
Hymenia perspectalis (Hbn.)		1
Hypsopygia olinalis (Gn.)		1
Macrotheca sp.		2
Microcrambus elegans (Clem.)		1, 2, 3
Microtheoris ophionalis (Wlk.)		2, 3
Neodactria caliginosella (Clem.)		1, 2, 3
Neodactria sp.		3
Nomophila nearctica Mun.		2, 3
Ostrinia obumbratalis (Led.)		3
Ostrinia penitalis (Grt.)		1
Palpita freemanalis Mun.		1, 3
Palpita magniferalis (Wlk.)		1, 2
Palpita quadristigmalis (Gn.)		3
Parapediasia decorella (Zinck.)		1
Parapediasia decorella (Zinck.)		2
Parapoynx allionealis Wlk.		4
Perispasta caeculalis Zell.		1, 2
Petrophila bifascialis (Rob.)		2
Petrophila fulicalis (Clem.)		4
Petrophila n.sp.		4
Pleuroptya silicalis (Gn.)		1
Polygrammodes flavidalis (Gn.)		3
Pyrausta acrionalis (Wlk.)		3
Pyrausta bicoloralis (Gn.)		1, 3
Pyrausta inveterascalis B. &McD.		2
Pyrausta onythesalis (Wlk.)		1
Samea baccatalis (Hulst)		1, 3
Saucrobotys futilalis (Led.)		1
Scoparia basalis gp.		1, 2 ,3
Spoladea recurvalis (F.)		3
Stegea eripalis (Grt.)		2
Udea rubigalis (Gn.)		1, 3
Urola nivalis (Drury)		2
Xanthophysa psychialis (Hulst)		1, 3
Drepanidae		
Drepana arcuata Wlk.		1
Oreta rosea (Wlk.)		1, 3
Elachistidae		
Antaeotricha schlaegeri (Zell.)		1, 2
Antaeotricha unipunctella (Clem.)		1, 2, 3
Antaeotricha vestalis (Zell.)		2, 3, 4
Eupragia hospita Hodges		1 ,2
Psilocorsis cryptolechiella (Cham.)		3
Psilocorsis reflexella Clem.		1, 3
Erebidae — Arctiinae		
Apantesis phalerata (Harr.)	R	
Apantesis sp.		
Cisseps fulvicollis (Hbn.)		1
Cisthene packardii (Grt.)	R G	1, 2, 3

Taxa	PVZ	MEM
Cisthene plumbea Stretch	R G	3
Clemensia albata Pack.	R G	1, 2, 3
Crambidia uniformis Dyar	G	1, 2, 3
Euchaetes egle (Drury)		2
Euerythra phasma Harv.	R	2
Grammia parthenice (Kby.)	R G	
Halysidota tessellaris (J.E. Sm.)	C R G	1 ,2, 3
Haploa clymene (Brown)	C R	2, 3
Hyphantria cunea (Dru.)	C G	
Hypoprepia fucosa Hbn.	R G	2
Leucanopsis longa (Grt.)	G	1
Pagara simplex Wlk.		3
Pyrrharctia isabella (J.E. Sm.)	C	
Spilosoma congrua Wlk.	C R G	
Spilosoma virginica (F.)	G	3
Utetheisa ornatrix (L.)	2	
Virbia aurantiaca (Hbn.)	R G	2, 3
Virbia ferruginosa (Wlk.)	G	
Virbia immaculata (Reakirt)	R G	
Virbia opella (Grt.)	R G	
Erebidae — Lymantriinae		
Dasychira atrivenosa (Palm)	R	3
Dasychira basiflava (Pack.)	G	
Dasychira meridionalis (B. & McD.)	R	
Dasychira tephra Hbn.	R	
Orgyia definita Pack.	G	2, 3
Orgyia leucostigma (J.E. Sm.)	R G	2, 3
Erebidae — other subfamilies		
Arugisa latiorella (Wlk.)		1, 2
Bleptina caradrinalis Gn.		1, 2, 3
Caenurgia chloropha (Wlk.)	C R G	3
Catocala amica (Hbn.)	C R	
Catocala amestris (Streck.)	C	
Catocala andromedae Gn.	R G	1, 3
Catocala connubialis Gn.	G	
Catocala dejecta Stkr.	C	
Catocala epione (Drury)	G	2
