Importance of Monitoring Terrestrial Arthropod Biodiversity in Illinois Ecosystems, with Special Reference to Auchenorrhyncha

Adam Wallner and Chris Dietrich

Introduction

Because arthropods are the most diverse group of terrestrial organisms both in numbers of species, and in behavior and ecological traits, arthropod assemblages provide an invaluable source of data for use in monitoring and conserving biological diversity (Brown 1991, Kremen *et al.* 1993). Despite increased awareness of the importance of terrestrial arthropods (Samways 1994, Samson and Knopf 1994, Arenz and Joern 1996), most monitoring programs continue to rely on other, less diverse groups of organisms, or incorporate an extremely limited subset of the overall arthropod fauna. However, reliance on data from a few well-known taxa such as birds or butterflies assumes that variation in the diversity of these groups is strongly correlated with the diversity of unsampled groups; thus far, there is little evidence to support this assumption (Prendergast *et al*. 1993). Indeed, different groups of organisms respond quite differently to different kinds of environmental perturbations, either natural or anthropogenic. For example, disturbances such as fire may have drastically different effects on plants and insects (Daubenmire 1968, Cancelado and Yonke 1970).

Since arthropods are extremely sensitive to environmental change they are an excellent model for monitoring changes in the natural landscape, which will provide useful data on species abundance and distribution patterns, provide a list of endemic, rare, and economically important species, and observe effects of disturbance on natural communities. However, the potential number of species sampled is enormous (more than 17,000 species of arthropods are known to occur in Illinois). With nearly four times the number of vascular plants and vertebrate animal species combined (Post 1991), it is important to choose a taxon that is well studied, readily identifiable, and is affected by landscape disturbance, such as Auchenorrhynchous Homoptera or AH (i.e., leafhoppers, planthoppers, spittle bugs, and treehoppers). This particular group of sap-sucking herbivores is ideal for monitoring because they are highly diverse and abundant in most terrestrial habitats, are habitat and host specific, are highly sensitive to environmental change, and have been extensively studied in Illinois. Dwight M. DeLong, from the Illinois Natural History Survey, conducted an extensive survey of Illinois leafhopper taxonomy and distribution in the 1940s (DeLong 1948). Wilson and McPherson (1981), from Southern Illinois University at Carbondale, also conducted an extensive survey of Illinois planthoppers taxonomy and distribution in the early 1980s. These surveys and the life history characteristics of the AH species made them the principal insect group for Critical Trends Assessment Program (CTAP) to monitor, in addition to all the other terrestrial insect orders collected in grassland, wetland, and forest habitats across Illinois.

In this report we present the first five years of terrestrial insect data collected from 1997-2001 that will serve as the baseline for future monitoring of terrestrial arthropods across Illinois grassland, wetland, and forest habitats for CTAP. Our main objectives are to: 1) compare terrestrial arthropod species richness across habitats; 2) examine relationships in species richness among arthropod taxonomic groups, 3) evaluate if Auchenorrhynchous species are a predictor of other arthropod taxa as well as overall arthropod diversity. In addition in this report we will provide a list of some new state and county records of auchenorrhychous Homoptera species.

Methods

Sampling: From 1997 to 2001, a total of 388 terrestrial arthropod samples were collected: 128 from forests, 127 from grasslands, and 133 from wetlands. Quantitative sampling for terrestrial arthropods consisted of two 50 m linear transects at each site, using a standard sweep net (100 sweeps). Terrestrial arthropods were then transferred into PTOIEs (Photo Tactic Optimal Insect Extractors) for 30 minutes. Samples were later placed in plastic bags and stored in a freezer for later sorting. After processing, all samples were stored in vials of 70% ethanol.

Specimen Identification: All terrestrial arthropods were sorted and identified to order using the "morphospecies" approach. In this approach, specimens are sorted into groups (morphospecies) based on distinctive morphological characteristics, but these putative characteristics remained unnamed. Relatively little time is required to count the number of morphospecies in a typical sample. These morphospecies counts provide a convenient means for estimating and comparing species richness and diversity among sites. A disadvantage of the morphospecies approach is that without positive identification of species, it is difficult to compare sites based on their species composition. Although such comparisons could be accomplished by standardizing the definitions of each morphospecies across all sites, this approach is tedious and requires considerable expertise.

Finally, all Auchenorrhynchous were identified to species when possible following DeLong (1948), Wilson and McPherson (1981), Dietrich (1994), and Hamilton (2000). In addition, AH species were classified into two groups following Dietrich and Biyal (1997 and 1998, unpublished CTAP reports): Group 1 -common, widespread, and generalist in host and habitat preference; Group 2 -rare, restricted in distribution, and/or host- or habitat-specific (Table 1).

Data Analysis. Species richness was estimated for each site based on sample counts of species or morphospecies. A Kruskal-Wallis One Way Analysis of Variance on Ranks (KW) followed by a Dunn's test was used to determine differences between habitats for species richness among the terrestrial arthropod taxa. Linear regressions were used to determine the extent to which AH species richness predicted overall species richness and that of other arthropod groups. Because the terrestrial arthropod data was not normally distributed, data transformations (square root plus 0.375) were implemented for the regression analyses.

Results

Species richness across habitats: Different patterns of species richness were observed for each taxon group (Figure 1, all KW: H values > 7.03, all P values < 0.030). Auchenorrhynchous

Table 1: List of auchenorrhynchous Homoptera (AH) species collected randomly from forests, grasslands, and wetlands across Illinois. The 'H Group' indicates the level of conservatism (1 = generalist species, vagile, exotic; and 2 = host-plant and or habitat specific, native, poor flyer (see report for additional information), and 'Origin' indicates the location of AH species, according to literature and museum specimens.

