Invertabrate Abundance and Biomass Distribution Patterns in Western and Central Montana

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Abstract

We measured terrestrial invertebrate abundance and biomass at six different locations in western and central Montana from 2000 to 2002. Habitats at these sites included grass, shrub, or forest. Each of the three habitats occurred at two separate locations. At each site, 10 pitfall traps were constructed and sampled on a monthly basis from June through October. We searched for 15 taxonomic orders or classes and found all but two. Grass habitats had the highest invertebrate abundance and biomass followed by shrub and forest habitats respectively. Terrestrial invertebrate abundance and biomass were highest in mid-to-late summer (July and August) in western and central Montana. Average peak invertebrate abundance occurred in August and average peak invertebrate biomass occurred in July.

Key words: abundance, biomass, class, forest, grass, habitat, invertebrates, order, shrub

Introduction

We studied invertebrates as possible food sources for small mammals that carry Sin Nombre virus (SNV), a hantavirus that has been contracted in Montana. The invertebrate study was part of an ongoing longitudinal hantavirus study (Douglass et al 1996). Invertebrates are known to be food sources for small mammals such as shrews, voles, and mice (Burt and Grossenheider 1980). White-footed mice (*Peromyscus leucopus*) have been found to be the major predator of gypsy moth pupae (Hastings et al 2002). In western Montana, 84-86 percent of deer mouse (*P. maniculatus*), the major SNV vector, winter diets can consist of gall fly larvae (Pearson 1999).

During the longitudinal SNV rodent study, we had the opportunity to incorporate a survey of invertebrates at several locations in western and central Montana. The objective of our invertebrate study was to describe invertebrate animal communities by order or class in three general habitat types. To the best of our knowledge, terrestrial invertebrate communities have not been studied in Montana on a broad geographic scale. Because of the lack of published material relating to our objectives, and the fact that *Peromyscus* species demonstrate opportunistic food habits, we initiated our investigations with an initial broad scale inventory of invertebrates. Terrestrial invertebrates are active in Montana seasonally and are limited by temperature. Winter typically lasts from October until April, which gives terrestrial invertebrates up to six months of activity in a wide variety of habitats. We sampled invertebrate communities from May through October 2000-2002. Our data will be useful in understanding deer mouse population ecology and the SNV cycle and provides new information concerning invertebrate communities in Montana.

Methods and Materials

We studied invertebrates at six different locations in western and central Montana (Fig. 1). The sites were near Wisdom, Polson, Gold Creek, Cut Bank, Cascade, and on the C. M. Russell National Wildlife Refuge. Because the study was conducted concurrently with the long-term

