What one can learn from collecting 25,000 moths in one's backyard during two years

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Abstract: Based on 25,000 voucher specimens of moths that were collected over two years (2005, 2006), this study is directed at understanding the overall abundance and seasonal composition of a moth community in North Central Florida and determining the phenology of its members. The dominant moth species at different times of the year, as well as the overall community composition, differed significantly for these two years. Analyzing phenologies of species in several major moth families showed that these families as a whole have different reproductive strategies in terms of voltinism, overwintering stages, and the time of flight of the first brood. The overall contribution of each Lepidoptera family to the biomass in the ecosystem changed between years. All taxa, regardless of the taxonomic level, exhibit a typical gamma species abundance distribution. At the genus level, analyses of phenologies suggest the presence of niche partitioning by means of allochronic distribution, supporting similar studies on birds. Analyses of speciose genera show marked differences in local abundance across related taxa which may be the result of adaptation to different life history strategies to reduce competition. Despite a significant increase in the diversity of adult Lepidoptera in April-September, peaking in May, assessing monthly species composition suggests that the fauna remains relatively unique throughout the year. Even during the normally colder months of November-February, there are many species that are not found during the summer. Hence, even in subtropical ecosystems, where below freezing temperatures shut down normal plant growth and most insect activity, sampling should be conducted throughout the year, if one is to comprehensively assess faunal composition.

Moths provide an enormous volume of biomass that feeds vertebrates, such as birds, bats, and even grizzly bears (Robinson & Holmes, 1982; Freeman, 1979; White et al., 1998). The pressure from moth caterpillars is responsible for much of the chemical defense found in plants (e.g., Feeny, 1970). They are also an important group of pollinators (e.g., Atwater, 2013), and, of course, many species are notorious pests (e.g., Solomon, 1995).

Despite the importance of moths, our knowledge of their biology is vastly incomplete. Even though we have a relatively good knowledge of the overall species composition of the moth community in Florida (e.g., Heppner, 2003; Kons and Borth, 2006), much less is known about their biology. The Lepidoptera of Florida catalog, compiled by John Heppner (2003) in collaboration with Lee Adair, David Baggett, Terry Dickel, Linwood Dow, Tom Emmel and Dale Habeck, offered a comprehensive (but now somewhat outdated) checklist and summarized known hostplant information. Kons and Borth (2006) led the way in providing an impressive amount of information on seasonal diversity and phenology of moths from the central and northern parts of the state, basing their assessment on 47 collecting localities. This region is located in a contact zone of temperate and tropical vegetation, and hence exhibits a diverse flora: the state as a whole has more native tree species than any other US state – over 480 (Nelson, 2010), but it is the north-central part of the state where the great majority of them are found. For instance, there are over 20 species of oaks and over 10 species of pines found around Gainesville, and while these are representatives of temperate genera, they are intertwined with tropical plants, such as palms, passion vines, pipevines, coral beans, and bromeliads. For one of their localities (a mesic hardwood-pine forest habitat in south Gainesville at the former location of the American Entomological Institute), Kons and Borth used 49,000 collecting records between 2001 and 2004 to thoroughly assess seasonal variation in diversity.

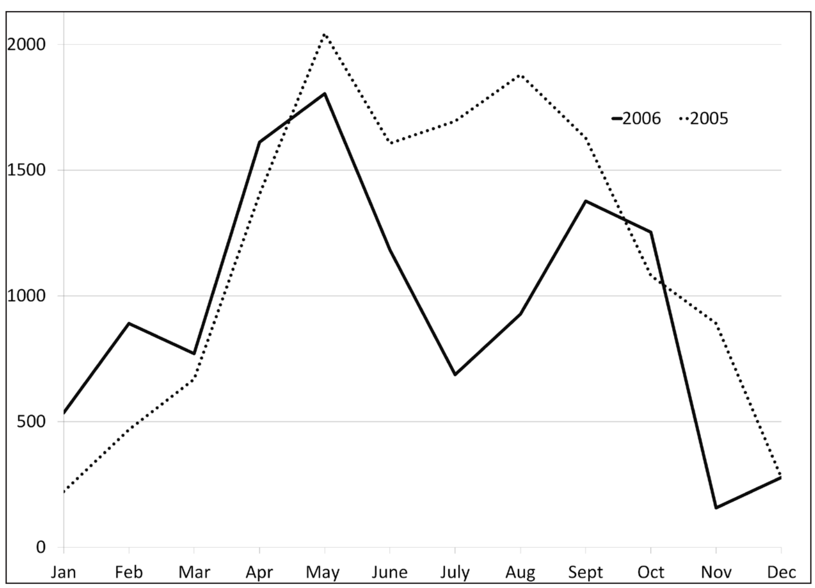


Fig. 1. Phenology of overall moth fauna estimated based on 2 years of indiscriminate collecting with a 12-volt black light near Paynes Prairie, north-central Florida.

