The Arthropods of a Early Sand Prairie Sere

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ABSTRACT

An inventory of ground-dwelling arthropods was conducted from March to August of 1999 on a recovering sand prairie near Edwardsville, IL. Drift fences and pitfall traps were utilized and arthropods were collected approximately once every month. We identified 81 different species represented by the following Orders (number of different species): Spirobolida (1), Hymenoptera (6), Hemiptera (7), Isopoda (1), Coleoptera (50), Homoptera (1), Orthoptera (2), Lepidoptera (3), Opilionida (1), and Araneae (10). Anisodactylus harrissi, Lycosa spp., Geopinus incrassatus, and Microporus obliquus were the most common arthropod species captured. Results suggest that there were no systemic spatial variation between drift fences and species caught, whereas there were temporal differences in the species caught.

INTRODUCTION

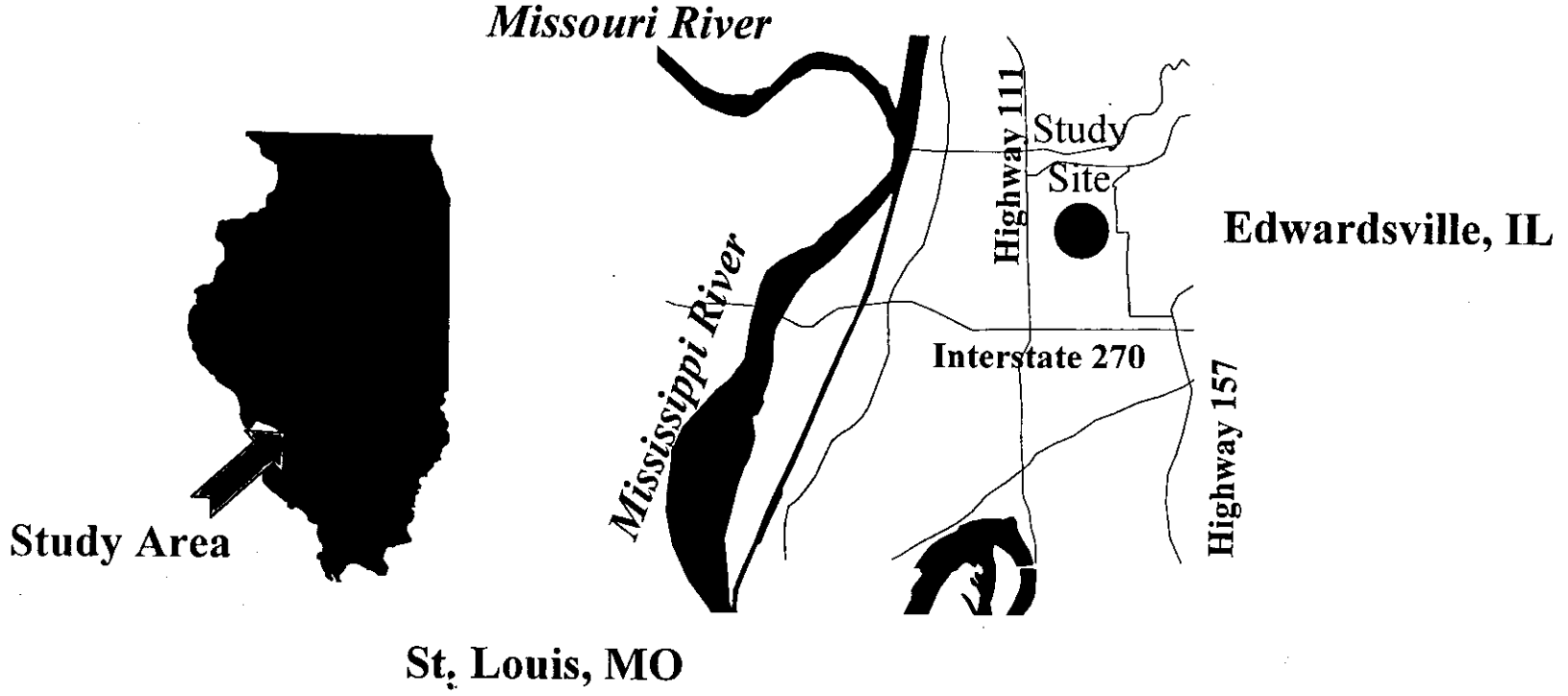
Approximately 75% of the organisms occupying earth are invertebrates (White, 1983; Borror et al., 1989). This includes spiders, insects, crustaceans, centipedes, and millipedes. Many are directly beneficial to humans providing pollination, food, wax, and silk. Invertebrates are also indirectly important as a key component of the food web, assisting in the decomposition of organic material, and foraging or parasitizing harmful organisms. Many are also viewed as important pests damaging agricultural crops and livestock. Unfortunately, they are probably the least understood of all organisms. In particular, knowledge of what, when and how many invertebrate species occupy a habitat is generally lacking.

