Insect Diversity on Mount Mansfield

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Abstract

The insect biodiversity survey continued in 1994 for selected groups of Lepidoptera, and Coleoptera (Carabidae) at three elevations on Mount Mansfield. The Lepidoptera records are entered on a computer database for 1991-1994. Annual comparisons are now available for the Noctuidae, Geometridae, Tortricidae, Pyralidae and Notodontidae that are being sampled each year. Examples are presented here for some species that have a recognized pest status in Vermont forests. Biennial patterns of development are illustrated for the conifer swift moth, *Korscheltellus gracilis*, and the St Lawrence tiger moth, *Platarctia parthenos*. Elevation comparisons are presented for the unique species present at each of the sample sites to identify high elevation restricted species. The implications of biennial life cycles and elevation patterns for long-term ecosystem management and climate change are discussed.

Introduction

The Mount Mansfield insect biodiversity program comprises four years of consecutive survey and inventory for the ground dwelling ground beetles (Carabidae: Coleoptera), and night flying moths (Lepidoptera). A three year survey of Hymenoptera and Diptera in the forest canopy was carried out from 1991-1993, supplemented by a two month survey in May-June 1994 to document the spring fauna that may be involved with pollination of tree species.

Interim species lists have been presented for all groups in the 1991-1993 VMC annual reports. Taxonomic identification to species represents a continuing research activity that is nearly complete for the Carabidae represented by a total of 70 species. The species composition of Lepidoptera is documented for most taxonomic groups and families appropriate for long-term monitoring identified (1993 VMC report). Identification of Diptera and Hymenoptera is currently being carried out by J. Boone for his MS dissertation with assistance from available specialists. Fully curated voucher collections of Diptera, Hymenoptera, and Coleoptera from Mount Mansfield and other localities in Vermont have been completed by J. Boone at the Entomology Research Laboratory.

The 1994 insect survey was primarily concerned with the continued monitoring Carabidae and selected families of Lepidoptera at the permanent survey sites on Mount Mansfield. This report presents comparisons between years for some species of Lepidoptera, and seasonal records for the Carabidae, new Lepidoptera records, and comparison of species representation between sites for the Lepidoptera.

Methods

Sampling continued at the established survey sites in a sugar maple forest at 400 m elevation (Proctor Maple Research Center; PMRC), a mixed hardwood forest at 600 m (Underhill State Park; USP), and a sub-alpine balsam fir forest at 1160 m near the southern summit of Mount Mansfield (MMS).

Each survey site comprises five permanent 20 m diameter plots with a malaise trap installed in the canopy of one dominant sugar maple or fir tree (sub-alpine site) in each of the four outlying plots. Six pitfall traps are located around each plot at 60° intervals and a single light trap was located in the center plot. The 1993 survey covered the period from 9 May to 31 October. A detailed account of field and laboratory methods is outlined in the 1991 VMC Annual Report.

The 1994 Lepidoptera light trap survey was limited to the following groups: Noctuidae, Geometridae, Notodontidae, Arctiidae, Saturniidae, Sphingidae, Lymantriidae, Lasiocampidae, Drepanidae, and Limacodidae. Nearly all species in these families can be identified with confidence without specialist assistance or extensive dissection (see 1993 VMC report).

Baiting was carried out in late April when daytime temperatures reached the mid to high 50's (F). Baiting at USP was, however, delayed due to excessive snow on the access road, and interim baiting was carried out below the park entrance at about 500 m elevation (USPa). In the afternoon (approx. 3-4 pm) bait was applied with a brush to trunks of about 30 trees approximately 1.5 m above ground. Moths feeding at the bait were collected in vials at dusk for at least one hour.

Further baiting was carried out on 8 October at Proctor Maple Research Center to collect females of *Pachypolia atricornis* (Noctuidae). This moth is widespread, but usually rare even though it occurs in ordinary maple forests (Grehan et al., 1995). The host-plant is unknown, and the females are not attracted to lights.