Species Name	H Group	Origin
Acanalonia bivittata	1	Native, Nearctic
Acanalonia conica	1	Native, Nearctic
Acanalonia sp.	1	Native, Nearctic
Aceratagalia vulgaris	2	Native, Nearctic
Aceratagallia sp.	2	Native, Nearctic
Aceratagallia uhleri	2	Native, Nearctic
Acertagallia sanguinolenta	2	Native, Nearctic
Acutalis tartarea	1	Native, Nearctic
Agallia constricta	1	Native, Nearctic
Agallia sp.	1	Native, Nearctic
Agallopsis novella	1	Native, Nearctic
Agallopsis sp.	2	Native, Nearctic
Alebra albostriella	2	Native, Nearctic
Amblysellus curtisii	1	Native, Nearctic
Amplicephalus osborni	1	Exotic, Palaearctic (Europe)
Anormenis septentrionalis	1	Native, Nearctic
Anoscopus flavistriatus	1	Exotic, Palaearctic (Europe)
Anoscopus serratulae	1	Exotic, Palaearctic (Europe)
Apache degeerii	2	Native, Neartic
Aphrodes bicincta	1	Exotic, Palaearctic (Europe, Asia)
Aphrophora quadrinotata	1	Native, Nearctic
Aphrophora sp.	1	Native, Nearctic
Athysanus argentanus	1	Exotic, Palaearctic (Europe)
Atymna helena	2	Native, Nearctic
Atymna sp.	2	Native, Nearctic
Atymna sp.1	2	Native, Nearctic
Bakerella rotundifrons	2	Native, Nearctic
Balcultha abdominalis	1	Native, Nearctic
Balcultha impicta	1	Native, Nearctic
Balcultha impunctata	2	Exotic, Palaearctic (Europe)
Balcultha neglecta	1	Native, Nearctic
Balcultha sp.	1	Native, Nearctic
Bruchomorpha dorsata	2	Native, Nearctic
Bruchomorpha oculata	2	Native, Nearctic
Bruchomorpha pallidipes	2	Native, Nearctic
Bruchomorpha sp.	2	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Campylenchia latipes	2	Native, Nearctic
Catonia cinctifrons	2	Native, Nearctic
Cedusa sp.	2	Native, Nearctic
Cedusa sp.1	2	Native, Nearctic
Cedusa sp.2	2	Native, Nearctic
Cedusa sp.3	2	Native, Nearctic
Chloriona slossoni	2	Native, Nearctic
Chlorotettix spatulatus	2	Native, Nearctic
Chlorottetix balli	2	Native, Nearctic
Chlorottetix dentatus	2	Native, Nearctic
Chlorottetix fallax	1	Exotic, Palaearctic (Europe)
Chlorottetix galabanatus	1	Native, Nearctic
Chlorottetix limosus	2	Native, Nearctic
Chlorottetix lusorius	2	Native, Nearctic
Chlorottetix sp.	1	Native, Nearctic
Chlorottetix sp.1	2	Native, Nearctic
Chlorottetix sp.2	2	Native, Nearctic
Chlorottetix suturalis	2	Native, Nearctic
Chlorottetix tergatus	2	Native, Nearctic
Chlorottetix unicolor	2	Native, Nearctic
Chlorottetix viridius	2	Native, Nearctic
Cicadula melanogaster	2	Native, Nearctic
Cicadula sp.	2	Native, Nearctic
Cixius basalis	2	Native, Nearctic
Cixius sp.	2	Native, Nearctic
Cixius sp.1	2	Native, Nearctic
Cixius sp.2	2	Native, Nearctic
Cixius sp.3	2	Native, Nearctic
Clastoptera achatina	2	Native, Nearctic
Clastoptera obtusa	2	Native, Nearctic
Clastoptera proteus	2	Native, Nearctic
Clastoptera xanthocephala	2	Native, Nearctic
Colladonus clitellarius	2	Native, Nearctic
Crytolobus inermis	2	Native, Nearctic
Crytolobus maculifrontis	2	Native, Nearctic
Crytolobus sp.	2	Native, Nearctic
Crytolobus sp.1	2	Native, Nearctic
Daltonia estacada	2	Native, Nearctic
Delphacodes analis	2	Native, Nearctic
Delphacodes basivitta	2	Native, Nearctic
Delphacodes campestris	2	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Delphacodes hyalina	2	Native, Nearctic
Delphacodes lutulenta	2	Native, Nearctic
Delphacodes magna	2	Native, Nearctic
Delphacodes mcateei	2	Native, Nearctic
Delphacodes pacifica	2	Native, Nearctic
Delphacodes pellucida	2	Native, Nearctic
Delphacodes pitens	2	Native, Nearctic
Delphacodes propinqua	2	Native, Nearctic
Delphacodes puella	2	Native, Nearctic
Delphacodes sp.	1	Native, Nearctic
Delphacodes sp.1	2	Native, Nearctic
Delphacodes sp.2	2	Native, Nearctic
Delphacodes sp.3	2	Native, Nearctic
Delphacodes sp.4	2	Native, Nearctic
Delphacodes sp.5	2	Native, Nearctic
Delphacodes sp.6	2	Native, Nearctic
Delphacodes sp.7	2	Native, Nearctic
Delphacodes sp.8	2	Native, Nearctic
Deltacephalus balli	2	Native, Nearctic
Dikraneura angustata	1	Native, Nearctic
Dikraneura mali	1	Native, Nearctic
Dikraneura sp.	1	Native, Nearctic
Dikraneura sp.1	2	Native, Nearctic
Dikraneura sp.10	2	Native, Nearctic
Dikraneura sp.2	2	Native, Nearctic
Dikraneura sp.3	2	Native, Nearctic
Dikraneura sp.4	2	Native, Nearctic
Dikraneura sp.5	2	Native, Nearctic
Dikraneura sp.6	2	Native, Nearctic
Dikraneura sp.7	2	Native, Nearctic
Dikraneura sp.8	2	Native, Nearctic
Dikraneura sp.9	2	Native, Nearctic
Dikrella cruentata	2	Native, Nearctic
Dikrella sp.	1	Native, Nearctic
Dikrella sp.1	2	Native, Nearctic
Dikrella sp.2	2	Native, Nearctic
Dikrella sp.3	2	Native, Nearctic
Dikrella sp.4	2	Native, Nearctic
Doratura stylata	1	Exotic,.Palaearctic (Europe)
Draeculacephala angulifera	2	Native, Nearctic
Draeculacephala antica	1	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Draeculacephala constricta	1	Native, Nearctic
Draeculacephala inscripta	2	Native, Nearctic
Draeculacephala mollipes	2	Native, Nearctic
Draeculacephala noveboracensis	2	Native, Nearctic
Draeculacephala palodusa	2	Native, Nearctic
Draeculacephala robinsini	1	Native, Nearctic
Draeculacephala sp.	1	Native, Nearctic
Driotura gammaroides	2	Native, Nearctic
Driotura robusta	2	Native, Nearctic
Elymana acuma	2	Native, Nearctic
Elymana caduca	2	Native, Nearctic
Elymana inornata	2	Native, Nearctic
Empoasca fabae	1	Native, Nearctic
Empoasca recurvata	1	Native, Nearctic
Empoasca sp.	1	Native, Nearctic
Empoasca sp.1	1	Native, Nearctic
Empoasca sp.2	2	Native, Nearctic
Empoasca sp.3	1	Native, Nearctic
Empoasca sp.4	2	Native, Nearctic
Empoasca sp.5	2	Native, Nearctic
Empoasca sp.6	2	Native, Nearctic
Enchenopa binotata	2	Native, Nearctic
Endria inimica	1	Native, Nearctic
Entylia bactriana	1	Native, Nearctic
Entylia carinata	2	Native, Nearctic
Erythroneura sp.	1	Native, Nearctic
Erythroneura sp.1	2	Native, Nearctic
Erythroneura sp.10	2	Native, Nearctic
Erythroneura sp.2	2	Native, Nearctic
Erythroneura sp.4	2	Native, Nearctic
Erythroneura sp.5	2	Native, Nearctic
Erythroneura sp.6	2	Native, Nearctic
Erythroneura sp.7	2	Native, Nearctic
Erythroneura sp.8	2	Native, Nearctic
Erythroneura sp.9	2	Native, Nearctic
Erythroneura vitis	2	Native, Nearctic
Erythronuera sp.3	2	Native, Nearctic
Euides sp.	2	Native, Nearctic
Euides weedi	2	Native, Nearctic
Eupteryx flavoscuta	2	Native, Nearctic
Evacanthus nigramericanus	2	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Exitanius exitiosus	1	Exotic, Palaearctic (Europe)