Sand Road is a 43-acre wetland/sand prairie mitigation site recently purchased by the Illinois Department of Transportation (Figure 1). The site includes an abrupt change from a xeric sand prairie to a mesic wetland and provides habitat for many rare and uncommon species of plants, invertebrates, reptiles, and amphibians, including the threatened Illinois chorus frog (*Pseudacris streckeri illinoensis*) (Tucker, 2000). The reptiles and amphibians rely heavily upon the invertebrates (mostly ground-dwelling arthropods) as forage. Studies of the food habits of six species of reptiles and amphibians occupying this site have been or are currently being determined (Tucker, 1997). The purpose of this project is to provide a partial inventory of ground-dwelling arthropods and to describe the changes in arthropod abundance throughout the warm season (April-August).

MATERIALS AND METHODS

Arthropods were sampled from a site located near Edwardsville, IL (Figure 1). Sampling was conducted on March 28, April 3, April 17, May 1, May 17, July 6, and August 9, in 1999. Thirteen drift fences (25 cm metal siding), each thirty meters in

Figure 1. Study site near Edwardsville, Illinois



length with six pitfall traps, were utilized (Tucker, 1995). The number of drift fences sampled varied according to the available time that the authors had to collect and process the samples (ranged from 6 to13 transects sampled every period). Several pitfall traps (1 to 2) were removed from the study each sample period due to silting in (wind blown sand). The data was analyzed by species using a General Linear Model (Statistical Analysis System, 1996) to determine if fence, pit, and period had any influence on variation in distribution and on the number of individuals captured. The average number of individual species captured per pit was then calculated to show changes in species density and frequency throughout the seven sampling periods.

RESULTS

Fence and pit location did not significantly ($p<0.05$; $F < 1$) predict the number of individuals captured by species. However, period was a significant predictor indicating that variation in season partially determined the number of individuals captured. Arthropod abundance peaked during the April 17th and May 1st sampling periods (12.0 and 11.7 individuals per pit, respectively; Table 2).

Most of the species captured throughout this study were ground beetles (Coleoptera; Table 1). Ground beetles were the most abundant arthropod in all sampling periods (ranging from 25 to 73%) except in the first sampling period (April 28th). The first sampling period was dominated by Lepidoptera larvae (Family Noctuidae (cutworm); Table 1). The relative abundance of Lepidoptera decreased thereafter. Araneae (spiders) abundance increased following the first sampling period, peaked around May 1st and then declined throughout the rest of the study. Hemipteran (true bugs) relative abundance increased throughout the study (Table 1).

Other than the first sampling period, Anisodactylus harrisii was the most frequent arthropod sampled (Table 2). Average number of individuals captured per pit was relatively low during the first period (0.1) but increased by 39-fold in one-weeks time. Lycosa spp. (four different species) were also abundant occurring in 9.6% of the pits and having an average capture of 3.5 individuals per pitfall throughout all time periods (Table 2). Density and frequency peaked during the April 3rd sampling period. Geopinus incrassatus was frequent from March 28 to July 6 (frequency ranged from 3.1 to 20.0) but dropped to no captures by August 9 (Table 2). Our sampling indicated that Microporus obliquus had low abundance during the early sampling periods but increased to about 17% by May 17 (Table 2).