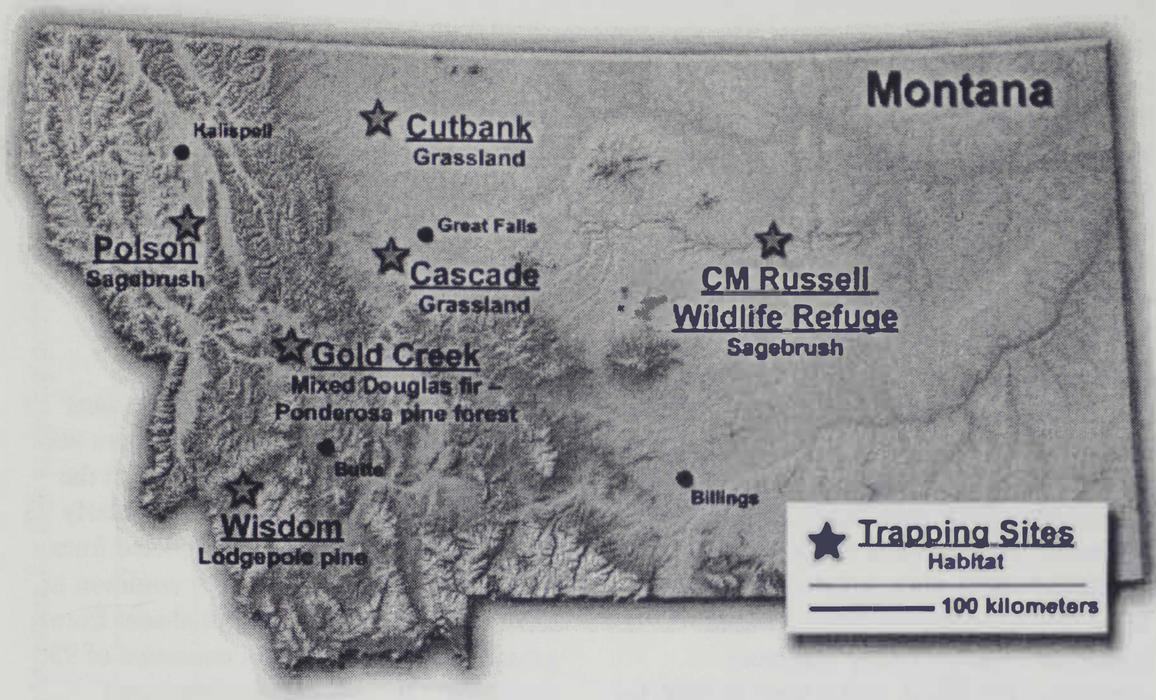

Figure 1. Locations and habitat types of invertebrate collection sites in Montana. Locations are associated with longitudinal small mammal – hantavirus studies.

longitudinal hantavirus research, all study sites were on the same study grids (100 X 100 m) as the hantavirus project (Douglass 1996). We classified each site as forest, shrub, or grass habitat. Topography was variable among sites and elevations ranged from 738 to 1957 m.

We did not intend this study to be a comprehensive analysis of invertebrate communities. We used pitfall traps in order to capture invertebrates that best represented what deer mice could use as a food. At each site, 10 pitfall traps were constructed at 15.7-m intervals. Two 355-ml (12-oz) plastic cups were placed one inside the other in the ground so the tops of the cups were level with the ground. The bottom cup provided a foundation and easy removal of the top cup. A 15-cm mesh, metal ladder was placed in the top cup to allow small mammals to escape. The top cup was filled one third full of "low-tox" antifreeze to kill invertebrates and to keep the cups' contents from freezing. A 30 X 30 cm board, weighted with rocks or sticks, was placed over the trap about 3 cm off the ground to allow invertebrates access, as well as keeping other animals and precipitation from disturbing the trap.

From 2000 to 2002, invertebrate collections were completed at one-month intervals from June through October with the exception of the Wisdom site, which was sampled July through October due to inaccessibility in June because of snow. On the day of collection, the cups' contents were poured through a strainer and invertebrates were removed and placed in individually marked plastic vials filled with isopropyl alcohol. Each pitfall trap was reset before moving on to the next trap.

Later, we extracted all non-invertebrate debris from each vial. Invertebrates were identified to their taxonomic order or class with the aid of a dissecting microscope. We measured wet biomass to 0.01 gm using a digital balance, recorded total numbers and biomass of each order or class from each individual pitfall trap site, and entered the data into a computer data base for analysis.

Results

We searched for 15 taxonomic orders within three taxonomic classes during the project (class Crustacea; order Isopoda, class Arachnida; order Araneida, class

Insecta; orders Coleoptera, Collembola, Dermatera, Diplura, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Neuroptera, Orthoptera, Thysanura, Diptura, and Homoptera). In addition, two classes, Chilopoda and Diplopoda, were found but not identified to order. Only two orders, Diplura and Neuroptera, of the 15 initially chosen were not identified during the project.