Extrusanus extrusus	2	Native, Nearctic
Flexamia atlantica	2	Native, Nearctic
Flexamia reflexa	2	Native, Nearctic
Flexamia sp.	2	Native, Nearctic
Flexamia sp.1	2	Native, Nearctic
Forcipata loca	1	Native, Nearctic
Graminella aureovittata	2	Native, Nearctic
Graminella fitchi	1	Native, Nearctic
Graminella nigrifrons	1	Native, Nearctic
Graminella sp.	1	Native, Nearctic
Graphacephala versuta	1	Native, Nearctic
Graphocephala coccinea	1	Native, Nearctic
Graphocephala hieroglyphica	2	Native, Nearctic
Graphocephala sp.	1	Native, Nearctic
Gypona contona	2	Native, Nearctic
Gyponana brevita	2	Native, Nearctic
Gyponana conferta	2	Native, Nearctic
Gyponana expanda	2	Native, Nearctic
Gyponana melanota	2	Native, Nearctic
Gyponana ortha	2	Native, Nearctic
Gyponana panda	2	Native, Nearctic
Gyponana sp.	2	Native, Nearctic
Gyponana sp.1	2	Native, Nearctic
Hecalus kansiensis	2	Exotic, Nearctic (Western United States)
Hecalus major	2	Native, Nearctic
Hecalus sp.	2	Native, Nearctic
Helochara communis	2	Native, Nearctic
Homalodisca sp.	1	Exotic, Nearctic (West of Rocky Mountains)
Homalodisca triquetra	1	Exotic, Nearctic (West of Rocky Mountains)
Idiocerus distinctus	2	Exotic, Nearctic
Idiocerus nervatus	2	Native, Nearctic
Idiocerus raphus	2	Native, Nearctic
Idiocerus snowi	2	Native, Nearctic
Idiocerus sp.	2	Native, Nearctic
Idiocerus sp.1	2	Native, Nearctic
Idiocerus suturalis	2	Native, Nearctic
Idiocerus taxodium	2	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Idiodonus kennicotti	2	Native, Nearctic
Japananus hyalinus	1	Exotic, Oriental (Japan)
Jikradia olitoria	1	Native, Nearctic
Kansendria kansana	1	Exotic, Nearctic (Kansas, Oklahoma, Texas)
Keonalla dolabrata	2	Native, Nearctic
Laevicephalus slyvestris	2	Native, Nearctic
Latalus missellus	2	Native, Nearctic
Latalus personatus	2	Native, Nearctic
Latalus sayi	1	Native, Nearctic
Latalus sp.	1	Native, Nearctic
Lebradea flavovirens	1	Exotic, Palaearctic (Scandinavia)
Lepyronia gibbosa	2	Native, Nearctic
Lepyronia quadrangularis	1	Exotic, Nearctic (Canada)
Lepyronia sp.	1	Native, Nearctic
Liburniella ornata	1	Native, Nearctic
Limotettix cuneatus	2	Native, Nearctic
Limotettix striolis	2	Native, Nearctic
Macropsis fumipennis	2	Native, Nearctic
Macropsis insignis	2	Native, Nearctic
Macropsis sp.	2	Native, Nearctic
Macropsis sp.1	2	Native, Nearctic
Macropsis sp.2	2	Native, Nearctic
Macrosteles 4-lineatus	1	Native, Nearctic
Macrosteles lepida	2	Native, Nearctic
Macrosteles sp.	1	Native, Nearctic
Macrosteles variata	2	Native, Nearctic
Magicicada sp.	1	Native, Nearctic
Magicicada tredecassini	2	Native, Nearctic
Magicicada tredecim	2	Native, Nearctic
Mensoma cincta	2	Native, Nearctic
Metcalfa pruinosa	1	Native, Nearctic
Microcentrus perditus	1	Exotic, Nearctic (Missouri)
Micrutalis calva	1	Native, Nearctic
Myndus sp.	2	Native, Nearctic
Myndus sp.1	2	Native, Nearctic
Neocoelidia tumidifrons	2	Native, Nearctic
Neohecalus magnificus	2	Native, Nearctic
Neokolla gothica	2	Native, Nearctic
Norvellina seminuda	2	Native, Nearctic
Norvillina sp.	2	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Oncometopia orbona	1	Native, Nearctic
Oncometopia sp.	1	Native, Nearctic
Oncopsis sp.	2	Native, Nearctic
Ormiendus venusta	1	Native, Nearctic
Osbornellus auronitens	1	Native, Nearctic
Osbornellus consors	2	Native, Nearctic
Osbornellus sp.	1	Native, Nearctic
Otiocerus sp.	2	Native, Nearctic
Otiocerus sp.1	2	Native, Nearctic
Palus sp.	2	Native, Nearctic
Paraphlepsius incisus	2	Native, Nearctic
Paraphlepsius irroratus	1	Native, Nearctic
Paraphlepsius luxurious	2	Native, Nearctic
Paraphlepsius rossi	2	Native, Nearctic (East Coast and Illinois)
Paraphlepsius sp.	1	Native, Nearctic
Paraulazices irrorata	1	Native, Nearctic
Pentagramma variegata	2	Native, Nearctic
Penthimia americana	2	Native, Nearctic
Philaenarcys bileneata	2	Native, Nearctic
Philaenus sp.	1	Exotic, Nearctic (Canada)
Philaenus spumarius	1	Exotic, Nearctic (Canada)
Philaronia abjecta	1	Exotic, Nearctic (Canada)
Phylloscelis atra	2	Native, Nearctic
Phylloscelis pallescens	2	Native, Nearctic
Pintalia dorsovitlata	2	Native, Nearctic
Pissinotus brunneus	2	Native, Nearctic
Pissonotus delicatus	2	Native, Nearctic
Pissonotus dorsalus	2	Native, Nearctic
Pissonotus flabellatus	2	Native, Nearctic
Pissonotus nigra	2	Native, Nearctic
Pissonotus sp.	2	Native, Nearctic
Pissonotus sp.1	2	Native, Nearctic
Pissonotus sp.2	2	Native, Nearctic
Pissonotus sp.3	2	Native, Nearctic
Planicephalus flavicostatus	2	Native, Nearctic
Plesiommata tripunctata	2	Native, Nearctic
Polyamia apicata	2	Native, Nearctic
Polyamia caperata	2	Native, Nearctic
Polyamia compacta	2	Native, Nearctic
Polyamia sp.	2	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Polyamia weedi	2	Native, Nearctic
Ponana scarlitina	2	Native, Nearctic
Ponana sp.	2	Native, Nearctic
Prairiana sp.	2	Native, Nearctic
Prokelisia crocea	2	Native, Nearctic
Prosopia bicincta	1	Exotic, Nearctic (Canada, Eastern United States)
Prosopia sp.	1	Exotic, Nearctic (Canada, Eastern United States)
Psammotettix lividellus	1	Exotic, Nearctic (not found in Illinois from 1948)
Publilia concava	1	Native, Nearctic
Publilia reticulata	2	Native, Nearctic
Sanctanus sanctus	2	Native, Nearctic
Scaphoideus cinerosus	2	Native, Nearctic
Scaphoideus crassus	2	Native, Nearctic
Scaphoideus elongatus	2	Native, Nearctic
Scaphoideus forceps	2	Native, Nearctic
Scaphoideus minor	2	Native, Nearctic
Scaphoideus opalinus	2	Native, Nearctic
Scaphoideus sp.	2	Native, Nearctic
Scaphoideus sp.1	2	Native, Nearctic
Scaphoideus sp.2	2	Native, Nearctic
Scaphoideus sp.3	2	Native, Nearctic
Scaphoideus sp.4	2	Native, Nearctic
Scaphoideus sp.5	2	Native, Nearctic
Scaphoideus sp.6	2	Native, Nearctic
Scaphoideus tergatus	2	Native, Nearctic
Scaphoideus titanus	2	Native, Nearctic
Scaphoideus transius	2	Native, Nearctic
Scaphoideus veterator	2	Native, Nearctic
Scaphytopius abbreviatus	2	Native, Nearctic
Scaphytopius acutus	1	Native, Nearctic and Palaearctic
Scaphytopius cinereus	1	Native, Nearctic
Scaphytopius frontalis	2	Native, Nearctic
Scaphytopius rubellus	1	Exotic, Nearctic (East Coast of the United States)
Scaphytopius sp.	1	Native, Nearctic
Scaphytopius sp.1	1	Native, Nearctic
Scolops angustatus	2	Native, Nearctic
Scolops pungens	2	Native, Nearctic