DISCUSSION

Determining species presence and abundance is an important step in describing the rarity and importance of a habitat and understanding the relationship of organisms to that habitat. This particular site is interesting because it is a zone where a disturbed sand prairie and a wetland meet. Many of the invertebrate species sampled by this study only occupy areas with large sand deposits (e.g., Bembidion spp., A. harrisii, Euryderus grossus, G. incrassatus, Cicindela spp., and M. obliquus) (Arnett, 1963; Slater and Baranowski, 1978; White, 1983). Other invertebrates are attracted by a particular vegetation type or prey whereas others are generalists. The invertebrates sampled could be classified into four groups based on feeding habits and habitat use, 1) herbivores, 2) predators, 3) scavengers/decomposers, and 4) transients.

Table 1. Changes in frequency by arthropod order and sampling period.

	Sampling Dates															
	3/28		4/03		4/17		5/01		5/17		7/06		8/09		Total	
Order	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**
Araneae	3.1 (1)	0.0	18.1 (124)	1.6	10.0 (24)	1.0	26.9 (110)	3.7	2.3 (6)	0.2	3.1 (5)	0.1	2.1 (2)	0.0	**15.2 (274)**	**6.9**
Coleoptera	25.0 (8)	0.3	69.3 (471)	6.2	73.4 (213)	8.7	58.7 (194)	6.4	71.2 (192)	7.9	70.5 (94)	2.6	71.3 (68)	3.0	**67.1 (1240)**	**34.6**
Hemiptera	0.0	0.0	1.0 (7)	0.1	7.9 (23)	1.0	6.0 (20)	0.7	17.4 (46)	1.9	14.0 (18)	0.5	21.3 (30)	1.3	**8.1 (144)**	**5.4**
Homoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4 (1)	0.0	0.8 (1)	0.0	0.0	0.0	**0.1 (2)**	**0.1**
Hymenoptera	0.0	0.0	0.0	0.0	1.4 (4)	0.2	3.0 (10)	0.3	3.0 (8)	0.3	7.8 (10)	0.3	5.3 (5)	0.2	**2.1 (37)**	**1.2**
Isopoda	0.0	0.0	0.0	0.0	2.1 (6)	0.3	1.8 (6)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	**0.7 (12)**	**0.5**
Lepidoptera	59.4 (19)	0.6	8.1 (55)	0.8	5.2 (15)	0.6	1.5 (5)	0.2	4.5 (12)	0.5	3.9 (5)	0.1	0.0	0.0	**6.1 (111)**	**2.8**
Opilionida	0.0	0.0	0.0	0.0	0.7 (2)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1 (2)**	**0.1**
Orthoptera	6.3 (2)	0.1	3.2 (24)	0.3	0.0	0.0	2.1 (7)	0.2	1.1 (3)	0.1	0.0	0.0	0.0	0.0	**1.9 (34)**	**0.7**
Spirobolida	6.3 (2)	0.1	0.3 (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2 (4)**	**0.1**
Total	**100.1 (32)**	**1.0**	**100.0 (683)**	**9.0**	**99.7 (289)**	**11.9**	**100.0 (352)**	**11.7**	**99.9 (268)**	**10.9**	**100.1 (133)**	**3.6**	**100.0 (105)**	**4.5**	**101.6 (1860)**	**52.4**

Table 2. Speci[redacted]requency and average capture per pit by sampling perio[redacted]