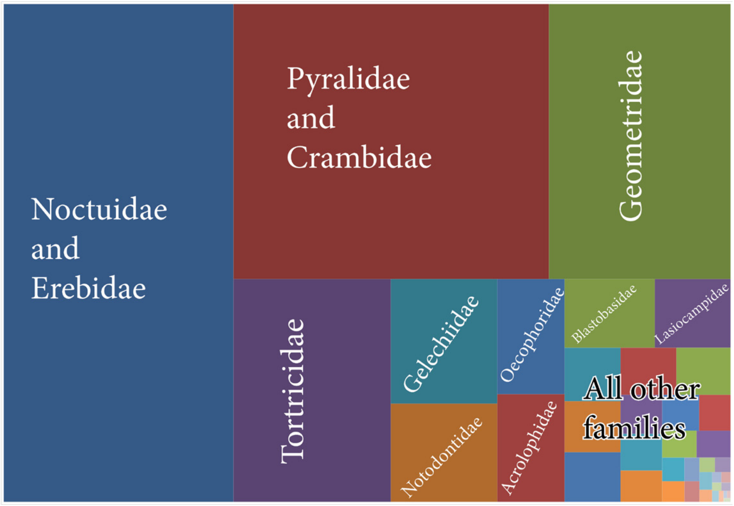


Fig. 2. Abundance of moths by family in 2006. The fauna was dominated by Pyraloidea, Noctuoidea, Geometridae and Tortricidae.

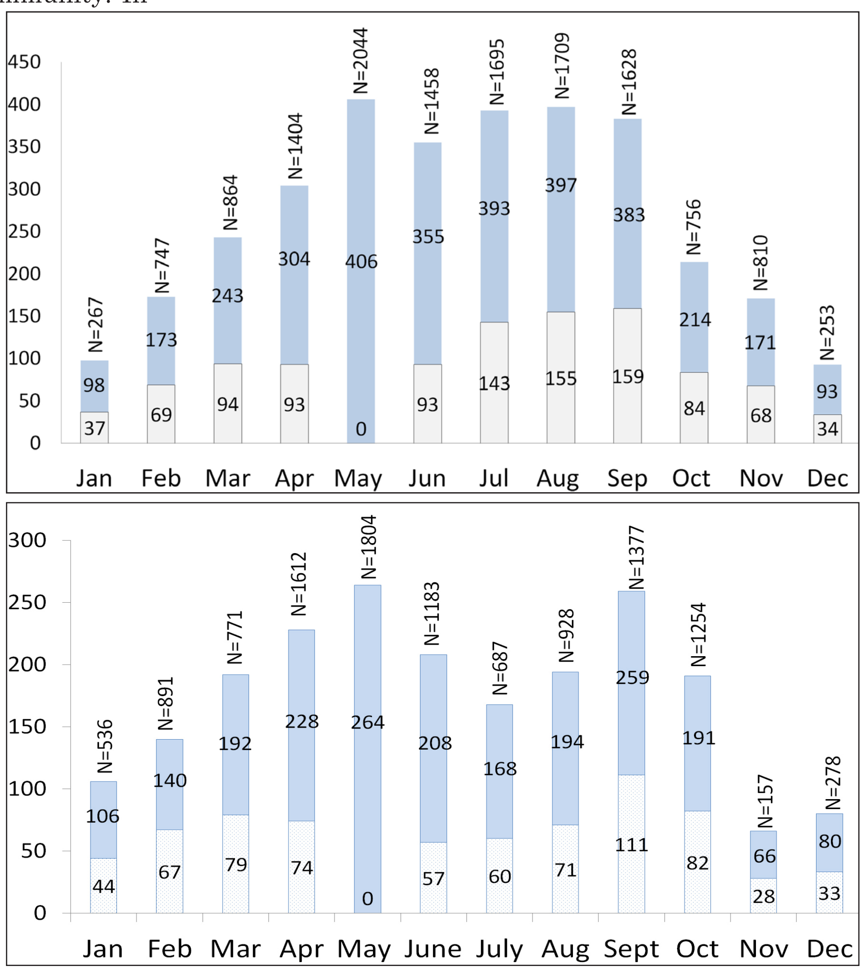
The present study is directed at analyzing phenology of moths found in a single habitat outside of Paynes Prairie, in Gainesville. The habitat is located only about 6 miles east of the main Kons and Borth (2006) survey site but is much closer to the wetlands. The richness of plant community translates into a similarly rich moth community. In this particular habitat, which is a secondary mixed forest surrounded by roadsides, pastures, and wetlands, close to 900 species of moths have been found (Austin, 2010). The second author started surveying his backyard for moths when he moved to Gainesville in 2004. Shortly after, upon suggestion from the first author, he began to collect regularly and indiscriminately and did so for two full years. During 2005-2006, every moth that came to a white sheet illuminated by a 12-volt black tube light was collected, spread, and identified by the second author and databased by the first author. The sampling occurred twice a week every month of the year, resulting in over 25,000 individual moths, which were deposited in the collection of the McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History.

In the present article, the first author attempted to analyze the rich collections made by the second author in his backyard, where he resided from 2004 until his untimely departure in 2009. The checklist of collected species was published shortly after the second author's death (Austin, 2010), while the preliminary results of the analyses were presented by Sourakov and Austin (2006) at the Lepidopterists' Society annual meeting and at the Forum Herbulot in 2010. While the temporal and geographical scope of this study are quite limited, the results offer another glimpse into community ecology and population dynamics of these ecologically important insects.

Results

Overall diversity and phenology

April through October are the months when the moths were the most abundant, and there were two peaks of abundance in May and August-September (Fig. 1), which likely represent two emergence peaks of two subsequent generations for many bivoltine species (e. g., *Automeris io*), combined with massive emergence of some univoltine species (e. g., *Malacosoma* sp.). The overall moth population decline in mid-summer may also be attributed to hotter temperatures of June-July, which coincide with more rain and fewer flowering nectar plants as compared with May and September. The sharp decline in moth numbers began in October and hit its lowest point in December, which coincided with the normal seasonal senescence of many plants due to lower temperatures and shorter days. Most of the moths found in this ecosystem throughout the year could be attributed to either pyraloids, noctuoids, geometrids or tortricids (Fig. 2).



