Communities of Canopy-Dwelling Arthropods in Response to Diverse Forages

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Communities of Canopy-Dwelling Arthropods in Response to Diverse Forages

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Core Ideas

- True bugs, grasshoppers, and spiders were among the more abundant canopy arthropods in pastures.
- Old world bluestem had among the least abundance of canopy arthropods in 2 out of 3 yr.
- Old world bluestem provides a less favorable habitat than alfalfa for canopy insects.

Abstract: 'WW-B.Dahl' old world bluestem (OWB) [*Bothriochloa bladhii* (Retz) S.T. Blake] is an important warm-season perennial grass pasture in semiarid western Texas. This grass deters pestiferous ants; however, its effect on canopy-dwelling insects is not documented. The abundance of canopy-dwelling arthropods among OWB, OWB–alfalfa (*Medicago sativa* L.), alfalfa, and native grass pastures was compared by sweep-net sampling over 3 yr (2014–2016). Forty-six families of nine insect orders and a single family of spider (Araneae: Araneidae) were identified. Among total individuals, 85% were insects and 15% were spiders. Housefly (*Musca* spp., Diptera: Muscidae), potato leafhopper (*Empoasca* spp., Hemiptera: Cicadellidae), lygus bug (*Lygus hesperus*, Hemiptera: Miridae), and spur-throated grasshopper (*Melanoplus* spp., Orthoptera: Acrididae) were other abundant taxa. Among the insects collected, spur-throated grasshoppers were the most abundant, comprising 12% of total taxa. Alfalfa hosted the greatest number of total insects, including pests such as potato leafhopper and lygus bug. Lower abundances of pestiferous insects were found in OWB while still hosting greater abundances of some arthropods of ecological significance such as spider and ladybird beetle (*Hippodamia* spp., Coleoptera: Coccinellidae).

The limited water supply for irrigation in the Texas High Plains has encouraged some growers to convert their irrigated annual cropland to perennial forages with low water needs. 'WW-B.Dahl' old world bluestem (OWB) [*Bothriochloa bladhii* (Retz) S.T. Blake] is a drought-tolerant, warm-season perennial grass in dryland and limited water conditions (Dahl et al., 1988). The grass matures 3 to 5 wk later than other old world bluestems (*Bothriochloa* spp.) (Dewald et al., 1995). Some old world bluestem species deter various insect taxa (Zalkow et al., 1980). A pasture containing OWB had 75% fewer red imported fire ant (*Solenopsis invicta* Buren, Hymenoptera: Formicidae) mounds compared with adjacent pastures of bermudagrass [*Cynodon dactylon* (L.) Pers.] in Texas (Sternberg et al., 2006). Recent work revealed that pastures containing OWB were essentially devoid of red imported fire ants and harvester ants (*Pogonomyrmex* spp.) (Bhandari et al., 2018c) and that OWB had minor inhibitory effects on honey bees (Hymenoptera: Apidae) and sweat bees (Hymenoptera: Halictidae) compared with adjacent alfalfa (*Medicago sativa* L.) and native grass pastures (Bhandari et al., 2018d). Bhandari et al. (2018b) demonstrated on the same pastures a numerical tendency for deterrence of horn flies (*Haematobia irritans* L.) on cattle grazing OWB, but horn fly densities still exceeded threshold levels that called for late-season insecticidal fly control. In contrast to evidence of inhibitory effects of OWB on insects, Bhandari et al. (2018a) found that OWB mixed with alfalfa had the greatest soil microbial biomass and enzyme activities and no suppressing effect of OWB alone on soil microbial community variables such as microbial biomass C, microbial biomass N, and enzyme activities linked to C, N, P, and S cycling.

Alfalfa typically hosts a wide range of insect communities that feed in the canopy. A study in the Central Valley of California reported about 1000 species of arthropods associated with alfalfa (van den Bosch and Stern, 1969).

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Abbreviations: OWB, 'WW-B.Dahl' old world bluestem.

On average, >13 insect species 1.5 m^{-2} of alfalfa were found in a study in Colorado (Dyer and Stireman, 2003). Bastola et al. (2017) found significantly greater abundance of canopy-dwelling arthropods in alfalfa than in cotton (*Gossypium hirsutum* L.) in the Texas High Plains. Various aphid species (Hemiptera: Aphididae), weevils (Coleoptera: Curculionidae), and potato leafhopper [*Empoasca fabae* (Harris); Hemiptera: Cicadellidae] are especially important insect pests of alfalfa (Chasen et al., 2014; Sulc and Lamp, 2007). Information on canopy-active arthropod communities is needed to complement information on pestiferous and beneficial organisms in the soil, forage, and animal strata to predict the ecological impact of converting cropland to OWB. This study characterizes the composition of arthropods in canopies of OWB, OWB–alfalfa, alfalfa, and native mixed forages.