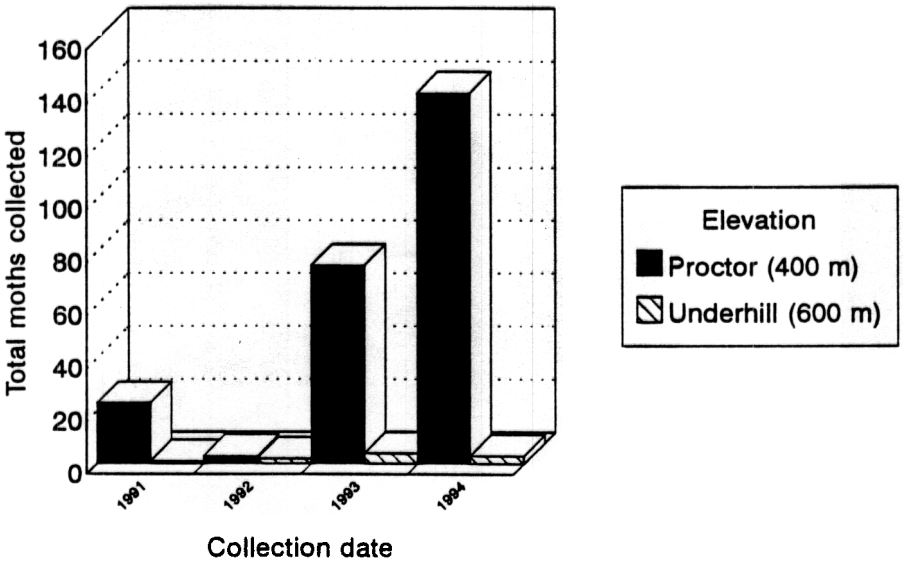
Results

Annual abundance of Lepidoptera

(i) Pest species

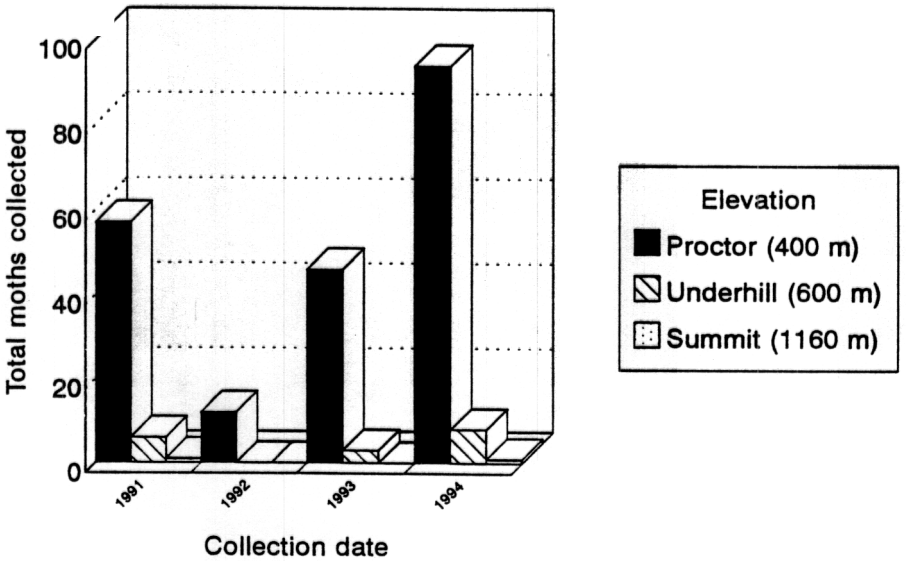
Population outbreaks of the forest tent caterpillar, *Malacosoma disstria*, occur 6-16 years apart and last only 3-6 years. High population numbers were last recorded in Vermont between the mid 1970's to the early 1980's (Parker et al., 1989). On Mount Mansfield higher numbers were collected at PMRC, with numbers being low in 1991 and decreasing in 1992 before showing a considerable increase in 1993 and 1994 (Fig. 1). No adults of forest tent caterpillar have been recorded from pheromone traps on Mount Mansfield during the last four years (see Wilmot et al VMC annual reports) and this contrast suggests that the pheromone is inactive. The eastern tent caterpillar, *Malacosoma americana*, is not a significant pest of forests in

Figure 1. Annual total number of adults of the forest tent caterpillar, *Malacosoma disstria*, collected from light traps over a four-year period on Mount Mansfield at Proctor Maple Research Center and Underhill State Park.



Vermont (cf. Parker et al., 1989), but its population trends may provide a significant comparison because of its close phylogenetic relationship with the forest tent caterpillar and its similar biology. The eastern tent caterpillar is regularly collected at USP and PMRC. The numbers collected show a similar pattern to the forest tent caterpillar (Fig. 2).

Figure 2. Annual total number of adults of the eastern tent caterpillar, *Malacosoma americana*, collected from light traps over a four-year period on Mount Mansfield at Proctor Maple Research Center and Underhill State Park.



Adults of the bruce spanworm, *Operopthera bruceata*, are often observed flying above the forest floor during the daytime in early October at USP and PMRC. Light trap numbers are low (Fig. 3), even when many moths were observed flying in the habitat during the preceding afternoon. This species is either not strongly attracted to the lights, or poor weather conditions (e.g. low temperatures) late in the season reduce their flight activity after sundown.

The fall hemlock looper, *Lambdina fiscellaria*, is abundant at USP and PMRC, with declining numbers being collected from 1991 to 1994 (Fig. 4). The numbers collected per night in 1991 are comparable to densities recorded for *L. fiscellaria* in population outbreaks responsible for considerable defoliation of spruce and hemlock in Maine. There is no indication that *L. fiscellaria* is responsible for defoliation of spruce or hemlock at Mount Mansfield, and it is possible that the moth is feeding on hardwoods, but not at an intensity great enough to result in significant defoliation.

The flight season of *L. fiscellaria* is from September to early October (Grehan and Parker 1994). The spring hemlock looper, *L. athasaria*, is occasionally a significant pest of hemlock in Vermont (Grehan, Parker and Dearborn, in press), but is rare on

Figure 3. Annual total number of adults of the bruce spanworm, *Operopthera bruceata*, collected from light traps over a four-year period on Mount Mansfield at Proctor Maple Research Center and Underhill State Park.