	Sampling Dates															
	3/28		4/03		4/17		5/01		5/17		7/06		8/09		Total	
Order/Species	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**	**F**	**A**
Araneae																
Cicurina spp.	0.0	0.0	0.1 (1)	0.0	0.0	0.0	6.0 (20)	0.7	0.0	0.0	0.8 (1)	0.0	0.0	0.0	**1.2 (22)**	**0.7**
Lycosa spp.	0.0	0.0	17.2 (117)	1.5	8.6 (24)	1.0	8.1 (24)	0.8	0.8 (2)	0.1	2.3 (3)	0.1	1.1 (1)	0.0	**9.6 (171)**	**3.5**
Oxyopes spp.	0.0	0.0	0.0	0.0	0.0	0.0	7.8 (26)	0.9	0.0	0.0	0.0	0.0	0.0	0.0	**1.4 (26)**	**0.9**
Pardosa spp.	0.0	0.0	0.0	0.0	0.0	0.0	6.9 (23)	0.8	0.0	0.0	0.8 (1)	0.0	0.0	0.0	**1.3 (24)**	**0.8**
Zelotes spp.	0.0	0.0	0.1 (1)	0.0	0.0	0.0	3.0 (10)	0.3	0.4 (1)	0.0	0.0	0.0	0.0	0.0	**0.7 (12)**	**0.4**
Other[1]	3.1	0.0	0.6 (5)	0.1	0.0	0.0	2.1 (7)	0.2	1.1 (3)	0.1	0.0	0.0	1.1 (1)	0.0	**1.0 (19)**	**0.6**
Opilionida																
Phalangidae	0.0	0.0	0.0	0.0	0.7 (2)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1 (2)**	**0.1**
Coleoptera																
Anisodactylus harrisii	12.5 (4)	0.1	49.3 (335)	4.3	33.1 (96)	4.0	28.7 (96)	3.2	54.9 (145)	6.0	46.5 (60)	1.7	55.3 (52)	2.2	**43.2 (788)**	**21.5**
Calathus gregarious	0.0	0.0	4.3 (29)	0.4	9.0 (26)	1.1	2.4 (8)	0.3	1.9 (5)	0.2	2.3 (3)	0.1	4.3 (4)	0.2	**4.1 (75)**	**2.2**
Callida spp.	0.0	0.0	3.1 (21)	0.3	4.5 (13)	0.5	1.2 (4)	0.1	1.1 (3)	0.1	0.0	0.0	0.0	0.0	**2.2 (41)**	**1.1**
Cicindela hirticollis	0.0	0.0	2.9 (20)	0.3	0.3 (1)	0.0	0.9 (3)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	**0.7 (24)**	**0.4**
Cicindela punctulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8 (1)	0.0	2.1 (2)	0.1	**0.2 (3)**	**0.1**
Geopinus incrassatus	6.3 (2)	0.1	5.7 (39)	0.5	20.0 (58)	2.4	5.7 (19)	0.6	3.8 (10)	0.4	3.1 (4)	0.1	0.0	0.0	**7.2 (132)**	**4.1**
Harpalus testaceus	0.0	0.0	0.0	0.0	0.0	0.0	0.3 (1)	0.0	1.1 (3)	0.1	2.3 (3)	0.1	0.0	0.0	**0.3 (7)**	**0.2**
Patrobus septentrionis	0.0	0.0	0.0	0.0	0.0	0.0	5.1 (17)	0.6	0.0	0.0	0.0	0.0	0.0	0.0	**0.9 (17)**	**0.6**
Scarites substriatus	0.0	0.0	0.0	0.0	0.3 (1)	0.0	8.4 (28)	0.9	1.5 (4)	0.2	9.3 (12)	0.3	6.4 (6)	0.3	2.8 (51)	1.7
Other[2]	6.3 (2)	0.1	3.8 (27)	0.4	5.9 (18)	0.7	5.4 (18)	0.6	9.6 (22)	0.9	8.8 (11)	0.3	4.4 (4)	0.2	5.5 (102)	2.7
Hemiptera																
Geocoris spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.6 (2)	0.1	0.0	0.0	0.0	0.0	2.1 (2)	0.1	0.2 (4)	0.2
Microporus obliquus	0.0	0.0	1.0 (7)	0.1	7.2 (21)	0.9	4.5 (15)	0.5	17.4 (46)	1.9	13.2 (17)	0.5	17.0 (16)	0.7	6.7 (122)	4.5
Nabis spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8 (1)	0.0	11.0 (10)	0.4	0.7 (11)	0.4
Other[3]	0.0	0.0	0.0	0.0	0.7 (2)	0.1	0.9 (3)	0.1	0.0	0.0	0.0	0.0	2.1 (2)	0.1	0.5 (7)	0.3
Homoptera																
Cicadellidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4 (1)	0.0	0.8 (1)	0.0	0.0	0.0	0.1 (2)	0.1
Hymenoptera																
Acropyga spp.	0.0	0.0	0.0	0.0	0.0	0.0	2.1 (7)	0.2	1.1 (3)	0.1	2.3 (3)	0.1	0.0	0.0	0.7 (13)	0.4
Hypoclinea spp.	0.0	0.0	0.0	0.0	0.7 (2)	0.1	0.6 (2)	0.1	0.8 (2)	0.1	3.1 (4)	0.1	2.1 (2)	0.1	0.7 (12)	0.4
Other[4]	0.0	0.0	0.0	0.0	0.7 (2)	0.1	0.3 (1)	0.0	1.2 (3)	0.1	2.4 (3)	0.1	3.3 (3)	0.1	0.7 (12)	0.4
Isopoda	0.0	0.0	0.0	0.0	2.1 (6)	0.3	1.8 (6)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.7 (12)	0.5
Lepidoptera																
Noctuidae	59.4 (19)	0.6	8.1 (55)	0.8	5.2 (15)	0.6	1.5 (5)	0.2	4.5 (12)	0.5	3.9 (5)	0.1	0.0	0.0	6.1 (111)	2.8
Orthoptera																
Gryllacrididae	6.3 (2)	0.1	3.2 (24)	0.3	0.0	0.0	2.1 (7)	0.2	1.1 (3)	0.1	0.0	0.0	0.0	0.0	1.9 (34)	0.7
Spirobolida	6.3 (2)	0.1	0.3 (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2 (4)	0.1
Total	**100.1 (32)**	**1.0**	**99.7 (683)**	**9.0**	**99.7 (289)**	**11.9**	**100.0 (352)**	**11.7**	**99.9 (268)**	**10.9**	**100.1 (133)**	**3.6**	**100.0 (105)**	**4.5**	**101.6 (1860)**	**52.4**