Catocala grynea (Cram.)	G	
Catocala ilia (Cram.)	R	
Catocala micronympha Gn.	R	1, 2, 3
Catocala minuta Edw.	G	
Catocala mira Grt. C		
Catocala miranda (Grt.)	G	
Catocala muliercula Gn.	G	
Catocala n.sp. nr. amica	R G	
Catocala orba Kusnezov	R	
Catocala robinsonii Grt.	G	
Catocala ultronia (Hbn.)	C G	
Catocala vidua (J.E. Sm.)	G	
Celiptera frustulum Gn.	C R G	
Colobochyla interpuncta (Grt.)	R G	
Colocasia flavicornis (Sm.)	R G	
Condica mobilis (Wlk.)	G	
Condica sutor (Gn.)	C	
Condica videns (Gn.)	R G	
Cosmia calami (Harv.)	G	
Drasteria grandirena (Haw.)		3
Neadysgonia smithii (Gn.)	R	
Dyspyralis illocata Warr.		4
Dyspyralis puncticosta (Sm.)R		
Hemeroplanis habitalis (Wlk.)	G	3
Hemeroplanis scopulepes (Haw.)	R G	1, 2
Hypena baltimoralis (Gn.)	R	
Hypena bijugalis (Wlk.)		2
Hypena madefactalis Gn.		2
Hypena manalis (Wlk.)		1
Hypena palparia (Wlk.)	R G	1, 2
Hypena scabra (F.)CR G		
Hypenodes fractilinea (Sm.)		1 ,3
Hyperstrotia aetheria (Grt.)		1
Hyperstrotia flaviguttata (Grt.)		3
Hyperstrotia pervertens (B. & McD.)	R G	
Hyperstrotia secta (Grt.)		1
Hyperstrotia villificans (B. & McD.)	R G	1, 2
Hypsoropha hormos Hbn.	C R	1
Idia aemula Hbn. CR G		1, 2, 3
Idia americalis (Gn.)	C R G	1, 2, 3
Idia forbesii (French)	R	
Idia julia (B. & McD.)	C R G	
Idia lubricalis (Gey.)		3
Idia majoralis (Sm.)	R G	3
Idia rotundalis (Wlk.)	R G	
Idia scobialis (Grt.)	R G	
Isogona tenuis (Grt.)	C G	
Lascoria ambigualis Wlk.	R	2
Lesmone detrahens (Wlk.)	G	1, 2
Leucania adjuta (Grt.)		
Leucania spp. R G		1, 3
Macrochilo hypocritalis Fgn.	R	2
Metalectra discalis (Grt.)	R G	1
Metalectra richardsi Brower	R G	3
Mocis texana (Morr.)	R	
Nigetia formosalis Wlk.	R	3
Ogdoconta cinereola (Gn.)	C R G	
Oruza albocostaliata (Pack.)	R	
Oxycilla mitographa (Grt.)	3	
Ozarba aeria (Grt.)	2	
Ozarba nebula B. & McD.	G	
Palthis angulalis (Hbn.)	C	1 ,3
Palthis asopialis (Gn.)		2, 3
Pangrapta decoralis Hbn.	R G	2
Panopoda carneicosta Gn.	C G	1, 3
Panopoda rufimargo (Hbn.)	3	
Parallelia bistriaris Hbn.	C	1
Phyprosopus callitrichoides Grt.	C R G	1
Phytometra ernestinana (Blanch.)		3
Phytometra rhodarialis (Wlk.)	R G	1, 2, 3
Ptichodis herbarum (Gn.)	R G	2, 3
Redectis pygmaea (Grt.)	3	
Redectis vitrea (Grt.)	1	
Renia adspergillus (Bosc)	R	
Renia discoloralis Gn.	C R G	
Renia fraternalis Sm.	R G	2
Renia sobrialis (Wlk.)	C	
Schrankia macula (Druce)	R G	2, 4
Scolecocampa liburna (Gey.)	R G	2
Spiloloma lunilinea Grt.	R	
Tetanolita floridana (Sm.)	G	3
Tetanolita mynesalis (Wlk.)	C R	2, 3
Tripudia rectangula Pogue	C	1, 2, 3
Zale confusa (Hbn.)	G	
Zale galbanata (Morr.)	R	1, 3
Zale helata gp.	C R	
Zale obliqua Gn.	C R G	
Zanclognatha atrilineella (Grt.)		2