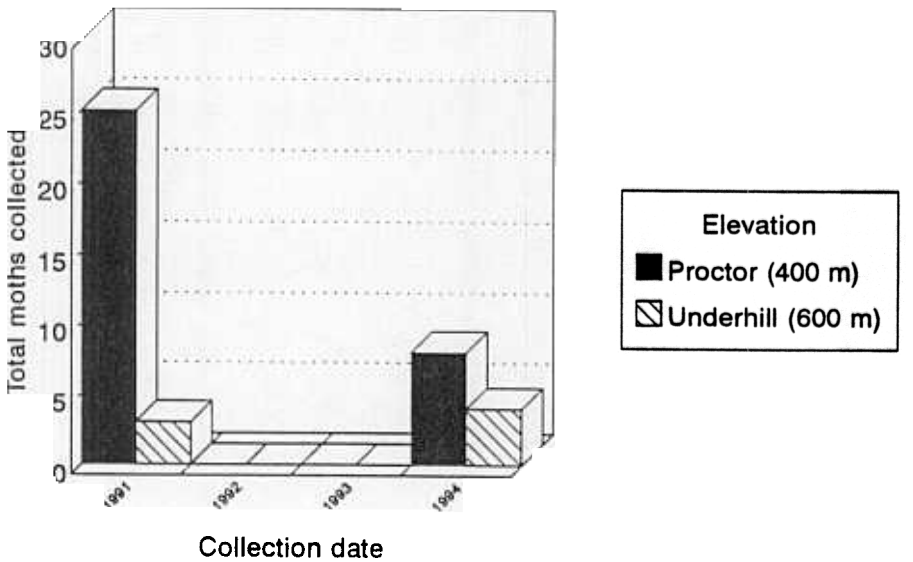
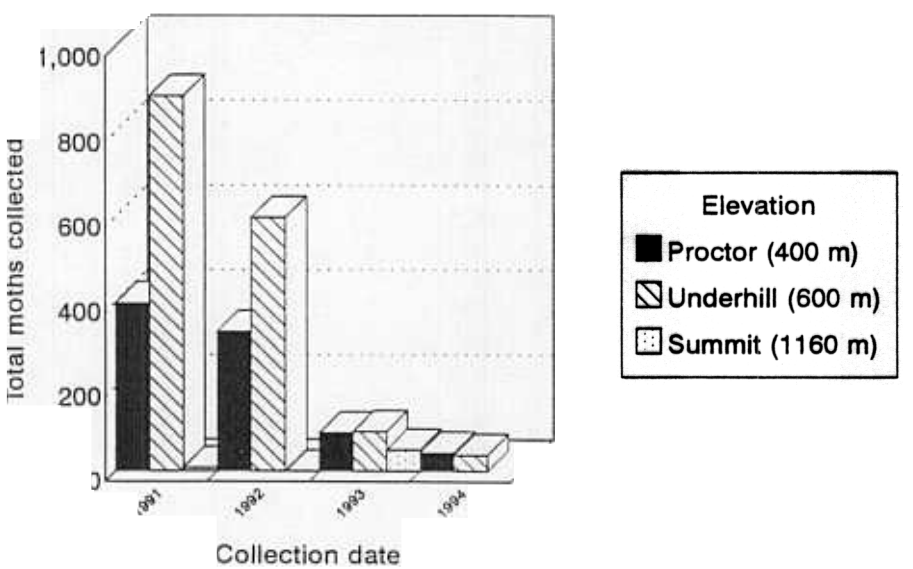


Figure 4. Annual total number of adults of the fall hemlock looper, *Lambdina fiscellaria* collected from light traps over a four-year period on Mount Mansfield at Proctor Maple Research Center, Underhill State Park, and near the Mountain summit.



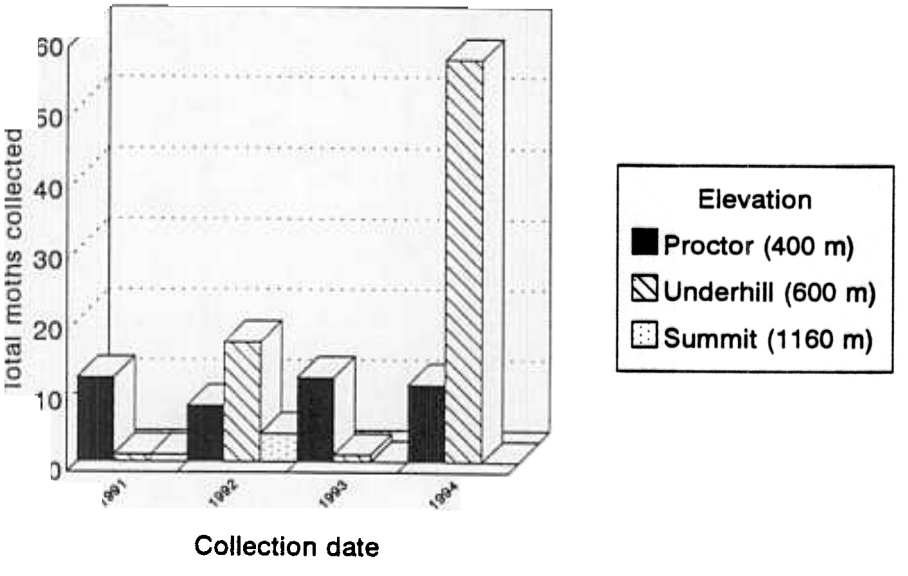
The spruce budworm, *Choristoneura fumiferana*, is recorded in pheromone traps each year at Mount Mansfield but it is rarely collected from the light traps. Only one specimen was recorded for 1994 and none in preceding years. The spruce budworm, like many other small moths, is either not strongly attracted to light or its flight behavior avoids becoming snared within the trap.