Table 1. continued.

Species Name	H Group	Origin
Scolops sp.	1	Native, Nearctic
Scolops suclipes	2	Native, Nearctic
Sorhoanus pascuellus	1	Exotic, Palaearctic (Europe)
Spissistilus cornutus	2	Native, Nearctic
Spissistilus sp.	2	Native, Nearctic
Spissitilus borealis	2	Native, Nearctic
Stenocranus delicatus	2	Native, Nearctic
Stenocranus sp.	1	Native, Nearctic
Stenocranus sp.1	2	Native, Nearctic
Stictocephala bisonia	1	Native, Nearctic
Stictocephala brevitylus	2	Native, Nearctic
Stictocephala lutea	2	Native, Nearctic
Stictocephala sp.	1	Native, Nearctic
Stictocephala taurina	2	Native, Nearctic
Stirellus bicolor	1	Native, Nearctic
Stirellus obtusus	2	Native, Nearctic
Stobaera tricarinata	2	Native, Nearctic
Syndoche impunctata	2	Native, Nearctic
Syntames uhleri	2	Native, Nearctic
Telamona unicolor	2	Native, Nearctic
Texanus sp.	2	Native, Nearctic
Thammotettix simplex	1	Exotic, Palaearctic (Europe)
Thionia simplex	2	Native, Nearctic
Tinobregnus viridescens	2	Native, Nearctic
Tylozygus bifidus	1	Native, Nearctic
Typhlocyba sp.	1	Native, Nearctic
Xestocephalus brunneus	2	Native, Nearctic
Xestocephalus piceus	2	Exotic, Nearctic (Ohio)
Xestocephalus pulicarius	2	Native, Nearctic
Xestocephalus sp.	2	Native, Nearctic