Several orders and one class were abundant. We calculated the average number and biomass of invertebrates/month (sampling period) by class or order over the course of the three-year study (Table 1). We found that in terms of abundance over three summers, Hymenoptera, which consisted mainly of ants, was most abundant ($\bar{x}$ = 100.2 individuals/month) for all six study sites. The following included average number of individuals for other groups: Orthoptera ($\bar{x}$= 61.0/month), Araneida ($\bar{x}$ = 59.4/month), Diptera ($\bar{x}$ = 55.1/month), Coleoptera ($\bar{x}$ = 53.8/month), and Diplopoda ($\bar{x}$ = 40.4/month). Orthoptera (mainly grasshoppers and crickets), Araneida (spiders), Diptera (flies), and Coleoptera (beetles) were common orders found among all six study sites. However, Diplopoda (millipedes) was mainly collected (89% of all collected Diplopodans) at the Gold Creek site. The ranking from highest three-year average invertebrate abundance to lowest by site (Table 2) was Cascade (542.4), Gold Creek (511.6), Cut Bank (407.7), Polson (396.9), CMR (395.6), and Wisdom (312.7).

The most productive, i.e., highest average biomass/month, taxonomic group over 3 years for the combined study sites was Orthoptera ($\bar{x}$ = 18.2 g; Table 1). While Orthopterans were most abundant and individual body size was larger than other orders/classes, which in turn produced an average biomass more than twice that of other orders/classes except Coleoptera ($\bar{x}$ = 11.6 g). Diplopoda ($\bar{x}$ 6.1 g), Hymenoptera ($\bar{x}$ = 2.9 g), Araneida ($\bar{x}$ = 2.9 g), and Diptura ($\bar{x}$ = 1.8 g) were also among the highest in average biomass. The most productive sites from most to least by 3-yr average biomass/sampling period (Table 2) were Cascade (64.8 g), Gold Creek (53.1 g), CMR (52.6 g), Cut Bank (50.7 g), Polson (24.5 g), and Wisdom (14.5).

As noted above for Diplopoda, certain orders or classes were strongly associated with certain habitats/sites. We found Phalangida (daddy-long legs) to be very abundant in a grassland at the Cascade study site but not at other study sites. Eighty-eight percent of all Phalangidans were collected at Cascade. Thysanura was strongly associated with sagebrush at the Polson study site and consisted of nearly 98 percent of all Thysanurans collected from all sites. Homoptera was very common in the grassland at Cascade (but absent from grassland at Cutbank) and consisted of 93 percent of all Homopteran specimens collected from all sites. Table 2 shows the most productive sites in relation to each taxonomic order or class.

Abundance of orders/classes was also analyzed by sampling period (Table 1). Over three years, the highest average abundance peaked during the August sampling period at 569.3 invertebrates. Abundance gradually increased until August and gradually declined after the August sampling period. Biomass, however, was variable among the 6-month sampling period. Average biomass started at 43.2 g on average in June, peaked in July with 59.0 g, fell to 53.8 g in August, increased to 55.8 g in September and then dropped to 17.6 g in October. Some of the low biomass in June resulted from not including the Wisdom site, which was not sampled due to accumulations of snow. Additionally during June 2001, collections were completed at all sites but misplaced, and thus, limiting our samples to only four periods for 2001 (Jul-Oct).

Of the six most abundant orders/class, average numbers of three (Araneida, Diplopoda and Diptura) peaked during August. Average numbers of Coleoptera and Hymenoptera were highest in June; and average numbers of Orthoptera peaked in September. The respective highest to lowest average invertebrate biomass/year

Table 1. Invertebrate abundance and biomass averaged for six locations in central and western Montana for five sampling periods from 2000 through 2002.

