Arthropod studies on the Shortgrass Steppe LTER: Past, Present and Future

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ABSTRACT

Arthropods play important roles in the ecology of shortgrass steppe as consumers, prey and detritivores. Here we describe past, ongoing, and future studies of arthropods conducted as part of the Shortgrass Steppe (SGS) LTER project in north-central Colorado. Our goals are to increase awareness of our arthropod research and existing datasets, and to identify opportunities for collaboration and cross-site comparisons with LTER researchers. Arthropods have been the focus of much short-term comparative and experimental research on the site, but we know of only two long-term studies. Since 1995, insects and spiders have been sampled monthly during summer (May-September) in live pitfall traps along a 1-km transect spanning a representative topographical gradient (catena). This project continues research conducted by other SGS-LTER scientists from 1990-1994 to investigate spatial dynamics of darkling beetle (Tenebrionidae) populations. A second project initiated in 1998 involves monthly summer sampling of macroarthropods in small pitfall grids in grassland and saltbush vegetation. This study was implemented to track changes in relative abundance of arthropod prey, and grids are located on trapping webs used for rodent population studies. In addition, we maintain on-site a small but growing reference collection of representative arthropods, which is mostly used to train field assistants and support other research projects.

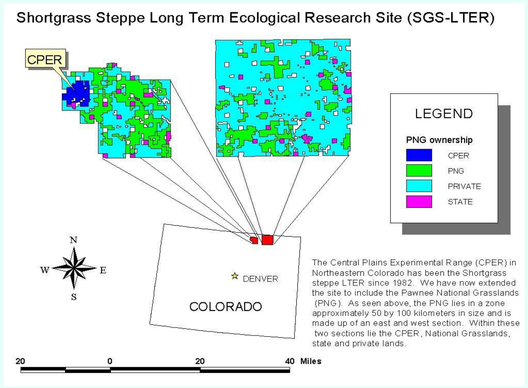
INTRODUCTION

Arthropods (insects and spiders) play important roles in the ecology of shortgrass steppe as consumers of plants and detritus, as predators and parasites, and by serving as prey for a wide variety of vertebrates (Crist in press, Milchunas and Lauenroth 1991). Although arthropods represent only ca. 1% of the total consumer biomass, their biomass exceeds that of vertebrates in shortgrass steppe. Most arthropods are present belowground for much or all of their lives, reflecting the highly seasonal climate on the surface and the disproportionately large amount of belowground primary production in shortgrass steppe. Of the macroarthropod species that occur aboveground, the most abundant and conspicuous are beetles (Tenebrionidae, Carabidae and Scarabaeidae) and ants (Formicidae), most of which feed on or scavenge plant material and seeds (Kumar et al. 1976). Predators and fungivores are considerably more common in the soil microarthropod fauna, although root-feeding larvae of certain beetles (notably *Phyllophaga fimbripes* and some Tenebrionidae) can cause significant damage to crops and native plants.

Several arthropod-related studies were conducted on the Pawnee site in north-central Colorado during the U.S. International Biological Program Grassland Biome studies (1969-1975). Although arthropods have not been a major focus of research during the NSF Shortgrass Steppe Long-Term Ecological Research (SGS-LTER) Project (1982-present), behavioural and population studies of shortgrass steppe arthropods have increased during the past decade. Our aim here is to provide a brief overview of past and current research on arthropods of shortgrass steppe, with the goal of increasing awareness of the resources and datasets available at the SGS-LTER and of our ongoing studies. We hope that our participation in this workshop will lead to more opportunities for collaboration and cross-site studies with other LTER sites.