(ii) Biennial life cycles

Most Lepidoptera on Mount Mansfield have one or more generations each year, two species are known to exhibit synchronized biennial patterns of development. The periodicity of the conifer swift moth, *Korscheltellus gracilis*, has been extensively documented in the northeastern United States and Canada (Leonard and Parker, 1994). In Vermont most moths emerge on even numbered years, with a small minority flying on the odd numbered years. The species is attracted to light, but not very intensively, and population surveys have focused, therefore, on sticky traps which are effective at intercepting the swift, directional flight of the adult moths. Soil surveys and adult trapping suggest that the species is very abundant at mid to high elevations in the northeastern United States (Tobi et al., 1992).

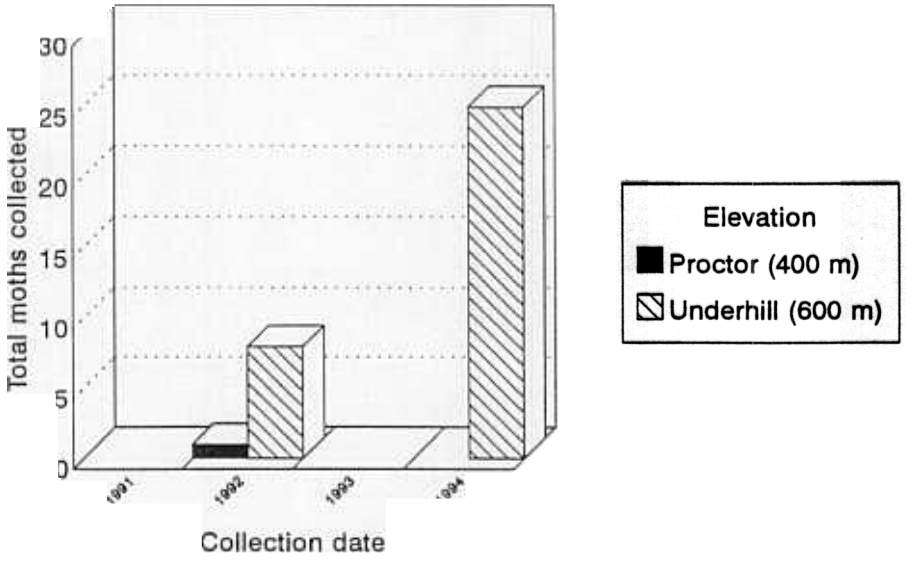
Only a small number of *K. gracilis* moths were collected each year in the light traps at Mount Mansfield, with no strong contrast between even and odd numbered years, with the exception of USP in 1994 where six times the usual number of moths was collected (Fig. 5). Light traps appear to provide an adequate record of the species' presence, but greatly underestimates its relative abundance.

Figure 5. Annual total number of adults of the conifer swift moth, *Korscheltellus gracilis*, collected from light traps over a four-year period on Mount Mansfield at Proctor Maple Research Center, Underhill State Park, and near the mountain summit.



In contrast to *K. gracilis*, the biennial development of the St Lawrence tiger moth, *Platarctia parthenos*, appears to be completely synchronized (Fig. 6). The species was first collected on Mount Mansfield in 1992 and again in 1994, coinciding with the main flight years of *K. gracilis*. The moth is recorded from a wide range of plants including alder, birches, willows and lettuce (Covell 1984), but does not represent a recognized forest pest.

Figure 6. Annual total number of adults of the St Lawrence tiger moth, *Platarctia parthenos*, collected from light traps over a four-year period on Mount Mansfield at Proctor Maple Research Center and Underhill State Park.



(b) Site representation of Lepidoptera

The 1991 annual report (Boone, Parker and Grehan 1992) reported on the similarity of total species numbers in the two lower elevation sites - PMRC and USP. This similarity is not surprising given their similar elevation, and the predominance of the same hardwood species in each area. This comparison can be further refined by considering the species unique to each site within Mount Mansfield, and the number of species shared between sites. The following comparisons were made for 1993 which covered all groups collected.