		ABUNDANCE						BIOMASS (grams)					
Order	Common Name	June	July	August	Sept	Oct	3 yr. Avg.	June	July	August	Sept	Oct	3 yr. Avg.
Isopoda	Sowbugs (pillbugs)	2.0	0.7	2.2	0.7	0.3	1.1	0.1	0.0	0.1	0.0	0.0	0.03
Araneida	Spiders	61.0	72.6	83.2	50.3	30.6	59.4	3.1	4.3	3.3	2.2	1.7	2.9
Phalangida	Harvestmen & daddy-l.l.	28.9	23.3	14.6	18.3	12.1	18.5	1.2	1.2	0.7	1.1	0.7	1.0
Chilopoda (class)	Centipedes	1.2	1.9	1.4	1.9	1.9	1.7	0.0	0.2	0.1	0.1	0.1	0.1
Diplopoda (class)	Millipedes	14.9	42.3	72.6	39.4	21.4	40.4	1.5	6.3	10.2	7.9	2.6	6.1
Coleoptera	Beetles	91.3	86.1	52.2	40.4	15.5	53.8	18.7	19.2	10.6	10.4	2.3	11.6
Collembola	Springtails	0.7	0.0	0.0	0.7	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.02
Dermaptera	Earwigs	0.0	0.0	0.0	0.0	0.1	0.01	0.0	0.0	0.0	0.0	0.0	0.04
Diplura	Diplurans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hemiptera	True bugs	0.0	1.0	0.2	0.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Hymenoptera	Ants, terrestrial wasps	184.4	152.8	118.5	67.5	19.9	100.2	4.5	5.6	2.6	1.9	0.6	2.9
Isoptera	Terrestrial termites	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lepidoptera	Larvae only (caterpillars)	3.1	2.8	1.7	7.3	0.9	3.2	0.6	0.6	0.2	0.2	0.1	0.3
Neuroptera	Antlions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Orthoptera	Grasshoppers, crickets,	29.8	63.7	72.7	91.4	31.7	61.0	12.1	20.1	21.0	26.8	8.2	18.2
Thysanura	Silverfish, Bristletails	0.8	6.3	19.6	9.7	2.4	8.5	0.0	0.1	0.3	0.2	0.1	0.1
Diptura	Flies	16.7	26.8	106.2	67.7	38.7	55.1	0.7	0.7	3.4	2.7	1.0	1.8
Homoptera	Cicads, Aphids	0.2	5.8	4.2	31.6	0.0	9.3	0.0	0.2	0.0	0.8	0.0	0.2
Lepidoptera	Butterflies, Moths	9.3	2.8	6.7	5.3	0.9	4.5	0.7	0.3	1.2	1.1	0.1	0.7
Other:		1.6	6.0	13.3	13.4	4.5	8.5	0.0	0.3	0.2	0.2	0.1	0.2
	Total	446.0	495.0	569.3	446.2	180.8	Total	43.3	59.0	53.8	55.8	17.6	

Table 2. Three year average invertebrate abundance and biomass for each of six locations in western and central Montana from 2000 through 2002.

		ABUNDANCE					
Order	**Common Name**	**Cascade**	**CMR**	**Cutbank**	**Gold Cr.**	**Polson**	**Wisdom**
Isopoda	Sowbugs (pillbugs)	1.8	0.0	0.0	0.0	4.6	0.0
Araneida	Spiders	39.9	76.9	44.5	60.0	63.6	73.4
Phalangida	Harvestmen & daddy-l.l.	95.6	2.5	0.3	9.3	0.4	0.6
Chilopoda (class)	Centipedes	1.4	1.1	3.2	0.8	0.3	3.8
Diplopoda (class)	Millipedes	0.2	25.4	0.0	210.8	0.1	0.0
Coleoptera	Beetles	47.7	20.8	92.6	74.9	33.2	53.2
Collembola	Springtails	0.0	0.0	0.5	0.9	0.0	0.0
Dermaptera	Earwigs	0.1	0.0	0.0	0.0	0.0	0.0
Diplura	Diplurans	0.0	0.0	0.0	0.0	0.0	0.0
Hemiptera	True bugs	0.0	0.3	1.3	0.0	0.7	0.3
Hymenoptera	Ants, terrestrial wasps	108.0	36.9	47.9	117.2	184.1	119.3
Isoptera	Terrestrial termites	0.0	0.0	0.0	0.1	0.1	0.3
Lepidoptera	Larvae only (caterpillars)	11.1	0.6	1.1	2.4	2.8	0.3
Neuroptera	Antlions	0.0	0.0	0.0	0.0	0.0	0.0
Orthoptera	Grasshoppers, crickets,	98.8	115.2	116.7	4.9	29.1	8.8
Thysanura	Silverfish, Bristletails	0.1	0.2	0.2	0.4	48.3	0.0
Diptura	Flies	74.6	101.9	80.9	21.6	19.1	34.5
Homoptera	Cicads, Aphids	50.1	1.1	0.0	0.6	0.2	1.9
Lepidoptera	Butterflies, Moths	4.9	3.4	11.4	0.1	7.6	0.1
Other:		8.1	9.5	7.1	7.5	2.7	16.3
	Total	**542.4**	**395.6**	**407.7**	**511.6**	**396.9**	**312.7**