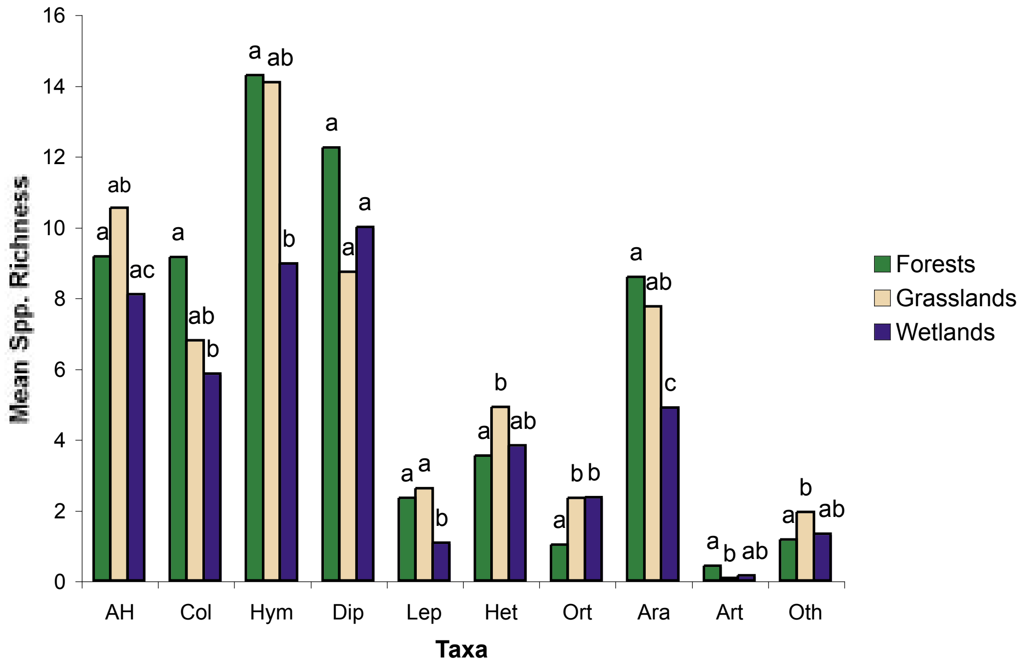

Fig. 1. Mean arthropod species richness across forest, wetlands, and grasslands, from 1997 to 2001.

species richness was higher in grasslands than wetlands and forests, although only significant differences were found between grasslands and wetlands. Coleoptera species richness was significantly higher in forests. Hymenoptera, Lepidoptera, and Arachnida species richness were significantly lower in wetlands than other habitats. Diptera species richness was not statistically different among any of the habitats.

Relationships among arthropod groups: A stronger relationship was observed between Coleoptera and total non-AH terrestrial arthropod species richness (Figure 2a) than AH species richness and total non-AH terrestrial arthropod species richness (Figure 2b). Hyperdiverse orders, such as Coleoptera showed a significant relationship to Hymenoptera (Figure 3). Heteroptera (i.e., seed, plant, and stink bugs) species richness had the highest significant relationship to AH species richness than any other terrestrial arthropod group (Figure 4).