The largest number of unique species are present in PMRC, with a slightly lower number in USP (Fig. 7). The high elevation site (MMS) supported only 12 species not found at the other sites on Mount Mansfield (Table 1). Six of the high elevation species are known from other lowland localities in Vermont and are either strays or able to live in both high and low elevation habitats. Their host-plants suggests that they are not permanent elements of the high elevation fir forest habitat. The MMS site is located just below the WCAX television station where the habitat is highly modified.

seven species recorded only at MMS and USP represent known lowland species. The exception is represented by *Acleris variana* (Tortricidae) which comprises two forms, a grey-colored high elevation moth, and an orange-brown lowland moth (illustrated in Grehan et al. 1995). Each form may represent a separate species since the high elevation form feeds on balsam fir while the low elevation form feeds on eastern hemlock.

Table 1. Mount Mansfield Lepidoptera records unique to the summit survey site (1160 m) in 1993. The list is divided into (a) those known from low elevation records in Vermont, and (b) those not recorded from lowland habitats in Vermont.

(a) Low elevation representatives
Noctuidae
Amphipoea velata (grass feeder)
Anagrapha falcifera (herbs, horticultural pest)
Caripeta angustifolia (pine feeder)
Eurois occulta (feeds on tamarack)
Lithacodia albidula (grasses)
Papaipema sp
Tortricidae
Choristoneura pinus
Epinotia lindana

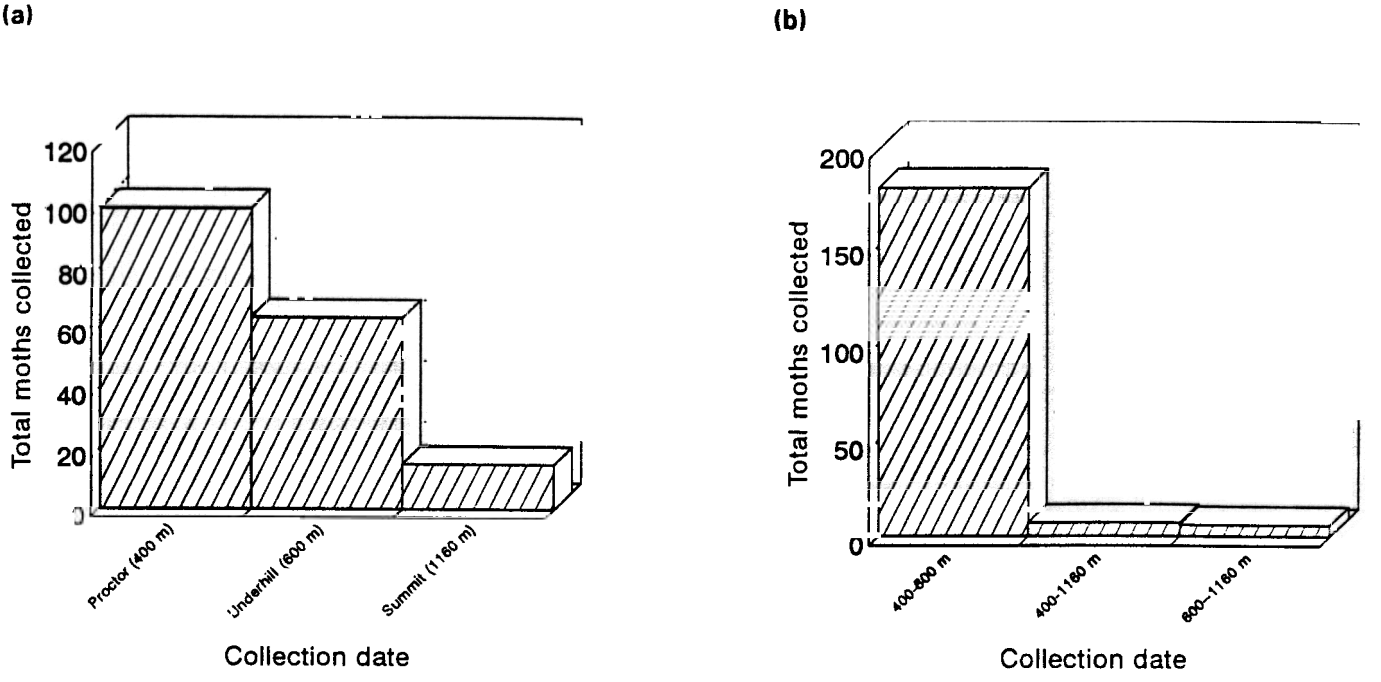
(b) High elevation representatives
Geometridae
Eulithis destinata (boreal distribution)
Eulithis flavibrunneata (boreal distribution)
Noctuidae
Melanchra adjuncta (trees and shrubs, alder, willow, elm and herbs)
Platypolia anceps
Xestia speciosa

Table 2. Mount Mansfield Lepidoptera records unique to the summit survey site (1160 m) and Underhill State Park (600 m) in 1993. The list is divided into (a) those known from low elevation records in Vermont, and (b) those not recorded from lowland habitats in Vermont.