		BIOMASS (grams)					
Order	**Common Name**	**Cascade**	**CMR**	**Cutbank**	**Gold Cr.**	**Polson**	**Wisdom**
Isopoda	Sowbugs (pillbugs)	0.0	0.0	0.0	0.0	0.1	0.0
Araneida	Spiders	1.9	0.4	2.2	3.5	3.1	3.7
Phalangida	Harvestmen & daddy-l.l.	5.0	0.2	0.0	0.4	0.0	0.0
Chilopoda (class)	Centipedes	0.3	0.1	0.2	0.0	0.0	0.1
Diplopoda (class)	Millipedes	0.0	2.4	0.0	33.4	0.0	0.0
Coleoptera	Beetles	13.5	9.3	6.7	9.1	5.2	4.8
Collembola	Springtails	0.0	0.0	0.0	0.1	0.0	0.0
Dermaptera	Earwigs	0.0	0.0	0.0	0.0	0.0	0.0
Diplura	Diplurans	0.0	0.0	0.0	0.0	0.0	0.0
Hemiptera	True bugs	0.0	0.0	0.0	0.0	0.0	0.0
Hymenoptera	Ants, terrestrial wasps	5.2	3.0	0.8	4.2	3.4	3.1
Isoptera	Terrestrial termites	0.0	0.0	0.0	0.0	0.0	0.0
Lepidoptera	Larvae only (caterpillars)	0.6	0.1	0.1	0.4	0.5	0.0
Neuroptera	Antlions	0.0	0.0	0.0	0.0	0.0	0.0
Orthoptera	Grasshoppers, crickets,	33.2	34.1	35.3	1.1	9.3	1.9
Thysanura	Silverfish, Bristletails	0.0	0.0	0.0	0.0	0.7	0.0
Diptura	Flies	2.5	2.3	4.1	0.5	1.0	0.5
Homoptera	Cicads, Aphids	1.1	0.0	0.0	0.0	0.0	0.2
Lepidoptera	Butterflies, Moths	1.2	0.7	1.2	0.0	1.1	0.0
Other:		0.3	0.1	0.2	0.2	0.1	0.2
	Total	**64.8**	**52.6**	**50.7**	**53.1**	**24.5**	**14.5**