Figs. 3 & 4. Number of moth species in any given month and their uniqueness as compared to the most speciose month (May). Year: 2005 (top) & 2006 (bottom).

Despite the drop in overall moth numbers in the middle of the summer, the species diversity remained high from May (when it was the greatest in both years of sampling) through September, declining sharply in October and hitting the bottom in December (Figs. 3-4). But despite high spring diversity, even in May, only about half of the total species found throughout the year was present. Moths, therefore, seem to exhibit high degree of individual seasonality. For instance, in the month of February, despite the fact that it is one of the colder months of the year, 40% and 47% of the total fauna present was not observed in the month of May in 2005 and 2006, respectively.

Viewed collectively by family, moths of different families tended to exhibit somewhat unique phenology patterns, which also differed by year (Figs. 5-6). For instance, in 2005, while geometrids peaked in February and May, the noctuoids and pyraloids peaked three times: in May, July, and September, perhaps reflecting three generations for most of the noctuid species. However, in 2006, while geometrids followed a similar pattern, the other two groups had two distinct peaks around May and September. Such changes in pattern could result from any number of abiotic conditions or from explosions in generalist moth predators, disease or parasites.

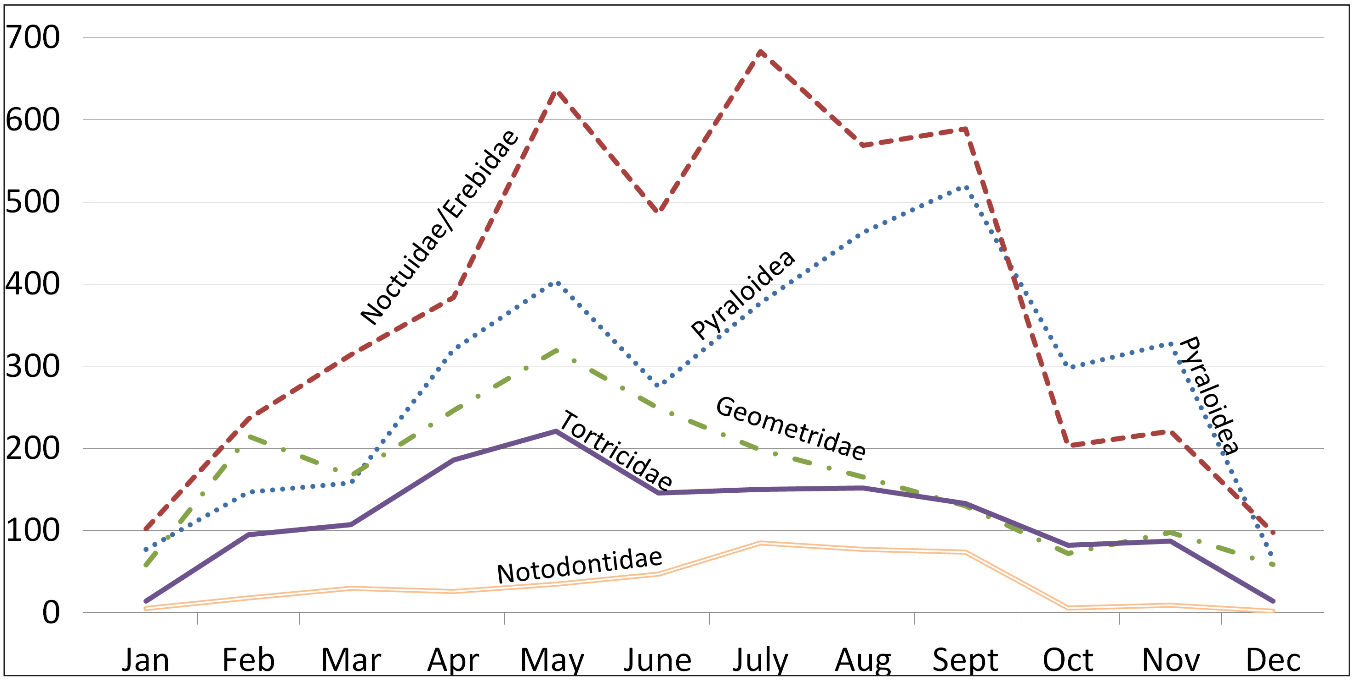


Fig. 5. Phenology of moths by family. Year 2005.