Zanclognatha lituralis (Hbn.)	R G	1
Zanclognatha theralis (Wlk.)	1	
Eutelidae		
Marathyssa inficita (Wlk.)	G	3
Paectes abrostoloides (Gn.)	C R G	

Taxa	PVZ	MEM
Paectes oculatrix (Gn.)		1
Gelechiidae		
Agnippe prunifoliella (Cham.)		1
Anacampsis conclusella (Wlk.)		1
Anacampsis coverdalella Kft.		1, 3
Anacampsis rhoifructella (Clem.)		1
Aristotelia corallina Wlsm.		2
Aristotelia pudibundella (Zell.)		1, 2, 3
Aristotelia roseosuffusella (Clem.)		1, 2
Aristotelia rubidella (Clem.)		1 ,2, 3
Battaristis nigratomella (Clem.)		3, 4
Chionodes bicostomaculella (Cham.)		1, 2
Chionodes cacula Hodges		1, 2
Chionodes discoocellella (Cham.)		3
Chionodes emptor Hodges		2
Chionodes mediofuscella (Clem.)		1
Chionodes suasor Hodges		2
Coleotechnites canusella (Free.)		2
Coleotechnites obliquistrigella (Cham.)		1, 2, 3
Deltophora glandiferella (Zell.)		1, 2, 3
Deltophora sella (Cham.)		1, 2
Dichomeris costarufoella (Cham.)		2, 3
Dichomeris flavocostella (Clem.)		2
Dichomeris georgiella (Wlk.)		1, 2
Dichomeris inversella (Zell.)		2, 3
Dichomeris ligulella Hbn.		1, 3
Dichomeris vacciniella Busck		1
Dichomeris ventrellus (Fitch)		1 , 2, 3
Exoteleia anomala Hodges		1, 2
Exoteleia pinifoliella gp.		1, 2
Fascista cercerisella (Cham.)		1, 3
Glauce pectenalaeella Cham.		1, 2
Isophrictis spp.		2, 3 ,4
Monochroa sp.		2
Polyhymno luteostrigella Cham.		2, 3
Pseudotelphusa sp.		1, 2,3
Pubitelphusa latifasciella (Cham.)		2
Stegasta bosqueella (Cham.)		1, 2, 3
Untomia albistrigella (Cham.)		1, 3
Geometridae		
Anavitrinella pampinaria (Gn.)	C R G	1, 2, 3
Antepione thisoaria (Gn.)	R G	
Besma quercivoraria (Gn.)		1
Costaconvexa centrostrigaria (Woll.)	C R	
Cyclophora myrtaria (Gn.)		1
Cyclophora packardi (Prt.)	C	
Cymatophora approximaria Hbn.	R G	
Dichorda iridaria (Gn.)	R G	
Digrammia continuata (Wlk.)	G	
Digrammia gnophosaria Gn.		1
Disclisioprocta stellata (Gn.)	C	
Dyspteris abortivaria (H.-S.)	G	2
Ecliptopera atricolorata (G. & R.)	G	
Ectropis crepuscularia ([D. & S.])	R	
Ennomis subsignaria (Hbn.)	C	
Epimecis hortaria (F.)	R G	
Ertastria cruentaria (Hbn.)	C R G	
Euacidalia sericearia Pack.	R	
Euchlaena amoenaria (Gn.)	R	1,2
Euchlaena deductaria (Wlk.)	R G	
Euchlaena obtusaria (Hbn.)	R	
Eulithis diversilineata (Hbn.)	R G	
Eulithis gracilineata (Gn.)	C R G	
Eupithecia miserulata Grt.	C	1,2
Eupithecia spp.	C R G	
Eusarca confusaria Hbn.	R G	
Eutrapela clemataria (J.E. Sm.)	C R G	
Exelis pyrolaria Gn.		1
Glena plumosaria (Pack.)	R G	1
Glenoides texanaria (Hulst)	R G	1, 2, 3
Horisme intestinata Gn.		3
Hypagyrtis esther (Barnes)	C R G	2
Hypagyrtis unipunctata (Haw.)	C R G	
Hypomecis umbrosaria	G	
Idaea demissaria (Hbn.)	R G	2 ,3
Idaea eremiata (Hlst.)		