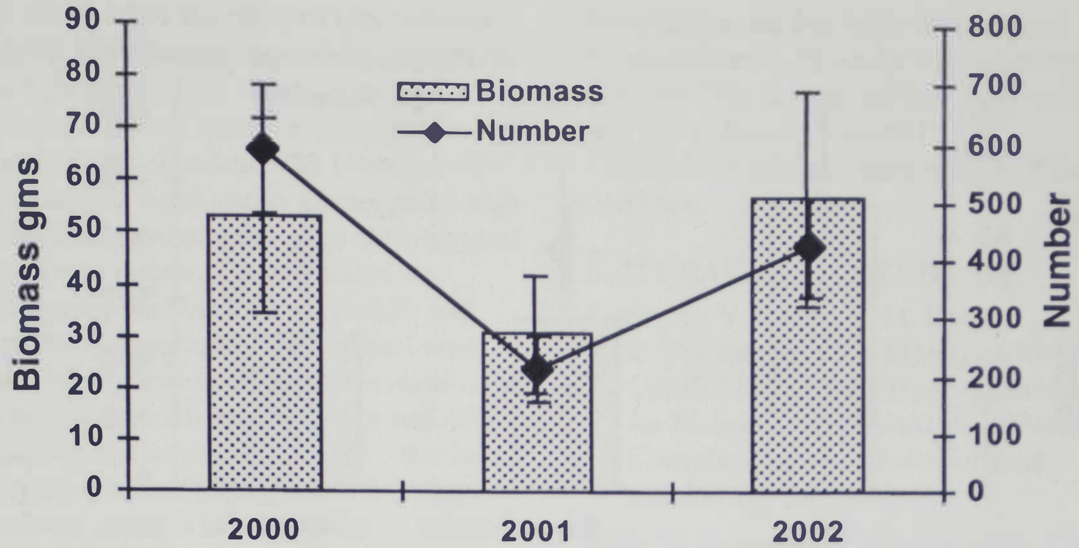

Figure 2. Average abundance and biomass of invertebrates captured in 10 pitfall traps at each of six locations in central and western Montana from 2000 through 2002. Error bars represent 95-percent CI for 30 sampling periods for 2000 and 2002 and 24 sampling periods for 2001.

was 2000, 2002, and 2001 (Fig. 2). Because averages included all habitats, the variance within years for both biomass and abundance was very high as indicated by the large 95-percent confidence intervals. Average invertebrate biomass by year from highest to lowest was the same as abundance—2000, 2002, and 2001 (Fig. 2). In 2001 average invertebrate biomass and abundance declined considerably (Fig. 2). The 2001 decline was consistent for all study sites except Cascade. Part of the 2001 decline could have been due to the loss of data from the 2001 June sampling period.

Grass habitats at Cascade and Cut Bank had the highest invertebrate biomass and abundance (Fig. 3). Shrub habitats at Polson and CMR had the next highest biomass, but the lowest abundance (Fig. 3). Forest habitats at Gold Creek and Wisdom had the lowest average invertebrate biomass (Fig. 3). Forested habitats had intermediate (between grass and shrub habitats) invertebrate abundance. Because the averages represent all sampling periods for each habitat, the intra-habitat variance is large. We found that eight orders/classes were most abundant in grassy habitats. Six orders of invertebrates were most abundant in shrub and forest habitats. Highest average biomass was similar to that of abundance when compared among habitat type. Eleven orders/classes had their highest average biomass in grass habitats, five orders highest in shrub habitat, and four order/classes had their highest biomass in forest habitats.

Discussion

We found all but two (Diplura and Nueroptera) of the 15 targeted taxonomic groups during the study. If pit fall traps effectively capture Diplura and Neuroptera, then the six sites studied were not suitable for sustaining communities of Diplura and Neuroptera. However, several orders were common in all three habitats. For example, orders Araneida, Orthoptera, Coleoptera, Hymenoptera, and Diptura occurred at all six study sites. Other orders or classes were collected at all six study sites but not necessarily in significant numbers at all times. According to McNett and Rypstra (2000), structural complexity of the environment is clearly related to both the abundance and diversity of species in an area as well as behavior of the organisms inhabiting it. Certain habitats might be beneficial to some invertebrates and detrimental to others. Stinson and Brown (1980) found that species richness and