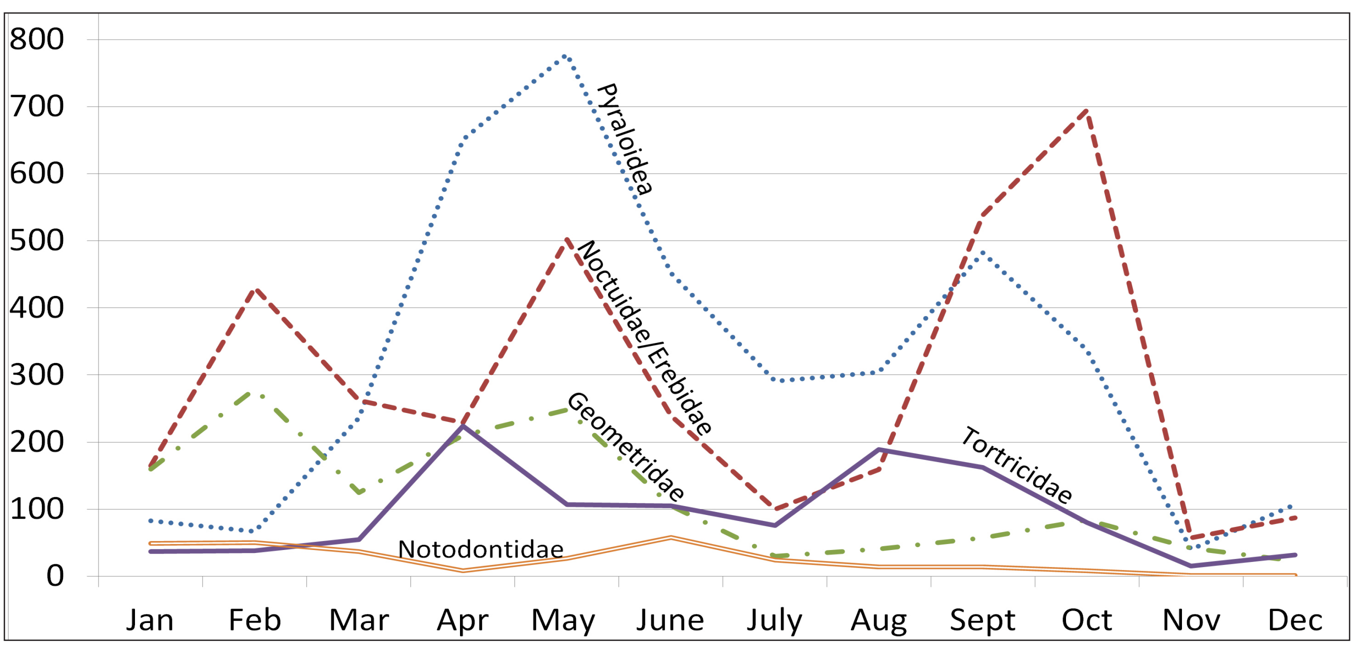


Fig. 6. Phenology of moths by family. Year 2006.

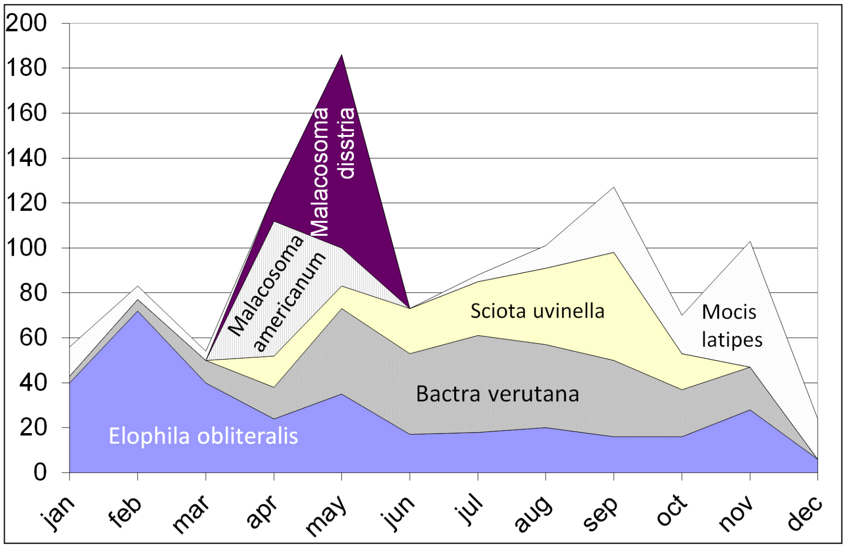


Fig. 7. Phenology of most dominant moth species in 2005: *Elophila obliteralis*, *Malacosoma americanum*, *Malacosoma disstria*, *Bactra verutana*, *Sciota uvinella*, *Mocis latipes*.

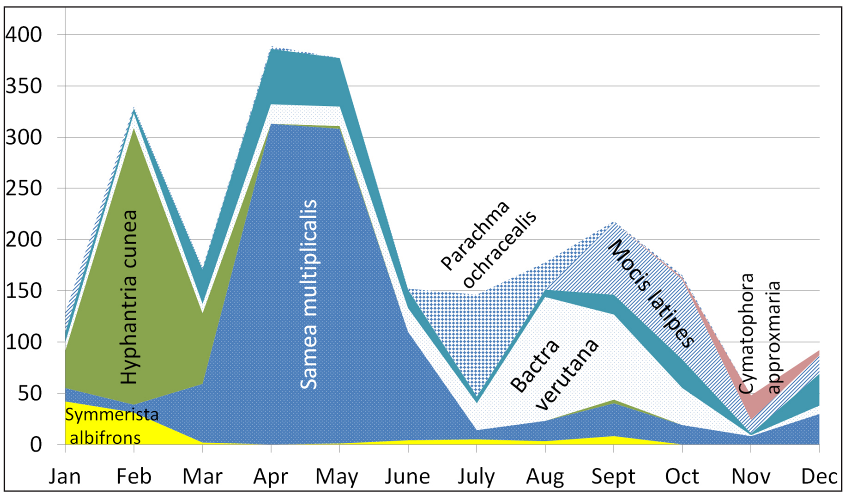


Fig. 8. Phenology of most dominant moth species in 2006: *Symmerista albifrons*, *Hyphantria cunea*, *Samea multiplicalis*, *Parachma ochracealis*, *Bactra verutana*, *Mocis latipes*, *Cymatophora approximaria*.