Idaea furciferata (Pack.)	R G	1, 2
Idaea obfusaria (Wlk.)	R G	1, 2
Idaea tacturata (Wlk.)	C R G	1, 2
Idaea violacearia (Wlk.)	R G	1, 2, 3
Iridopsis defectaria (Wlk.)	C R G	1, 3
Iridopsis vellivolata (Hulst)	R G	2, 3
Lambdina pultaria (Gn.)	2,3	
Lobocleta ossularia (Gey.)	G	3
Lobocleta peralbata (Pack.)		1
Lomographa vestaliata (Gn.)	R G	1, 2, 3
Lophosis labeculata (Hulst)	R	1
Lytrosis unitaria (H.-S.)	R G	
Lytrosis sp.	R	
Macaria aemulataria Wlk.	R	1
Macaria bicolorata (F.)	CR G	1, 2
Macaria multilineata Pack.	R G	1, 2, 3
Macaria promiscuata (Fgn.)	R	1, 2
Macaria transitaria (Wlk.)	R G	2
Melanolophia canadaria (Gn.)	C R G	3
Metarranthis homuraria (G. & R.)	R	1
Nematocampa resistaria (H.-S.)	C R G	
Nemoria bistriaria Hbn.		1, 3
Nemoria lixaria (Gn.)	R	2, 3
Nemoria saturiba Fgn.	R G	1
Nemoria sp.	G	
Nepytia semiclusaria (Wlk.)	C R G	1
Patalene olyzonaria (Wlk.)	C R G	1, 2, 3
Pimaphera sparsaria (Wlk.)		3
Plagodis fervidaria (H.-S.)	G	1
Pleuroprucha insulsaria (Gn.)	C G	1, 2, 3
Plusiodonta compressipalpis Gn.	C R G	
Probole alienaria H.-S.	R	3
Probole amicaria (H.-S.)	R	
Prochoerodes lineola (Goeze)	C R G	2, 3
Protoboarmia porcelaria (Gn.)	R	1, 2
Rheumaptera prunivorata Fgn.		1, 2
Scopula limboundata (Haw.)	C R G	1, 3
Scopula ordinata (Wlk.)		3
Speranza pustularia (Gn.)	G	
Synchlora frondaria Gn.		1, 3
Synchlora sp.	G	
Timandra amaturaria (Wlk.)		1
Tornos scolopacinaria (Gn.)		2
Gracillariidae		
Caloptilia belfrageella (Cham.)		1, 3
Caloptilia violacella (Clem.)		1
Cameraria sp.		3
Mamara sp.		1, 2 ,3
Neurobathra strigifinitella (Clem.)		1, 2
Parectopa robiniella Clem.		3
Phyllocnistis insignis F. & B.		3
Heliodinidae		
Cycloplasis panicifoliella Clem.		3

Taxa	PVZ	MEM
Lasiocampidae		
Artace cribraria (Ljungh)		3
Malacosoma americana (F.)	C R G	
Malacosoma disstria Hbn.	C R G	
Tolype notialis Franc.	C R G	3
Limacodidae		
Adoneta spinuloides (H.-S.)	R	
Apoda biguttata (Pack.)		3
Apoda y-inversum (Pack.)	R G	
Euclea delphinii (Bdv.)	G	
Isa textula (H.-S.)	C	
Isochaetes beutenmuelleri (Hy. Edw.)	R	2, 3
Lithacodes fasciola (H.-S.)	C R G	1, 2
Monoleuca semifascia (Wlk.)	G	
Natada nasoni (Grt.)	C G	
Packardia geminata (Pack.)		2
Parasa chloris (H.-S.)	R	
Phobetron pithecium (J.E. Sm.)	R	1
Prolimacodes badia (Hbn.)	C	1, 2
Tortricidia testacea Pack.	1	
Megalopygidae		
Megalopyge crispata (Pack.)	G	
Megalopyge opercularis (J.E. Sm.)	G	1
Norape ovina (Sepp)	R	
Momphidae		
Mompha circumscriptella (Zell.)		3
Mompha eloisella (Clem.)		1
Noctuidae		
Abagrotis alternata (Grt.)	C	
Achatodes zeae (Harr.)		2
Acronicta afflicta Grt.	C	3
Acronicta americana (Harr.)	R	3
Acronicta clarescens Gn.		2, 2
Acronicta hasta Gn.		1, 2, 3
Acronicta impleta Wlk.	C	3