Other[1] (n) includes: Gnaphosa spp. (3), Habrocestum spp. (1), Micryphantidae (5), and Misumenops spp. (10); Other[2] includes: Acaromimus spp. (2), Acupalpus spp. (2), Adalia spp. (7), Agonoderus spp. (1), Agonum spp. (4), Amara interpunctatus (3), Anadaptus spp. (2), Anomala binotata (1), Apion spp. (1), Bembidion spp. (2), Calathus advena (1), Calligrapha bidenticola (1), Cerotoma trifurcata (3), Cicindela repanda (1), Cicindela scutellaris (2), Cybister spp. (2), Dicaelus elongatus (1), Elateridae (3), Eucnemidae (2), Euryderus grossus (1), Evathrus spp. (5), Harpalus caliginosus (5), Harpalus pleuriticus (6), Hydrophilus spp. (2), Hypera spp. (1), Languria trifasciata (2), Nicrophorus spp. (5), Odontonyx spp. (2), Oedionychus quercata (2), Oedionychus vians (1), Pasimachus spp. (5), Plegaderus spp. (7), Pseudomorpha spp. (2), Pterostichus spp. (4), Scaphinotus elevatus (5), Sphenophorus spp. (1), Stenolophus conjúnctus (1), Tenebrionidae (2), and Trichotichnus spp. (2); Other[3] includes: Ceratocapsus spp. (3), Nabicula spp. (1), Ornithocoris spp. (1), and Sehirus cinctus (2); and Other[4] includes: Leptothorax spp. (6), Mutillidae (2), and Tetramorium spp. (4).

Many of the invertebrates occupying the site are herbivores. The dominant vegetation on the sand prairie included yellow sweetclover (Melilotus officianalis), daisy (Aster spp.), cheatgrass brome (Bromus tectorum), and mouse-eared chickweed (Cerastium pumilum) (unpublished data). The wetland was dominated by sedges (Carex spp. and Cyperus spp.) and bulrushes (Scirpus spp.). The sporadic occurrence of young burr oak (Quercus marilandica), black oak (Q. velutina), black willow (Salix nigra), and eastern cottonwood (Populus deltoides) trees characterize this site.