AH State and County Records: A total of 344 AH species were identified. Out of these 344 species 95 species belong to group 1 (24 exotic species and 71 native species) and 249 belong to group 2 (4 exotic species and 245 native species) (Table 1). In addition, 191 out of 344 (56 percent) AH species collected represent new county records (Table 1). Some of the new county records include *Penthimia americana*, an indicator of oak savanna (Figure 5a), *Apache degeerii* (Figure 5b), and *Evacanthus nigramericana* (Figure 5c), which are indicators of highly undisturbed forest sites. Some new county and state records include: *Athysanus argentarius* (Figure 5d), an introduced European species that is known to vector economically important diseases to agriculture crops, which was found in wetlands and grasslands; and *Aphrodes bicinta*

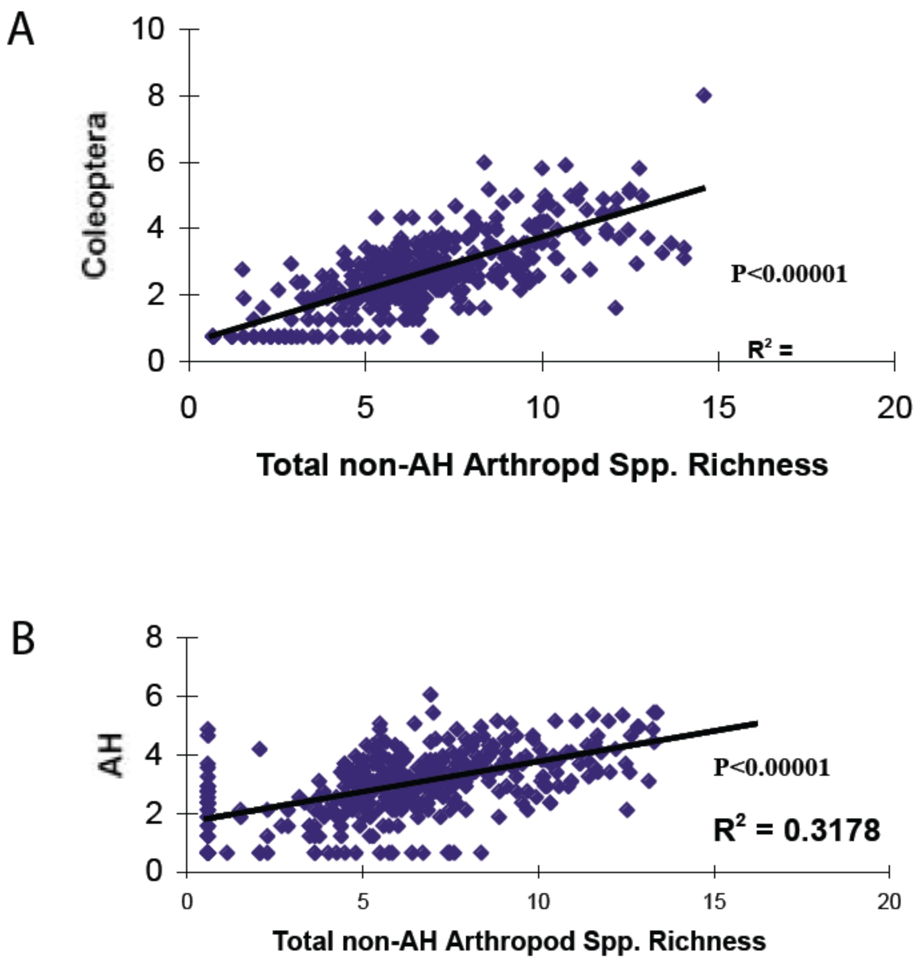

Fig. 2. Relationship (R2) of Coleoptera total species richness to total arthropod species richness (excluding Coleoptera) (a); and AH total species richness correlated to total arthropod species richness (excluding AH) (b).

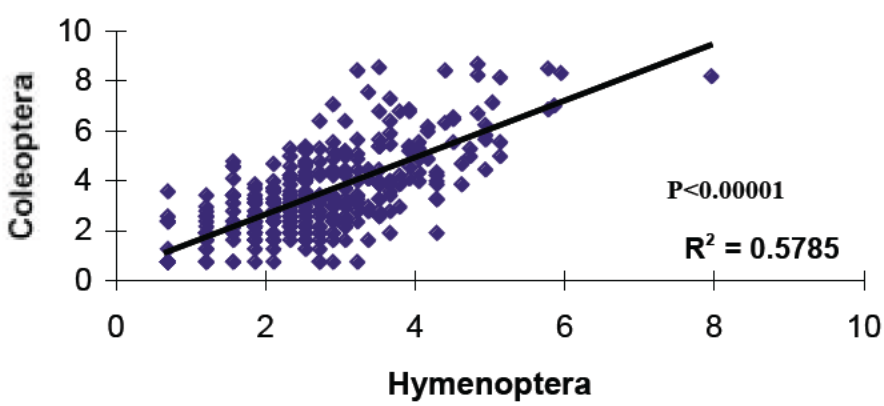

Fig. 3. Relationship of Coleoptera total species richness to Hymenoptera total species richness.

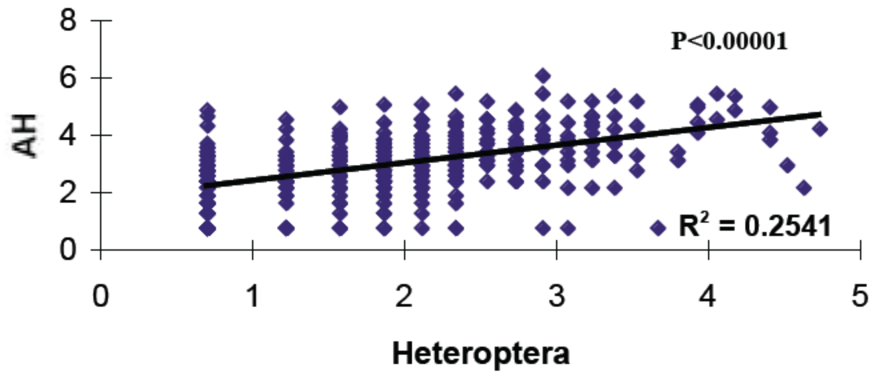

Fig. 4. Heteroptera total species richness relationship (R2) with AH total species richness.