Acronicta inclara - increta gp.	C R	1, 2, 3
Acronicta interrupta Gn.		3
Acronicta laetifica Sm.		2, 3
Acronicta lobeliae Gn.	C	3
Acronicta modica Wlk.		1
Acronicta noctivaga Grt.	C	
Acronicta retardata (Wlk.)	G	
Acronicta rubricoma Gn.	C	1
Acronicta vinnula (Grt.)	G	2, 3
Agnorisma badinodis (Grt.)	R	
Agrotis gladiaria Morr.	R	
Agrotis ipsilon Hufn.	C R	
Agrotis malefida Gn.	C	
Agrotis venerabilis Wlk.	G	
Allotria elonympha (Hbn.)	C R G	
Amolita roseola Sm.		2, 3
Amphipyra pyramidoides Gn.	C R	
Anicla infecta (Ochs.)	C R G	3
Argyrogramma verruca (F.)	R	
Argyrostrotis anilis (Dru.)	C R G	
Arugisa latiorella (Wlk.)	R G	
Arugisa lutea (Sm.)	R	
Azenia obtusa (H.-S.)	R G	1, 3
Bagisara rectifascia (Grt.)		1, 2
Baileya ophthalmica (Gn.)	R G	
Balsa labecula (Grt.)	R	
Bleptina caradrinalis Gn.	R	
Caenurgia chloropha (Hbn.)	C R G	
Callopistria cordata (Ljungh)		1, 2
Callopistria mollissima (Gn.)	R G	
Charadra deridens (Gn.)		3
Chaetaglaea sericea (Morr.)	C	
Choephora fungorum G. & R.	G	
Chytolita morbidalis Gn.	2	
Chytonix palliatricula (Gn.)	R G	1, 2
Condica sutor (Gn.)		1, 3
Condica videns (Gn.)		1, 2, 3
Cosmia calami (Harv.)		2
Ctenoplusia oxygramma (Gey.)		3
Cydosia aurivitta G. & R.	R G	1
Dypterygia patina (Haw.)		3
Elaphria chalcedonia (Hbn.)		1, 3
Elaphria festivoides (Gn.)	R	
Elaphria grata Hbn.	C R G	2
Elaphria versicolor (Grt.)	R	1, 3
Ellida caniplaga (Wlk.)	G	1, 3
Eublemma minima (Gn.)	1	
Feltia subterranea (F.)	C G	
Galgula partita Gn.	C R G	1, 3
Harrisimemna trisignata (Wlk.)	C	1
Helicoverpa zea (Boddie)	R G	
Homophoberia apicosa (Haw.)	G	3
Iodopepla u-album (Gn.)	G	2
Lacinipolia implicata McD.	C	
Leucania sp.		1, 3
Marimatha nigrofimbria (Gn.)	C R G	1, 2, 3
Mythimna unipuncta (Haw.)	C R G	
Noctua pronuba (L.)	C	
Ogdoconta cinereola (Gn.)		3
Orthodes cynica Gn.		2
Orthodes goodelli (Grt		3
Orthodes majuscula (H.-S.)	R	1
Perigea xanthioides Gn.		1,3
Phlogophora periculosa Gn.	R	
Phosphila miselioides (Gn.)	C R G	2
Polygrammate hebraeicum (Hbn.)	C R G	1, 3
Ponometia candefacta (Hbn.)		
Protodeltote muscosula (Gn.)	R	
Rachiplusia ou (Gn.)	C	2
Raphia abrupta Grt.		1, 2
Schinia arcigera (Gn.)	G	
Spodoptera dolichos (F.)	C	
Spodoptera frugiperda (J.E. Sm.)	C	
Spodoptera latifascia (Wlk.)	C	2
Spodoptera ornithogalli (Gn.)	C R G	2, 3
Spragueia apicalis (H.-S.)		3
Spragueia dama (Gn.)	C	
Spragueia leo (Gn.)	R	3
Sunira bicolorago (Gn.)	C R	
Sympista kappa (Grt.)		1, 2
Tarache aprica (Hbn.)	C	
Tricholita signata (Wlk.)	C	
Xestia dilucida (Morr.)	C	
Xestia elimata (Gn.)	C	
Nolidae		
Baileya arcadiana Brou		1, 3
Baileya australis (Grt.)		3
Baileya ophthalmica (Gn.)		1, 2
Meganola minuscula (Zell.)	R	
Meganola phylla (Dyar)	R	1, 2, 3
Meganola spodia Franc.		