(a) Low elevation representatives
Noctuidae
Amphipyra tragopoginis (herbs)
Apamea amputatrix (very wide host range, includes vegetables)
Cryptocala acadiensis
Xestia smithii

(b) High elevation representatives
Noctuidae
Xestia rhaetica
Geometridae
Eulithis propulsata
Xanthorhoe iduata

Figure 7. Site comparisons of total number of Lepidoptera species collected at Mount Mansfield in 1993. (a) Number of species unique to each site; (b) total number of species shared between any two sites.



(c) Bait sampling of Lepidoptera

Moths collected at bait are listed in Table 3. Sixteen species were not previously collected from the light traps. All species are already recorded in Vermont, and all should occur in both PMRC and USP. Five females of *Pachypolia atricornis* were collected at bait in September. The moths were fed a solution of water and apricot jelly. Eggs were deposited in rearing chambers comprising a surface of soft hand-towel. To obtain larvae for rearing and host-plant study in 1995 the eggs are being overwintered at the Entomology Laboratory and by other lepdiopterists.

(d) Seasonal patterns in Carabidae

When all carabid records are confirmed it will be possible to establish a statistical comparison of seasonal activity of adults that could be used to assess long-term environmental trends. The seasonal records will need to be interpreted in relation to the biology and ecology of each species. Overwintering may occur as adults, larvae, or both, and individual activity may be greatly reduced during unfavorable conditions such as hot, dry weather. Results from the 1991 season indicate that most adult carabids are collected in the early part of the summer, with considerable decline towards the beginning of fall.

Table 3. Lepidoptera collected at bait at Mount Mansfield, April 1994. * - species not previously collected at light traps on Mount Mansfield. USPa - collected next to access road below entrance to Underhill State Park (500 m approx.). USP - Underhill State Park VMC site (600 m). PMRC - Proctor Maple Research Center VMC site (400 m).

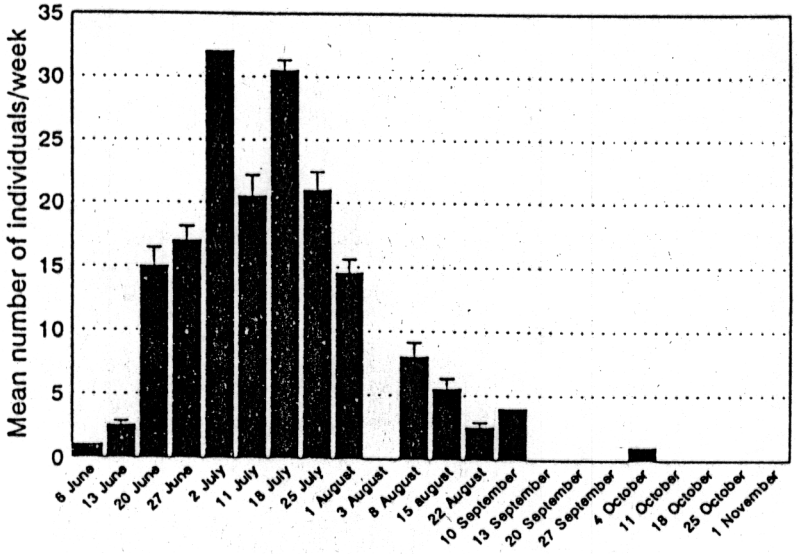
	Collection Site		
Species	**USPa**	**USP**	**PMRC**
Noctuidae: Cuculliinae			
**Copivaleria grotei* Morr., 1874)			+
**Eupsilia devia* (Grt., 1875)		+	
Eupsilia morrisoni (Grt., 1874)	+	+	+
**Eupsilia vinulenta* (Grt., 1864)			+
**Eupsilia tristigmata* (Grt., 1877)	+	+	+
Lithophane baileyi Grt., 1877	+	+	+
Lithophane fagina Morr., 1874			+
**Lithophane gotei* Riley, 1877		+	
**Lithophane hemina* Grt., 1874	+		+
**Lithophane innominata* (Sm., 1893)	+	+	+
**Lithophane petulca* Grt., 1874)	+		+
**Lithophane unimoda* (Lint., 1878)			+
**Pyreferra pettiti* (Grt., 1874)			+
**Xylena curvimacula* (Morr., 1874)			+
Noctuidae: Hadeninae			
Achatia distincta Hbn., 1813			+
**Egira dolosa* (Grt., 1880)			+
**Orthosia hibisci* (Gn., 1852)			+
**Orthosia revicta* (Morr., 1876)			+
Orthosia rubescens (Wlk., 1865)			+
Noctuidae: Noctuinae			
Cerastis tenebrifera (Wlk., 1865)			+
Notodontidae			
Gluphisia lintneri (Grt., 1877)			+
Tortricidae			
**Acleris cerviana* (Fern., 1882)			+
**Acleris flavivittana* (Clem., 1864)			+
Thyatiridae: Thyatirinae			
Euthyatira pudens (Gn., 1852)			

The elevational distribution of the carabid *Synuchus impunctatus* is an example of a mid and lower elevation species where most adults were collected between June and mid September (Fig. 8). This species usually overwinters in the larval stage and the lack of adults at the end of this season may reflect this pattern of development.