(Figure 5e), also introduced from Europe and is often found with other exotic species, such as *Athysanus argentarus*, and *Lebradea flavovirens* (Figure 5f), which is introduced from Finland. *Lebradea flavovirens* is endangered in Finland and primarily feeds on *Calamagrostis* spp., which commonly occurs in wet prairies and wetland habitats.

Discussion

Species richness across habitats: Differences among habitats for each taxon group were found. In the case of Auchenorrhyncha (AH) species they were more abundant in grasslands, followed by forests, then wetlands, although statisitically significant differences were found only between grasslands and wetlands (Figure 1). Several explanations such as collection period, vegetation stratum sampled, and sampling technique can be provided for these results. Since different habitats were sampled at different times (forests in late spring/early summer, wetlands in early summer, grasslands in mid summer), the higher species richness in grasslands may simply reflect seasonal difference in AH richness among habitats. In addition, collection of AH during mid to late summer is preferred since in temperate regions, AH require several months to reach reproductive maturity, which occurs in mid-to-late June (Nickel 2003).

The vegetation stratum that is sampled can also explain the AH differences between habitats. Only the herbaceous stratum is sampled at CTAP sites. In forests, a lot of the insect diversity is within and just above the forest canopy (see citations in Su and Woods 2001). Due to sampling protocols we may miss additional AH species in forests. In addition, the successional stage of the sampled plant community in the herbaceous stratum may affect AH species richness. Hollier *et al.* (1994) and Stinson and Brown (1983) found that the successional stage and architecture of plant communities are significantly correlated with AH biodiversity. As the plant community

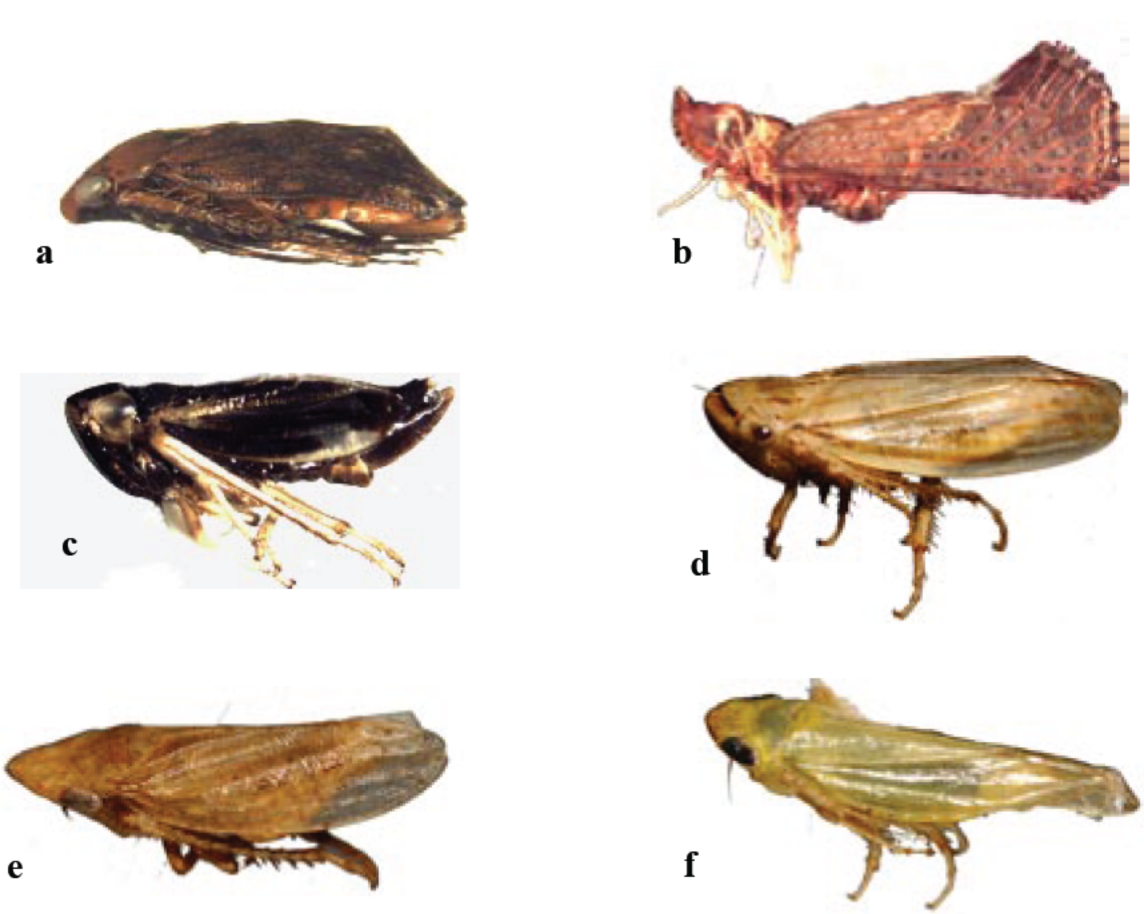

Fig. 5. Images of Penthimia americana (a); Apache degeerii (b); and Evacanthus nigramericana (c); Athysanus argentarius (d); Aphrodes bicincta (e); and Lebradea flavovirens (f).

becomes more diverse in species and the plant architecuture becomes more complex over time, it provides more resource availability for AH colonization. Based on our 1997-2000 CTAP vegetation data (Molano-Flores *et al*. 2002), forests, not grasslands, should have more AH species, since the forest plant communities are more species diverse. However as previously pointed out, AH are collected too early in the forests. In addition, we may be missing AH species due to the sampling technique we employ. Because we only conduct sweeps at our sites, some AH species that occur in the canopy will be missed (see a further explanation under *Terrestrial Arthropod Relationships*).