Cerotoma trifurcata, Apion griseum, Hypera spp., and Languria trifasciata feed upon the abundant legumes (yellow sweetclover) (Blatchley and Leng, 1916; Kissinger, 1964; Ross et al., 1982; White, 1983; Borror et al., 1989; Haarstad, 1999). Calligrapha bidenticola may feed upon the less common tickseed sunflower (*Bidens aritosa*) and black willow (Haarstad, 1999). Sphenophorus spp. feed primarily on grasses and sedges occupying both the sand prairie and wetland (Blatchley and Leng, 1916; Kissinger, 1964; Haarstad, 1999). Microporus obliquus, Sehirus cinctus, Elateridae (click beetle Family), and Feltia spp. all feed at or below ground level on the roots or stems of plants (Arnett, 1963; Slater and Baranowski, 1978; Ross et al., 1982; White, 1983; Haarstad, 1999). Stenolophus conjunctus, Harpalus spp., Amara spp., Anisodactylus harrisii, Euryderus grossus, Geopinus incrassatus, and members of the Formicidae (ants) feed heavily upon seeds (Arnett, 1963; White, 1983; Borror et al., 1989; Hölldobler and Wilson, 1990; Haarstad, 1999). From the roots, to the stem, to the leaves, to the seeds of the plants occupying the Sand Road site, there is an invertebrate herbivore counterpart.

The diversity of predators at this site was astounding and included species that were highly specialized in mode of capture and consumption of prey, as well as generalists. For instance, Scaphinatus elevatus is a beetle that has a narrowed head that allows it to feed on snails through the opening in the shell (White, 1983; Borror et al., 1989; Haarstad, 1999). Dicaelus elongatus also feeds upon snails (White, 1983). Snails (Physella spp.) are common in the wetland.

Other specialists include Pasimachus spp. and Scarites substriatus that feed upon caterpillars (e.g., Feltia spp.) and other beetle larvae (White, 1983). Calleida spp. feeds primarily upon plant lice, while Adalia spp. preys on aphids and scale insects (Haarstad, 1999; Borror et al., 1989; White, 1983; Ross et al., 1982). Plegaderus spp. and Nicrophorus spp. are beetles that occupy carrion and dung in wait of prey (e.g., fly larvae) (White, 1983; Borror et al., 1989; Haarstad, 1999). Members of the Mutillidae (velvet ant) are wingless wasps (the females only) that paralyze and lay their eggs on a prey (e.g., beetle larvae) (Borror et al., 1989; Haarstad, 1999). The larvae then develop and feed upon the paralyzed insect. Other insect predators sampled including Bembidion spp., Anisodactylus harrisii, Agonum spp., Calathus spp., Evathrus spp., Odontonyx spp., Pterostichus spp., Cicindela spp., Ceratocapsus spp., Geocoris spp., Nabicula spp., and Nabis spp. are more generalists (Slater and Baranowski, 1978; White, 1983; Borror et al., 1989; Haarstad, 1999).

Florinda spp. and Micryphantidae (dwarf spider family) are spiders that utilize low webs in the grass to capture insects (Katson, 1972; Moulder, 1992). Zelotes spp., Lycosa spp., Pardosa spp., Oxyopes spp., and Habrocestum spp. are spiders that do not utilize a web to capture prey (Katson, 1972; Moulder, 1992). Instead they stalk and pounce upon potential food items. Likewise, Misumenops spp. doesn't utilize a web to

capture prey. This species has excellent camoflauge that resembles foliage (flower or leaf) allowing it to ambush prey (Katson, 1972; Moulder, 1992).

Several of the species that were captured were scavenger/decomposers. Acaromimus spp. feeds upon fungus that occupies dead or dying trees or on the smut in grasses, while the Eucnemidae Family (false click beetle) feeds upon rotting wood (Dillon and Dillon, 1961; Arnett, 1963; White, 1983; Borror et al., 1989). The Gryllacrididae (camel cricket) are scavengers and Anomala binotata, Nicrophorus spp. and species of Tenebrionidae (darkling beetle) feed upon dead plant material, dung, carrion and, or fungi (Arnett, 1963; Ross et al., 1982; White, 1983; Borror et al., 1989; Haarstad, 1999).