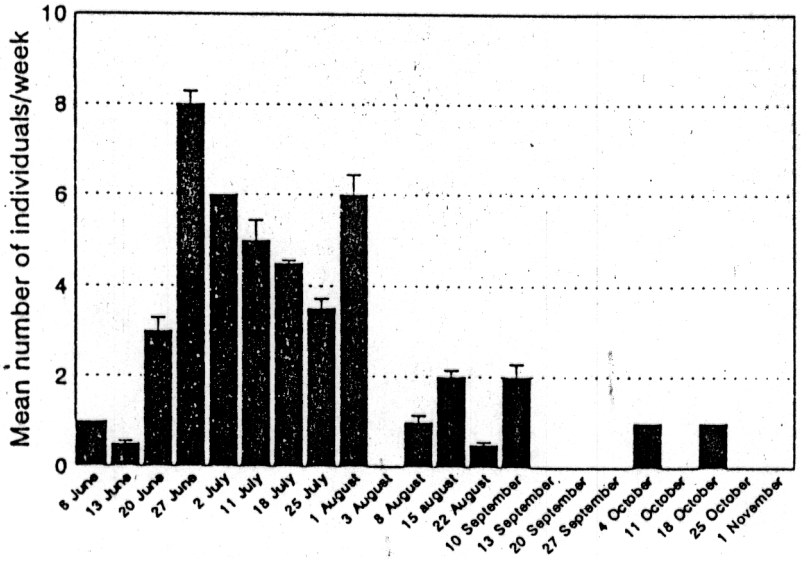
Adults of *Pterostichus rostratus* are most abundant at USP between June and August with only a few

Figure 8. Seasonal distribution of *Synuchus impunctatus* adults collected from pitfall traps on Mount Mansfield in 1991. (a) Underhill State Park, 600 m; (b) Proctor Maple Research Center, 400 m.

(a)



(b)



adults collected towards the end of the sampling season (Fig. 9). Although this species may overwinter in the adult stage, it is possible that the activity level of fall adults is very low and specimens are rarely collected in the pitfall traps. The high elevation species occur in lower numbers than USP or PMRC and population trends may be less evident. Records of *Pterostichus brevicornis* fluctuate considerably, but no adults occur beyond the end of August although the species probably overwinters in the adult stage (Fig. 10).

Figure 9. Seasonal distribution of *Pterostichus rostratus* adults collected from pitfall traps on Mount Mansfield in 1991 at Underhill State Park, 600 m.

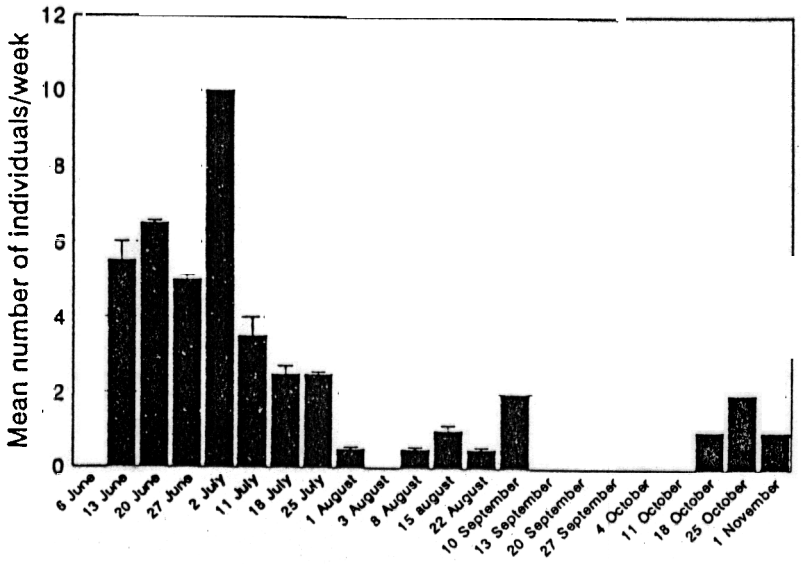
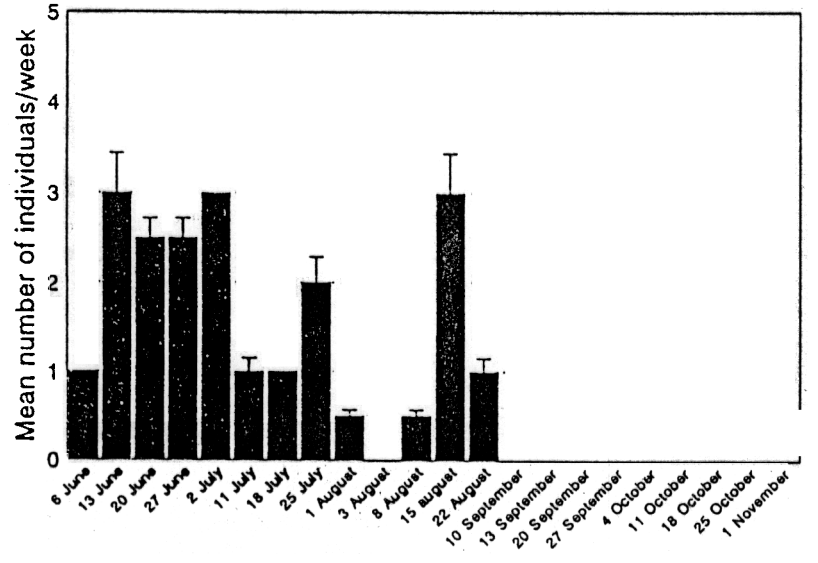


Figure 10. Seasonal distribution of *Pterostichus brevicornis* adults collected from pitfall traps on Mount Mansfield in 1991 at Underhill State Park, 600 m.