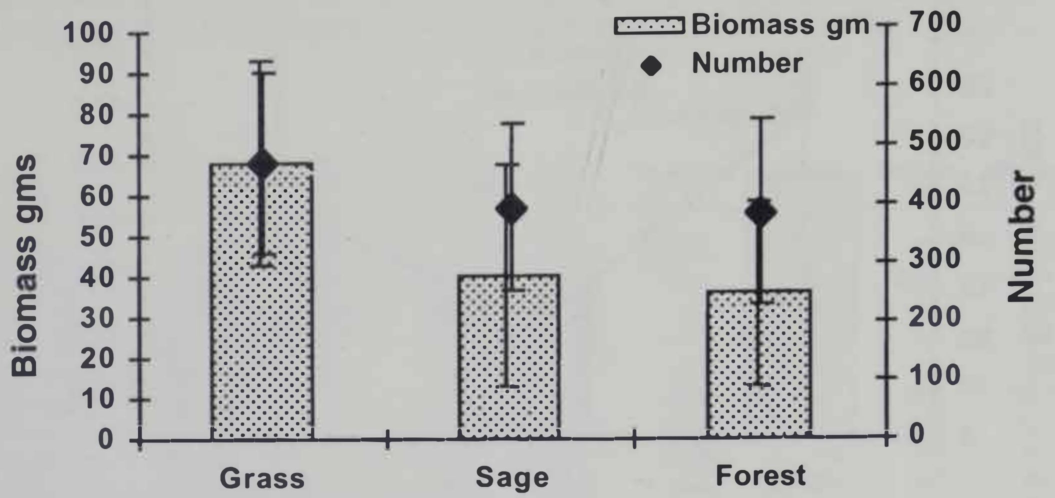

Figure 3. Average abundance and biomass of invertebrates captured in pitfall traps set in three habitats in central and western Montana from 2000 through 2002. Error bars represent 95-percent CI for 29 sampling periods for grass and sage habitats and 26 periods for forest habitats.

abundance of certain leafhoppers was strongly correlated with the architecture of their host plants. Therefore, forested habitats may be beneficial to diplopodans, as long as the architecture of that forest adheres to needs of that particular order or, more specifically, that species. In addition to habitat complexity, food or prey abundance may also contribute to invertebrate distribution (Mcnett and Ryptsra 2000).

Craig et al. (1999) reported that warm and sunny open ground was critical to survival and reproduction of several grasshopper species. At Cut Bank and Cascade, both open grass habitats, Orthoptera was the most common order found. The average biomass of Orthopterans at Cut Bank over the three years during each sampling period was 35.3 g, more than five times the next closest average biomass, Coleoptera, in the same traps.

Many factors may contribute to abundance and distribution of invertebrates across a landscape, including land use activities such as agriculture and silviculture, ambient temperature, moon-phase, air movements, amount of precipitation, amount and time of direct sunlight during a trapping period, local vegetation, natural population fluctuations, time of year, and trap design, kind, and positioning (Butler et al. 1999). In a study conducted by Rogers and Woodley (1978) in South-central Washington, invertebrate density and biomass was highest during April and May and steadily declined through summer and fall. The invertebrate density and biomass patterns paralleled the live plant biomass trend. Peak biomass values for green vegetation occurred during April or May and then declined with the onset of summer drought conditions. The parallel time of vegetation productivity and insect biomass and population density suggests that biomass and density of dominant invertebrate groups are correlated with the green growth period of early spring (Rogers and Woodley 1978). Similar trends occurred throughout our six study sites, except peak values occurred in July and August. Later timing was likely due to longer, colder winter seasons in Montana. By October, invertebrate abundance significantly declined probably reflecting frosts that begin in mid-September.

We intend to incorporate invertebrate data as we try to explain deer mouse population dynamics. However, at this point deer mouse abundance has been highest in sage communities (Douglass et al. 2001) while invertebrate (trappable in pitfall traps) abundance and biomass tended to be highest in grasslands. Data summarized in Figure 2 suggest that neither invertebrate abundance nor biomass differ statistically significantly among grass, sage and forest communities. The abundance of both deer mice and invertebrates are extremely variable both temporally and spatially. Consequently additional work will be required to elucidate the relationship between invertebrate abundance and deer mouse populations. Deer mouse numbers usually increase during fall as freezing reduces captures of invertebrates. Although freezing probably severely limits invertebrate movement in the fall, it may not limit their availability to rodents. Answering our questions about the importance of invertebrates to rodent ecology requires further investigation into the spatial relationship between individual invertebrate taxa and rodent communities and food habits.

Insects dwell within complex ecosystems and interact with other taxonomic groups and the abiotic environment (Hunter 2002). While our study covered a broad scale, we believe our findings can be used as a basis for appropriate future research in geographic areas that we studied. Future analysis will include taxa-by-taxa comparisons among years and habitats conducted simultaneously with rodent stomach content analysis. The results of this project add to our knowledge of invertebrate distribution and abundance in western and central Montana and provide relative abundance and biomass of potential food for vertebrates such as rodents and insectivores.

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