STUDY AREA

The SGS-LTER research site is located approximately 60 km northeast of Fort Collins, CO on USDA Forest Service Pawnee National Grasslands (PNG) and the USDA Agricultural Research Service Central Plains Experimental Range (CPER). The climate is semi-arid, and most of the 300-500 mm annual precipitation falls in spring and summer thunderstorms. The topography consists of gently rolling uplands and broad swales. Vegetation is dominated by blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*), with prickly-pear cactus (*Opuntia polyacantha*) and scarlet globemallow (*Sphaeralcea coccinea*) as important non-graminoids. Aboveground net primary production is low, vegetation is short (<10 cm) and few woody plants are present except in drainages and along sandy ridges, where shrub cover (*Atriplex canescens*, *Artemesia filifolia*, *Yucca glauca*) can be extensive.



PAST RESEARCH (US/IBP Grassland Biome and SGS-LTER Projects)

Arthropod research on the Pawnee site began in earnest as part of the US/IBP Grassland Biome Program in 1969. Coinciding with the broad but arguably shallow scope of this project, many of the studies during the Grassland Biome were taxonomic surveys of the insect fauna of shortgrass steppe (studies by Kumar, Lavigne, Rogers and their collaborators), ecological studies of grasshoppers (Capinera, Pfadt) or part of the intensive environmental stress experiment that was a central focus of research at the Pawnee site (Lavigne). Since the conclusion of the Grassland Biome Program in 1975, most arthropod research has been conducted by other researchers and graduate students at Colorado State University (CSU) with considerable logistical and financial support of the focal SGS-LTER research group.

Using existing bibliographies and the search engines on the SGS-LTER web site **(http://sgs.cnr.colostate.edu)**, we compiled a record of the types of research that have been conducted and published from studies during the Grassland Biome and SGS-LTER projects:

Taxonomically (Fig.1), this analysis revealed the emphasis during the IBP studies on surveys and species lists, and the disproportionately large attention given to grasshoppers, beetles and ants. Other taxa have been largely ignored; for example, R. Weeks' (1998) MS research was the only known study of spiders on the site. Surprisingly, there were relatively few studies of soil microarthropods during the IBP and by graduate students, but studies of this fauna generated a large number of journal publications, largely through the work of John Moore (University of Northern Colorado) and his colleagues.

By subject (Fig. 2), as expected, most research has focused on the natural history and ecology of insects. Insects, especially beetles and grasshoppers, have also been used as model organisms for landscape ecological studies, largely under the direction of John Wiens in the CSU Department of Biology. Despite the economic importance of shortgrass steppe for range and crop production, we found few studies of the economic effects of insects or of the effects of range management practices or pesticides on native arthropods.

Fig. 1. SGS Arthropod Studies - by Taxon

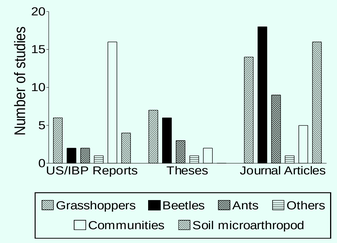
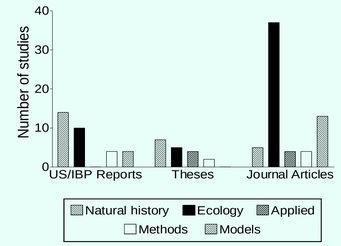


Fig. 2. SGS Arthropod Studies - by Subject



Datasets available on-line (http://sgs.cnr.colostate.edu)

A limited number of datasets are available on-line **(Table 1)**. These include data from Grassland Biome research as well as more recent projects. Additional datasets will be made available as these studies are completed and data and metadata are compiled. If you are interested in using these datasets, please follow the protocols provided on the web site and/or contact the appropriate principal investigators.

Table 1. Data collected from arthropod studies that is available on-line at the SGS-LTER web site (http://sgs.cnr.colostate.edu) (keywords: animals, populations, processes, disturbance).