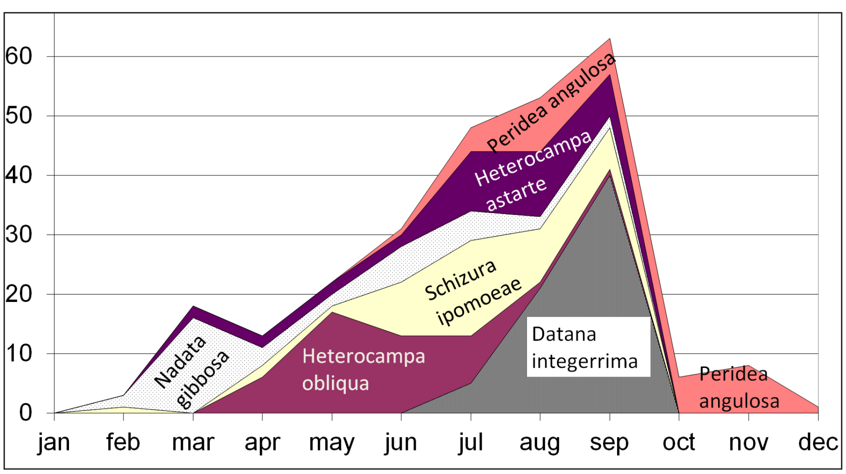


Fig. 9. Phenology of 6 most common Notodontidae species in 2005: *Nadata gibbosa*, *Heterocampa obliqua*, *Heterocampa astarte*, *Peridea angulosa*, *Datana integerrima*, *Schizura ipomoeae*.

Dominant and most common species

Only three species of moths that were most numerous throughout 2005 also proved to be dominant in any given month. In 2005 (Fig. 7), a crambid, the waterlily leafcutter moth, *Elophila obliteralis*, dominated the moth fauna in January-March; a pyralid, the sweetgum leafroller moth, *Sciota uvinella*, was a dominant species in October; a tortricid, the javelin moth, *Bactra verutana*, dominates the fauna from July until September, and also in November. Not among the most numerous moths, the two tent caterpillar moths, *Malacosoma americanum* and *M. disstria,* had a very compact emergence time and a short flight period, so they dominated moth fauna in April and May, respectively. The striped grass looper moth, *Mocis latipes* (Noctuidae) mostly flew in the fall and was the most numerous moth in November - December.

In 2006 (Fig. 8), the fauna in January was dominated by the white-headed prominent moth, *Symmerista albifrons* (Notodontidae); February was dominated by the fall webworm, *Hyphantria cunea* (Erebidae), followed in April-June by the salvinia stem-borer moth, *Samea multiplicalis* (Crambidae), and then by a sudden explosion of the parachma moth, *Parachma ochracealis* (Pyralidae) in July. While *B. verutana* was dominant again in August and September and the striped grass looper was present in high numbers again in September-October, the most numerous moth in November of 2006 was a geometrid, the giant gray moth, *Cymatophora approximaria*. Hence only three out seven dominant species in 2006 were also dominating the fauna in any given month in 2005.

As far as which moth species were the most numerous overall during the year, in addition to the above-mentioned *B. verutana*, *S. uvinella*, and *E. obliteralis*, in 2005, the most common were the waterlily borer moth, *Elophila gyralis*, the banded tiger moth, *Apantesis vittata*, and the geometrid, *Iridopsis defectaria*. Three of these species (*B. verutana*, *S. uvinella*, and *E. obliteralis*) remained among the six most numerous moths in 2006, joined by *M. latipes*, *H. cunea*, and *S. multiplicalis*.

Relative abundance of closely related moths

Analyzing phenologies of most common species within individual families (e.g., Figs. 9-10)

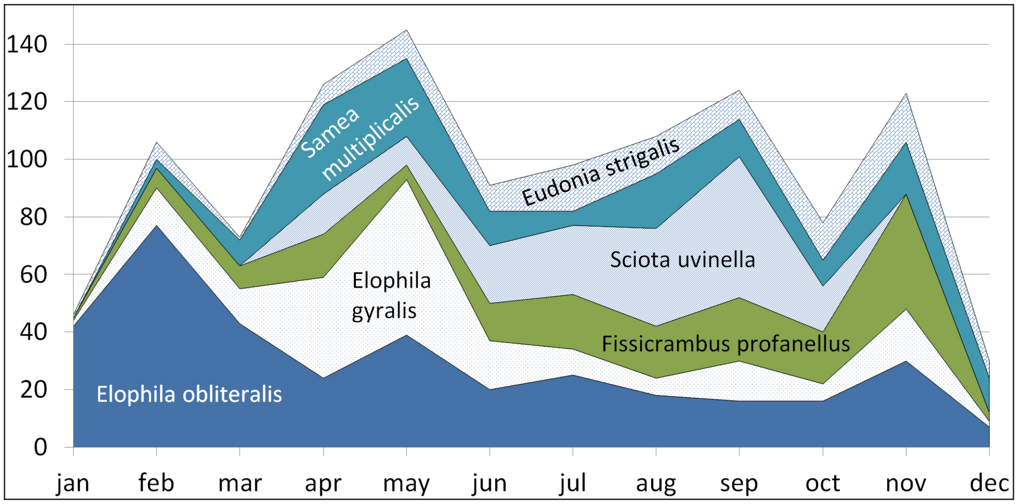


Fig. 10. Phenology of 6 most common Pyraloidea species in 2005: *Elophila obliteralis*, *Eudonia strigallis*, *Samea multiplicalis*, *Sciota uvinella*, *Elophila gyralis*, *Fissicrambus profanellus*.