Nola cereella (Bosc)		1, 3
Nola cilicoides (Grt.)		3

Taxa	PVZ	MEM
Nola pustulata (Wlk.)		1
Notodontidae		
Clostera inclusa (Hbn.)		3
Dashylophia anguina (J.E. Sm.)	R	
Datana angusii G. & R.	R G	3
Datana integerrima G. & R.	R	3
Datana major G. & R.		1
Datana ministra (Drury)		3
Datana spp.	C R G	3
Furcula borealis (Gu,r.)		1
Heterocampa biundata Wlk.	R G	
Heterocampa guttivitta (Wlk.)	C R G	3
Heterocampa obliqua Pack.	C R G	
Heterocampa umbrata Wlk. R		3
Hyperaeschra georgica (H.-S.)	C R	2, 3
Lochmaeus bilineata (Pack.)	C R G	1, 2, 3
Lochmaeus manteo Dbdy.	C	3
Macrurocampa marthesia (Cram.)	C R G	
Misogada unicolor (Pack.)	R	1
Nadata gibbosa (J.E. Sm.)	C R G	1, 3
Nerice bidentata Wlk.	R	3
Oligocentria lignicolor (Wlk.)		1
Peridea angulosa R G		
Peridea basitriens (Wlk.)	R G	3
Schizura ipomoeae Dbdy.	R G	
Schizura leptinoides (Grt.)	C	3
Schizura unicornis (J.E. Sm.)		2
Symmerista albifrons (J.E. Sm.)	C R G	3
Oecophoridae		
Decantha boreasella (Cham.)		1
Epicallima argenticinctella Clem.		1, 2, 3
Inga cretacea (Zell.)		3
Inga sparsiciliella (Clem.)		3
Opostegidae		
Pseudopostega sp.		1
Plutellidae		
Plutella xylostella (L.)		3
Prodoxidae		
Prodoxus quinquepunctella (Cham.)		1
Tegeticula yuccasella (Riley)		1
Pterophoridae		
Pselnophorus belfragei (Fish)		1, 2, 3
Stenoptilia pallistriga (B. & McD.)		3
Pyralidae		
Acrobasis caryae Grt.		2, 3
Acrobasis demotella Grt.		1
Acrobasis ostryella Ely		2, 3
Acrobasis stigmella Dyar		3
Adelphia petrella (Zell.)		2, 3
Arta sp.		3
Atrix sp.		2
Cabnia myronella Dyar		1
Canarsia ulmiarrosorella (Clem.)		2, 3
Dioryctria amatella (Hulst)		2
Dioryctria disclusa Heinr.		2
Ephestia columbiella Neunzig		1
Ephestiodes infimella Rag.		2
Eulogia ochrifrontella (Zell.)		1
Eurythmia hospitella (Zell.)		3
Euzophera ostricolorella (Hulst)		2
Euzophera semifuneralis (Wlk.)		1
Glyptocera consobrinella (Zell.)		2 ,3
Homoeosoma electellum (Hulst)		1
Immyrla nigrovittella Dyar		2
Laetilia sp.		1, 2
Macrorrhinia endonephele (Hamp.)		1
Parachma ochracealis Wlk.		2, 3
Peoria approximella (Wlk.)		1, 2
Pococera asperatella (Clem.)		3
Quasisalebria atratella (Blanch. & Kn.)		2
Salebriaria carolynae Neunzig		2, 3
Salebriaria fasciata Neunzig		2
Salebriaria rufimaculatella Neunzig		2
Salebriaria turpidella (Rag.)		1
Sciota subfuscella (Rag.)		1, 2
Sciota uvinella (Rag.)		2
Tampa dimediatella Rag.		3
Tosale oviplagalis (Wlk.)		1, 2
Tulsa finitella (Wlk.)		1, 2
Varneria postremella Dyar		1, 2, 3
Saturniidae		
Actias luna (L.)	R G	2
Anisota stigma (F.)	R G	3
Anisota virginiensis (Dru.)	R	
Antheraea polyphemus (Cram.)	R G	3
Automeris io (F.)	R G	2
Callosamia angulifera (Wlk.)	R	
Callosamia promethea (Drury)		1
Dryocampa rubicunda (F.)	R	3
Eacles imperialis (Drury)	R G	2, 3
Sesiidae		
Synanthedon acerni (Clem.)		1
Synanthedon exitiosa (Say)	C	
Sphingidae		
Agrius cingulata (F.)	G	