Discussion

Annual and seasonal Lepidoptera records cannot be compared on a statistical basis, and this will limit the significance of annual and seasonal patterns. The traps will, however, provide information on species representation not available from other techniques at present, and provide an alternative check to pheromones for pest species such as the forest tent caterpillar. The species composition is currently being developed into a biodiversity list that will relate species to their host-plant associations to provide an ecological measure of

lepidopteran biodiversity at Mount Mansfield. Biennial species may be particularly significant for forest ecosystem management. Where development is completely synchronized the impact of forest management at the adult or larval year could be completely different, and have a major impact on the local survival of that species.

Species with limited elevational ranges may have the most significance for assessment of long-term ecological and climatic trends on Mount Mansfield. The high elevation species may provide the most sensitive indicators of changes affecting the elevational limits of species. Because most insects have at least an annual turnover between generations, they may show a rapid response to changes in ecological or climatic variables (including management techniques). At present there is a considerable distance in elevation between MMS and USP sites so the precise distributional limits are not known. Further sampling at 1000 m could be very informative. This elevation is closer to the MMS site, but represents an transitional area of mixed spruce, fir, and paper birch.

The low elevation species *Pachypolia atricornis* may prove to qualify as an indicator species for forest management and health when its host-plant relationships are determined. The species appears to be strongly associated with sites with fertile soil and dominated by sugar maple (D. F. Schweitzer, personal communication). Attempts will be made in 1995 to rear larvae emerging from eggs.

Future Plans

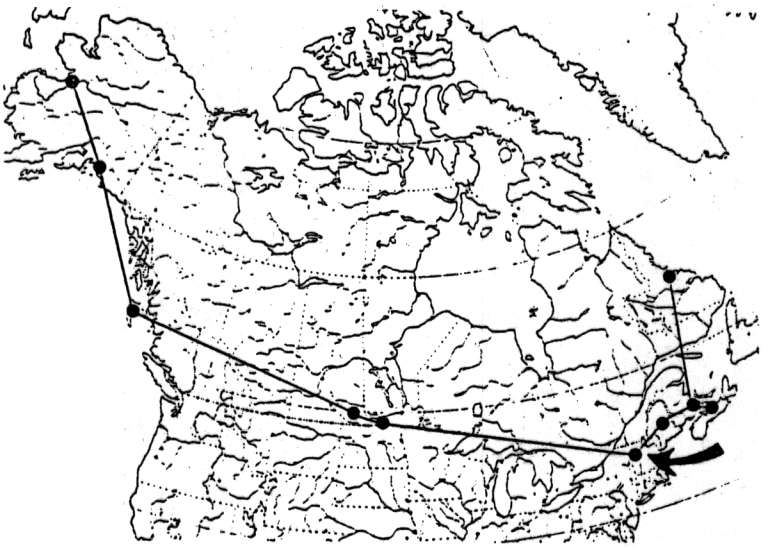
A regional context should be developed for the insect diversity at Mt Mansfield. This effort would be limited to species where regional geographic records are available. Rather than attempting to cover all species (some with very widespread distributions may be redundant) it could be targeted to those that qualify as local indicators. The geographic track of the high elevation species *Eulithis flavibrunneata* (Lepidoptera: Geometridae), for example, has a "boreal" range across Canada (Fig. 11). The Mount Mansfield locality represents a node that may be close to the southern range limit of the species along the Appalachian system.

We anticipate that a primary monitoring program of the current taxa from pitfall and light traps will continue with possible modification of the upper elevation sites to develop a more precise map of species distribution on the mountain. Replication for the Lepidoptera survey is desirable and this may be initiated for 1995. Other sources of biodiversity information are being considered, including the use of tree-trunk traps that may provide important information on the ecological and diversity relationships between invertebrates on the forest floor and the tree canopy.

Detailed statistical comparisons of biodiversity are too be developed by J. Boone for the carabids and selected Diptera and Hymenoptera. Once these methods are available, long-term assessment will be feasible for these groups. Analysis of seasonal patterns will also be carried out to provide a basis for correlation between insect activity and physical/climatological

parameters currently documented by VMC.

Figure 11. Geographic track of the "boreal" moth *Eulithis flavibrunneata*. Mount Mansfield (arrow) is represented by a high elevation population at 1160 m. (Distribution data from the Smithsonian Institution).



Acknowledgements

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