Subject	PI	Dates	No. of datasets	Contact
Abundance of ground arthropods in three shrub sites	P. Stapp	1992-95	2	PI
Insect composition in diet of rodents	P. Stapp	1992-94	1	PI
Soil organic matter in ant mounds	I. Burke	1993-95	2	PI
Movements & densities of beetles	N. McIntyre	1994	2	J. Wiens
Plant recovery on grub kills	D. Coffin	1977-80, 1982, 1990	1	PI
Aboveground plant damage by herbivores	W. Lauenroth	1978	1	PI
Invertebrate density & biomass on sites with different grazing intensity	C.E. Dickinson & R.J. Lavigne	1970-74	4	W. Lauenroth
Invertebrate density & biomass, US/IBP network comparison	R.J. Lavigne	1971-72	2	W. Lauenroth
Invertebrate density & biomass on insecticide plots	George Van Dyne	1972	3	W. Lauenroth
Aboveground insects in sweep nets	R.J. Lavigne	1971	1	W. Lauenroth
Aboveground insects in pitfalls	R.J. Lavigne	1971	1	W. Lauenroth
Insect-range plant associations	R.J. Lavigne	1971	1	W. Lauenroth

PRESENT (Ongoing Studies)

There are currently four arthropod-related projects on the SGS-LTER site:

a) Long-term tracking of arthropod populations across a topographical gradient

In 1990, J. Wiens and T. Crist began a project to study spatial variation in the abundance and diversity of shortgrass steppe arthropods along a topographical gradient representing the major soil and vegetation types of shortgrass steppe. At the conclusion of these studies in 1995, we resumed data collection along this transect to continue the one long-term study of arthropod populations on the site.

Dates: 1995 - present (1990-94 by J. Wiens and T. Crist, CSU)

Design: One 910-m transect of 182 pitfall traps along a gradient of vegetation and soil texture from ridge to swale. Traps are opened for 4 consecutive days in each session.

Frequency of sampling: Monthly during the growing season (April-September)

Data collected: Number of individuals captured per trap (usually identified to Order and Family; to Species for some common taxa)

b) Trends in abundance of arthropod prey of small mammals (Fig. 3)

We have tracked populations of small mammals in two representative shortgrass steppe habitats, grassland and saltbush (*Atriplex canescens*)-dominated lowlands, since 1994. Because most rodents present on the site are omnivores or insectivores, arthropods represent an important food resource that may explain temporal variation in rodent abundance. These studies also allow us to monitor changes in arthropod communities over time in these two habitat types (Fig. 3).

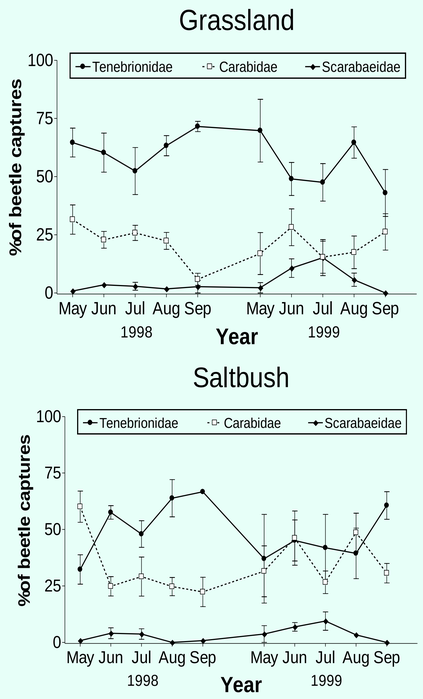
Dates: 1998 - present

Design: One 30-by-40 m pitfall grid (20 traps) on each of three grassland and three saltbush trapping webs. Traps are opened for 4 consecutive days in each session.

Frequency of sampling: Monthly during the growing season (April-September)

Data collected: Number of individuals captured per trap (usually identified to Order and Family; to Species for some common taxa)

Fig. 3. Beetle communities differ between grassland and saltbush-dominated sites. Tenebrionids are numerically dominant in both habitats but carabids are more common in shrub areas, where vegetative cover is higher.



c) Effects of prairie dogs on shortgrass-steppe arthropods

We recently completed comparative studies to determine the effects of prairie dogs (*Cynomys ludovicianus*) on fauna of shortgrass steppe. Because arthropods are likely to be affected by the burrowing and grazing of prairie dogs and because many vertebrate species rely on insect prey, we compared relative abundance and diversity of arthropods between active colonies and areas without prairie dogs **(Fig. 4)**. Additional research on grasshoppers and beetles associated with colonies were conducted by Jeanine Junell as part of her MS research in the CSU Department of Biology.