Other terrestrial arthropods showed different trends in species richness across habitats (Figure 1). Arachnida, Diptera, Coleoptera, Hymenoptera, and Lepidoptera species richness were lower in wetlands than forests and grasslands. The low diversity observed in these orders in the wetland sites may be a result of lower plant diversity. Many of the CTAP wetland sites have high levels of anthropogenic disturbance and are very small, which may have resulted in high extirpation rates of these highly speciose orders. These hyperdiverse groups, which comprise a plethora of guilds such as scavengers, detritivores, predators, parasitoids, and herbivores, may prefer forests because of the complex vertical stratitication that provides suitable habitat to support a variety of niches. However, phytophagous insects such as Orthoptera and Heteroptera had higher numbers of species in grasslands and wetlands than forests. Sap-sucking and leaf-chewing insects may favor grasses and forbs more than trees and shrubs for several reasons: grassland habitats may have a higher carbon to nitrogen ratio, the vertical stratification of grassland habitats may be more preferable for the location of mates, and grassland plant communities may not hinder the insects ability to disperse to new locations as much as forest habitats.

Terrestrial Arthropod Relationships: The species richness of both AH and hyperdiverse groups of terrestrial arthropods, in particular Coleoptera, showed signficiant positive relationships to total non-AH terrestrial arthropod species richness, however AH displayed a lower positive significant relationship to total non-AH arthropod species richness (Figure 2b) than hyperdivese groups of terrestrial arthropods (Figure 2a). This data suggests that hyperdiverse groups of terrestrial arthropods may be less sensitive to habitat disturbance than AH. Many of the sites sampled by CTAP are of poor to moderate quality, thus more vagile, highly competitive species, for example the spittlebug *Philaneus spumarius*, may be replacing other highly conservative species such as *Flexamia spp*. (personal observation). This process is accelerated when natural habitats such as forests and grasslands are fragmented, near an edge, and/or near a matrix of agriculture. Summerville and Crist (2004) studied moth species richness and abundance in fragmented deciduous forest fragments and observed that as forest size decreases or becomes closer to an agricultural landscape, species richness decreases and species composition changes. AH may be more susceptible to nearby agriculture fields and may be more dependent on larger habitat size than Coleoptera.

Another explanation of why Coleoptera species richness displayed a stronger relationship to total non-AH terrestrial arthropods than AH species richness is the sampling technique. Because AH and other terrestrial arthropods were sampled by using a sweep net, additional sampling methods, such as vacuum sampling, should be implemented to determine if these trends (Figures 2a, b) are a naturally occurring phenomenon or sampling artifact. Wilson *et al.* (1993) used a modified leafblower to sample planthopper species and other terrestrial arthropods from aquatic vegetation, as well as grasslands. Their results showed that the leafblower vacuum was more efficient in collecting adults and early instars than other sampling techniques such as the D-vac, sweep, and dip nets. In addition, Nickel (2003) observed that vacuum sampling is the most efficient method of quantitative sampling for Auchenorrhyncha species. Thus, additional sampling at CTAP sites, using a modified leafblower vacuum to sample AH and other terrestrial arthropd may be necessary to efficiently collect all possible AH and other terrestrial arthropod species, and to statistically analyze their differences in species richness and abundance across space and time.

Finally, when comparing non-AH terrestrial arthropods to AH, only Heteroptera displayed the strongest significant positive relationship to AH (Figure 3). This is most likey due to the fact that AH is a subgroup of Heteroptera and they share similar life histories. Most Heteroptera feed on plant sap, have similar numbers of generations, and reach reproductive maturity at the same time as AH. However, among all the non-AH terrestrial arthropod groups, Coleoptera had the strongest significant positive relationship to Hymenoptera (Figure 4). Several reasons that may explain this relationship are: these groups may have similar functional guilds (see Basset *et al.* 2004); have similar distribution patterns of species richness and abundance across space and time; and have similar patterns in abundance and species richness after anthropogenic disturbance. The CTAP data suggests that hyperdiverse groups may be better predictors of other hyperdiverse groups.

AH State and County Records: A somewhat higher proportion of the known Illinois AH fauna were documented (344 from over 900) and most of these species belong to group 2 (i.e., rare, restricted in distribution, and/or host- or habitat-specific; 72 percent). The great number of species that were documented most likely was the result of the sampling method employed, which is particularly effective for this group of insects and to the numbers of sites that have been visited by CTAP. In addition, this sampling effort over a five-year period (1997-2001) has resulted in an increase in the number of new county records for AH. This increase in the number of new state and county records obtained by CTAP demonstrates the need for this type of statewide monitoring program to update current records and detect changes in biodiversity across Illinois which may include the detection of introduced and economically important arthropods. At this point, we have identified 28 exotic species from our CTAP sites.

The collection of terrestrial insects by CTAP between 1997-2001 has provided invaluable data on differences between habitats for terrestrial insects and new state and county records for Auchenorrhynchous Homoptera. These data in combination with the plant and bird data collected by CTAP will allow us to have a better understanding of the overall conditions of our forests, wetlands, and grasslands.

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CRITICAL TRENDS ASSESSMENT PROGRAM

2003-04 REPORT

ILLINOIS
DEPARTMENT OF
NATURAL
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Critical Trends Assessment Program
2004-04 Report

Illinois Department of Natural Resources

Office of Realty and Environmental Planning
Division of Review and Coordination
One Natural Resources Way
Springfield, Illinois 62702-1271

Office of Scientific Research and Analysis
Illinois Natural History Survey
607 East Peabody Drive
Champaign, Illinois 61820

December 2004

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Printed by the authority of the State of Illinois