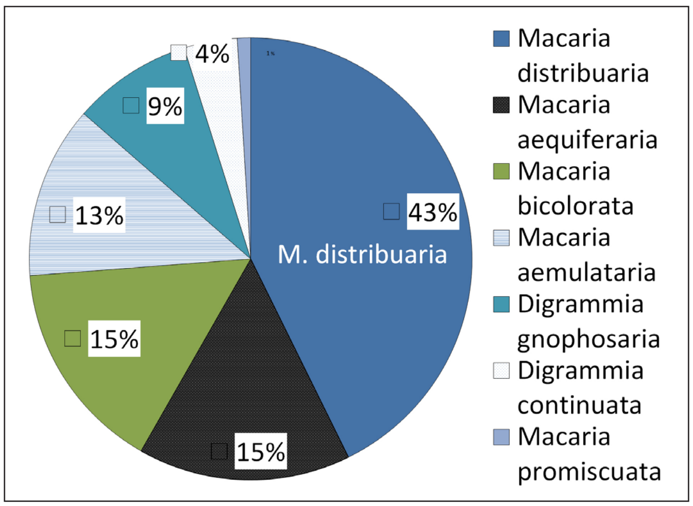


Fig. 11. Relative abundance of species within macariine geometrids in 2005.

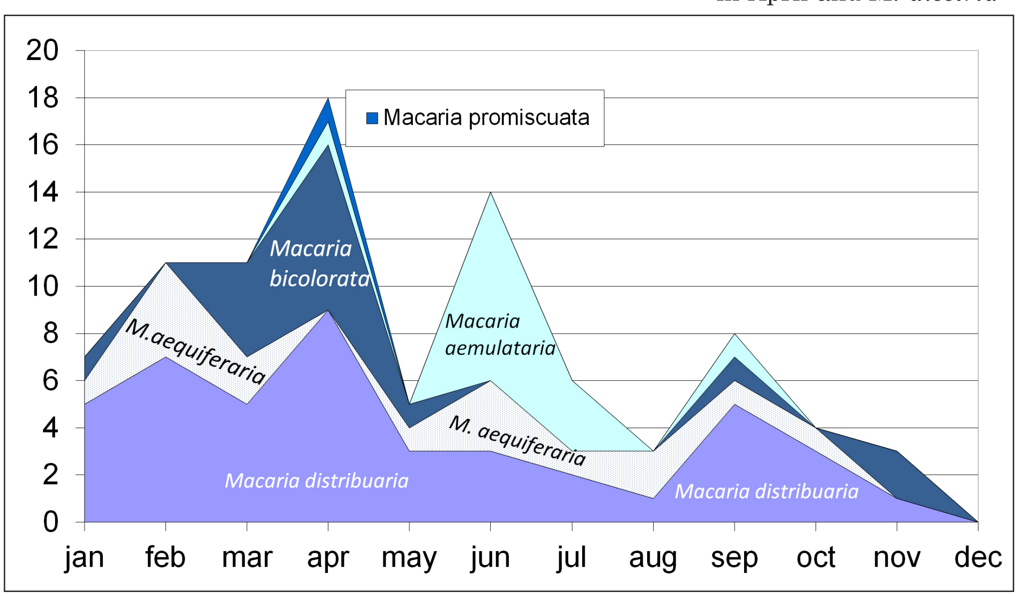


Fig. 12. Phenology of species within the genus *Macaria* (Geometridae) in 2005.

can provide some insight into the role of different species by family in the overall biomass of moths in the ecosystem. For instance, notodontids mostly peak in July-September (Fig. 9), pyraloids peaked throughout the season (Fig. 10), and tortricids and geometrids tend to peak in the spring.

Relative abundance showed similar pattern in all the families and speciose genera: following one or two unequivocal leaders, numbers of common species rapidly declined with the majority represented by few individuals (e.g., Figs. 11, 13, 15, 17). Members of the same genus normally were scattered more or less evenly through the abundance spectrum within their respective families (e. g., Fig. 15). Within speciose moth genera such as *Macaria* (Geometridae), *Catocala* (Erebidae), *Acronicta* (Noctuidae), *Choristoneura*, *Cydia*, *Epiblema* and *Platynota* (Tortricidae), or *Acrolophus* (Acrolophidae) the tendency was for one or two more common species to be responsible for more than 50% of all the captured individuals in that genus (e.g., Figs. 11, 13). Similar tendency was observed in smaller families, such as Sphingidae (Fig. 17).

Niche partitioning

If more than one species within a single genus was very common, they tended to peak at different times, perhaps as a result of evolving life history strategies that reduce competition. For instance, *Malacosoma americanum* flew in April and *M. disstria* – in May (Fig. 7). Together they accounted for 85% of all Lasiocampidae of which seven species were present, and both species flew in such high numbers that they dominated the entire moth fauna during these times. Congeneric extremely common aquatic crambids, *Elophila obliteralis* and *E. gyralis* were peaking at different times, with the former reaching the highest numbers in February and the latter in May (Fig. 10). Peaking of the third aquatic crambid, the salvinia stem-borer moth, *Samea multiplicalis*, began in April.