Amorpha juglandis (J.E. Sm.)	C G	1
Ceratomia catalpae (Bdv.)	G	1, 2, 3
Ceratomia undulosa (Wlk.)	2	
Darapsa choerilus (Cram.)	R	1
Darapsa myron (Cram.)	G	
Eumorpha pandorus (Hbn.)	G	
Lapara coniferarum (J.E. Sm.)	R G	3
Manduca sexta (L.)	C	
Paonias excaecata (J.E. Sm.)	R G	3
Paonias myops (J.E. Sm.)	G	1
Paratrea plebeja (F.)		2
Thyrididae		
Thyris maculata Harr.		3
Tineidae		
Acrolophus arcanella (Clem.)		1, 2, 3
Acrolophus mycetophagus Davis		1
Acrolophus plumifrontella (Clem.)		2
Acrolophus popeanella (Clem.)		3
Diachorisia velatella Clem.		2, 3
Homosetia n. sp.		1
n. gen. n. sp.		3
Tinea apicimaculella Cham.		1, 2, 3
Tinea unomaculella Cham.		2, 3
Tischeriidae		
Tisheria sp.		1, 3

Taxa	PVZ	MEM
Tortricidae — Olethreutinae		
Ancylis burgessiana (Zell.)		1
Ancylis comptana (Fr"l.)		1, 3
Ancylis n. sp.		2
Bactra verutana Zell.		2, 3
Corticivora parva Brown		1, 2
Cydia caryana (Fitch)		3
Cydia latiferreana (Wlsm.)		1, 2,3
Cydia rana (Fbs.)		2, 3
Ecdytolopha punctidiscana (Dyar)		1
Endothenia hebesana (Wlk.)		1, 2,3
Epiblema "minutana" (Kft.)		1, 2
Epiblema brightonana (Kft.)		2
Epiblema strenuana (Wlk.)		1
Episimus argutana (Clem.)		1, 3
Episimus tyrius Heinr.		1
Eucosma fiskeana Kft.		3
Eucosma matutina (Grt.)		1
Eucosma robinsonana (Grt.)		1
Eumarozia malachitana (Zell.)		1, 3
Gretchena concitatricana (Heinr.)		2
Olethreutes fasciatana (Clem.)		1, 2
Olethreutes ferriferana (Wlk.)		1
Olethreutes inornatana (Clem.)		1, 2
Paralobesia viteana (Clem.)		3
Pelochrista pallidipalpana (Kft.)		1, 3
Pelochrista scintillana (Clem.)		1, 2, 3
Phaecasiophora niveiguttana Grt.		1, 3
Phaneta awemeana (Kft.)		3
Proteoteras naracana Kft.		1, 2
Pseudogalleria inimicella (Zell.)		1
Retinia houseri (Miller)		1
Retinia taedana (Miller)		1
Rhyacionia frustrana (Comst.)		1, 2, 3
Satronia tantilla Heinr.		2
Sonia paraplesiana Blanch.		3
Zomaria interruptolineana (Fern.)		3
Tortricidae — Tortricinae		
Archips georgiana (Wlk.)		1, 2
Archips infumatana (Zell.)		2
Archips rileyana (Grt.)		1, 2
Argyrotaenia floridana Obr.		1, 2, 3
Argyrotaenia quercifoliana (Fitch)		1, 2
Argyrotaenia velutinana (Wlk.)		2, 3
Carolella sartana (Hbn.)		1
Cenopis diluticostana (Wlsm.)		1
Cenopis directana (Wlk.)		1, 2
Cenopis ferreana (Bsk.)		1
Cenopis niveana (Wlsm.)		1
Cenopis saracana Kft.		1
Choristoneura rosaceana (Harr.)		1, 2, 3
Clepsis peritana (Clem.)		2
Cochylis sp.		1, 2, 3
Pandemis limitata (Rob.)		1
Platynota exasperatana (Zell.)		1, 2
Platynota flavedana Clem.		1
Platynota idaeusalis (Wlk.)		1
Platynota rostrana (Wlk.)		1, 2
Recavicula sp.		1, 2, 3
Sparganothis caryae (Rob.)		1
Sparganothis sulfureana (Clem.)		1, 2, 3
Yponomeutidae		
Lactura pupula (Hbn.)		1, 2
Yponomeuta multipunctella Clem.	R	
Zelleria retiniella Fbs.		1, 2
Zygaenidae		
Harrisina americana (Guer.)	R	1

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