Dates: 1997-1999

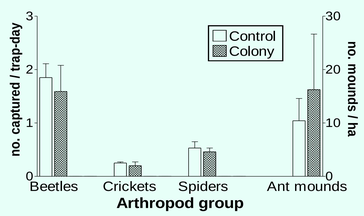
Design: Two live pitfall arrays (4 large cans connected by 3-m drift fences) on four prairie dog colonies and four uncolonized grassland sites. Traps were checked daily for 3-6 consecutive days in each session.

Frequency of sampling: Usually monthly during the growing season (April-September)

Data collected: Number of individuals captured per trap (usually identified to Order and Family; to Species for some common taxa)

Fig. 4. Although individual species were affected differently by the activities of prairie dogs, there were no significant differences in abundance of most ground-dwelling insects or in the density of harvester ant (*Pogonomyrmex occidentalis*) mounds between colonies and control plots.

Fig. 4. Effects of prairie dogs on insects



d) On-site arthropod reference collection for field crew training and education

We currently maintain a collection of arthropods for use in training field crew members, for educational/outreach visits by schools and other community groups, and to support other researchers on the site **(Table 2)**. At present our collection is small but contains representatives of the most common macroarthropods on the site, including a relatively complete collection of ants, grasshoppers, and tenebrionid beetles. We continue to build upon and improve this and our other on-site specimen collections with funds from a recent collections grant from NSF (DEB 9350273).

Table 2. Specimens currently housed in SGS-LTER Arthropod Reference Collection.

	Present on site[1]		In Collection	
Order	**No. families**	**No. species**	**No. Families**	**No. species (no. specimens)**
Acarina	19	33	1	1(1)
Anoplura	1	1	0	0(0)
Araneida	7	32	5	5(5)
Chelonethida	1	1	0	0(0)
Coleoptera	45	484	14	42(130)
Collembola	4	12	0	0(0)
Diptera	42	257	1	3(5)
Ephemeroptera	1	3	1	1(1)
Hemiptera	19	98	8	9(20)
Homoptera	13	138	1	1(1)
Hymenoptera	39	306	8	41(111)
Isoptera	1	1	0	0(0)
Lepidoptera	21	93	3	8(8)
Lithobiomorpha	1	1	0	0(0)
Neuroptera	4	8	1	2(5)
Odonata	4	10	2	2(2)
Orthoptera	7	59	3	13(14)
Psocoptera	1	5	0	0(0)
Siphonaptera	1	1	0	0(0)
Solpugida	1	3	1	1(1)
Trichoptera	3	3	0	0(0)
Thysanoptera	4	14	0	0(0)
Thysanura			1	1(1)

1 Based on Kumar et al. (1976)

CONCLUSIONS AND FUTURE PLANS

Despite the potential ecological importance of arthropods in shortgrass steppe grasslands, there are only a handful of arthropod related projects ongoing on the SGS-LTER. Most of these studies are designed to support and complement other SGS-LTER research projects.

We expect to continue our ongoing field projects aimed at tracking arthropod populations in representative shortgrass steppe habitats (a-c above) for the foreseeable future, and to continue building our reference collection (d above).

Entomological research on the SGS-LTER site is significantly limited by the lack of taxonomic expertise of the researchers currently conducting arthropod projects on the site (none of us are formally trained as entomologists). Collaboration with dedicated and trained insect ecologists would improve our ongoing studies. Interest in initiating new and cross-site comparative projects would greatly benefit our knowledge of the arthropod fauna.

Potentially fruitful areas of future research include experimental studies of the role of vertebrate predators in limiting arthropod populations and comparative analyses of population variability and stability of key taxa (e.g., grasshoppers, tenebrionid beetles) across grassland and desert LTER sites.

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