Among *Macaria* (Geometridae), *M. aequiferaria* peaked in

February and June, *M. bicolorata* in April, and *M. aemulataria* in June (Fig. 12). The most common, *M. distribuaria*, which accounted for 43% of *Macaria* specimens in 2005, peaked three times: in February, April and again in September.

At first glance, the noctuid genus *Acronicta* seems like an exception, as most of its 13 species peaked in July (Fig. 14). However, the two most common species in that genus, *A. oblinita* and *A. afflicta* (which together accounted for 43% of all *Acronicta* in 2005), peaked at different times from most of the species: *A. oblinita* in April, June and October, and *A. afflicta* – in March and June.

Among noctuids and erebids, both *Mocis disseverans* and *M. latipes* were extremely common in 2005, the former was more common in August, while the latter peaked in September-November (Fig. 16). The armyworms also peaked at different times: *Spodoptera eridania* was common from March through July, while *S. dolichos* increased in numbers in August-September (Fig. 16).

This study highlights the complexities of understanding insect population dynamics and making predictions about future insect abundance. While extremely time consuming, a similar study conducted over a longer period of time may reveal interesting trends on how a moth fauna responds to environmental changes, but these trends may not become apparent for a number of years. It will be of great interest to investigate further the ecological mechanisms underlying the supposed niche partitioning by congeneric species.

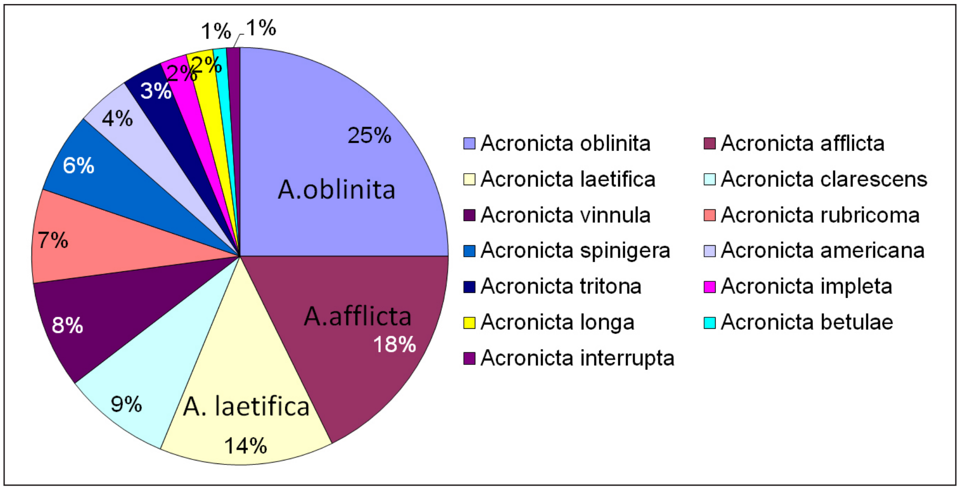


Fig. 13. Relative abundance of species within genus *Acronicta* (Noctuidae) in 2005.