Both Cybister spp. and Hydrophilus spp. are water beetles that were more than likely transient catches rather than actually utilizing the sand prairie area (White, 1983; Borror et al., 1989; Haarstad, 1999). They have the ability to fly and were probably in the process of relocating from the nearby wetland. Ornithocoris spp. is a parasite of birds (Slater and Baranowski, 1978). Occasional killdeer and bobwhite quail chicks were captured in the pits and may explain the capture of this parasite.

The most common species at this site was A. harrisii. This species apparently transforms from a grub stage to an adult beetle form around the first of March. In addition to being the most common species on the sand prairie site, A. harrisii is also commonly consumed by the reptiles and amphibians occupying this site making it an important component of the food web (unpublished data). However, being a ground-dwelling insect that prefers an open habitat, it is likely that the abundance of A. harrisii will decline as the sand prairie matures and plant cover increases. This raises the question of whether A. harrisii is a preferred forage species by a declining herp population, or if it is utilized by these vertebrates simply because it is the dominant ground-beetle.

Wetland and sand prairie are rare vegetative communities in Illinois. We show that a wide variety of ground dwelling arthropods occupy and utilize the Sand Road site. Even so, our study only examined mobile, ground-dwelling arthropods occupying this site at an early sere stage. The complexity and lack of understanding increases with the addition of invertebrates prone to flight or that are stationary. The arthropod species composition is also likely to change as the sand prairie becomes established.

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LITERATURE CITED

Arnett, R.H., Jr. 1963. *The Beetles of the United States (A Manual for Identification)*. The Catholic University of America Press, Washington, D.C. 1112 pp.

Blatchley, W.S., and C.W. Leng. 1916. *Rhynchopora or Weevils of North Eastern America*. The Nature Publishing Company, Indianapolis, Indiana. 682 pp.

Borror, D.J., C.A. Triplehorn, and N. F. Johnson. 1989. *An Introduction to the Study of Insects*. Harcourt Brace College Publishers, New York. 875 pp.

Dillon, E.S., and L. S. Dillon. 1961. *A Manual of Common Beetles of Eastern North America*. Row, Peterson and Company, Evanston, Illinois. 884 pp.

Haarstad, J.A. 1999. The Insects of Cedar Creek. http://cedarcreek.umn.edu/insects/insects.html (Version 01APR1999).

Hölldobler, B., and E. O. Wilson. 1990. *The Ants*. The Belknap Press of Harvard University Press, Cambridge, Massachusetts. 732 pp.

Kaston, B.J. 1972. *How to know the spiders.* (2nd ed.)Wm. C. Brown Company Publishers, Dubuque, Iowa. 289 pp.

Kissinger, D.G. 1964. *Curculionidae of America North of Mexico. A Key to the Genera.* Taxonomic Publications, South Lancaster, Massachusetts. 143 pp.

Moulder, B. 1992. *A guide to the common spiders of Illinois*. Illinois State Museum Popular Science Series, Vol. X. 125 pp.

Ross, H.H., C.A. Ross, and J.R.P. Ross. 1982. *A Textbook of Entomology*. John Wiley and Sons, New York, New York. 666 pp.

SAS Institute. 1996. SAS/STAT User's Guide. SAS Institute, Cory, North Carolina, USA.

Slater, J.A., and R.M. Baranowski. 1978. *How to know the true bugs (Hemiptera-Heteroptera)*. Wm. C. Brown Company Publishers, Dubuque, Iowa. 256 pp.

Tucker, J.K. 1995. Early post-transformational growth in the Illinois chorus frog (*Pseudacris streckeri illinoensis*). Journal of Herpetology. 29(2):314-316.

Tucker, J.K. 1997. Food habits of the fossorial frog *Pseudacris streckeri illinoensis*. Herpetological Natural History. 5(1):83-87.

Tucker, J.K. 2000. Growth and survivorship in the Illinois chorus frog (*Pseudacris streckeri illinoensis*). Transactions of the Illinois State Academy of Science. 93(1):63-68.

White, R.E. 1983. *A Field Guide to the Beetles of North America*. Houghton Mifflin Company, New York, New York. 368 pp.