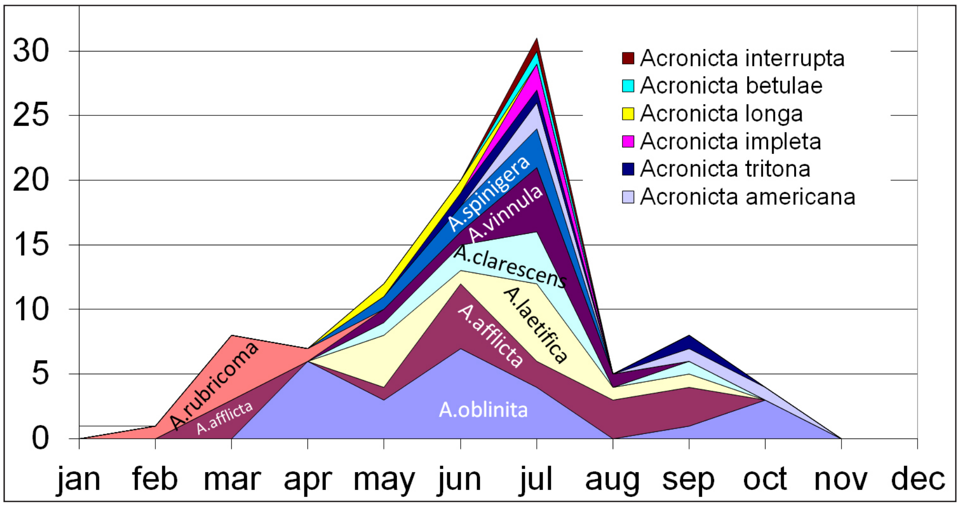


Fig. 14. Phenology of species within genus *Acronicta* (Noctuidae) in 2005

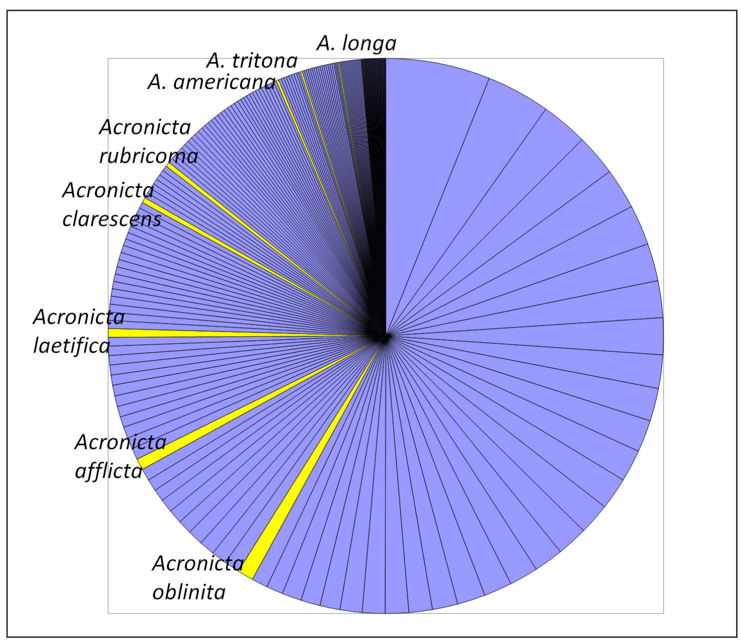


Fig. 15. Distribution of relative abundance of species of the genus *Acronicta* among 201 other noctuid/erebid species in 2005.

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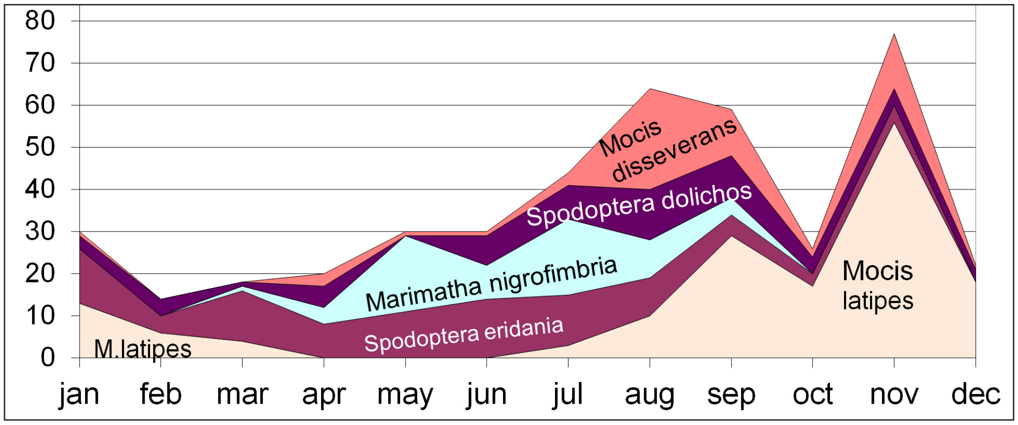

Fig. 16. Phenology of five most common noctuid/erebid species in 2005.

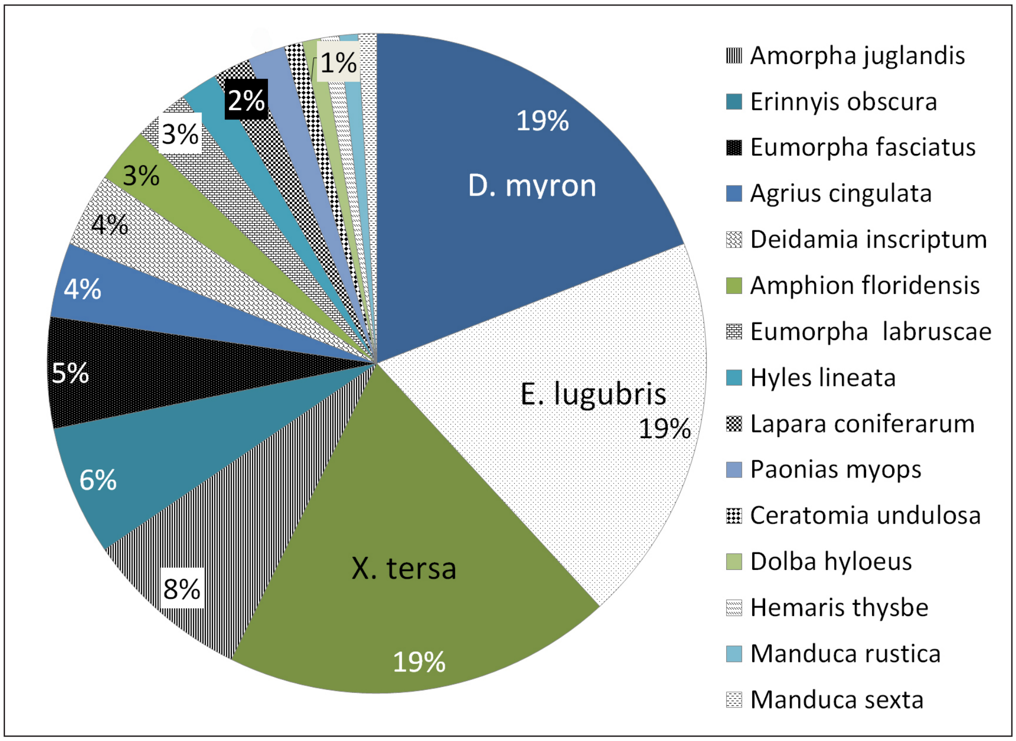

Fig. 17. Relative abundance of species within Sphingidae in 2005.

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