Materials and Methods

The study was conducted at the New Deal Research Farm of Texas Tech University in Lubbock County, Texas (33°45′ N, 101°47′ W; 993 m elevation). The site has 0 to 1% slope with Pullman clay loam (fine, mixed, superactive, thermic Torrertic Paleustolls) soil. This survey was performed on pastures concurrent with beef-cattle grazing research on different forage types, which constitute treatments in the insect surveys. Forage types consisted of (i) a pure stand of 2.06 ha of each of three replicates of OWB established in 2003; (ii) 2.10 ha of OWB with 'RSI 707' alfalfa and 'Madrid' yellow sweet clover [*Melilotus officinalis* (L.) Lam.], of which the OWB component was established in 1998 and into which the alfalfa and sweet clover components were interseeded in 2010 and 2014; (iii) 0.93 ha of alfalfa with 'Jose' tall wheatgrass [*Thinopyrum ponticum* (Podp.) Z.-W. Liu & R.-C. Wang] established in 2009; and (iv) 4.53 ha of a native-grass mix containing buffalograss [*Bouteloua dactyloides* (Nutt.) J.T. Columbus], blue grama [*B. gracilis* (Willd. ex Kunth) Lag. ex Griffiths], sideoats grama [*B. curtipendula* (Michx.) Torr.], and green sprangletop [*Leptochloa dubia* (Kunth) Nees]). Yellow sweet clover was present only in spring and early summer 2015 with less than 2%; thus, we refer to this treatment here simply as OWB–alfalfa. Alfalfa content on a dry weight basis in that mixture was usually less than 15% (Baxter et al., 2017a). The tall wheatgrass content with alfalfa was usually less than 10%, so it is referred to herein as alfalfa. Supplemental irrigation to the OWB, OWB–alfalfa, and alfalfa pastures was provided from underground drip trapes (Netafim, USA); the native mix was not irrigated. The native mix did not receive N inputs. In 2014, the native grass mix was cut for hay only once (but not grazed) and was not cut for hay in 2015 and 2016; the other forage types were cut for hay once in each year and grazed frequently. Details on pasture establishment and management can be found in Baxter et al. (2017b).

Arthropods were collected on clear-sky days on 29 June 2014, from 19 to 26 June 2015, and from 13 to 20 July 2016. A sweep net was used to sweep the canopy vegetation in a back-and-forth motion along three 20-m transects. Collected insects were transferred to zipper-lock freezer bags, and the bags were stored in a cooler with ice for the duration of field sampling. In the laboratory, samples were stored at –20°C to kill the arthropods, which were then identified to family level and counted. A few adult beetles and larvae of butterfly and moth were not identified to family level, but their numbers were included in the total and order levels. Arthropods were noted as to their functions as pollinator, herbivore, or predator. Timings of sweep-net samplings were set when forage canopies had at least 50% ground cover and before they were intensively grazed or cut for hay.

The sum of arthropod abundances across all sweep-net transects (60 m by 1.2 m) within an individual pasture constituted an experimental unit. Data were analyzed using analysis of variance in a randomized complete block design that consisted of four forage types and three replicates for within-year tests. Main effects of forage type, year, and forage × year interactions on taxon-level abundances were tested by combining years. Data were analyzed using Proc Mixed in SAS 9.4 (Littell et al., 2006). Forage type was set as a fixed effect, and replicate and year were set as random effects. LSMEANS procedure was used to compare means. Differences among the treatments were considered significant at $P \leq 0.05$.

Results and Discussion

Forty-six families of nine insect orders and one spider order were collected (Table 1). The arthropods collected were adults, except for some larvae of butterflies and moths. Both adults and larvae were included in the analysis and data tables. Functional groupings resulted in 72.0% herbivores, 25.5% predators, 2.0% pollinators, and 0.5% mixed functions depending on species make-up. The most abundant arthropod collected was spider (Araneae: Araneidae), followed by spur-throated grasshopper (*Melanoplus* spp.; Orthoptera: Acrididae). The next less abundant taxa were potato leafhopper (*Empoasca* spp.; Hemiptera: Cicadellidae) and lygus bug (*Lygus hesperus* Knight; Hemiptera: Miridae). Other insect taxa of interest, such as ladybird beetle (*Hippodamia* spp.; Coleoptera: Coccinellidae), flies (Diptera), red imported fire ant, and sweat bee (*Augochlorella* spp.; Hymenoptera: Halictidae), were present in relatively low abundances.

Total canopy-dwelling arthropods were most abundant in pastures containing alfalfa and least in OWB (Table 2). Some orders are not shown in Table 2 because numbers were relatively low and forage effects were not significant in at least 2 out of 3 yr. These include Coleoptera, which comprised eight identified families (10% of total abundance), and Diptera, which comprised nine families (7% of total abundance) (Table 1). Furthermore, Neuroptera, Odonata, and Thysanoptera were each present in less than 0.4% of total individuals. Pastures that contained OWB had among the least abundant bee, wasp, and ant (Hymenoptera) abundances. Butterfly and moth (Lepidoptera) abundances were among the highest in the pastures that contained alfalfa and among the least in grass-only pastures such as OWB and native mix, especially in 2015. The OWB–alfalfa hosted the greatest abundances of spur-throated grasshopper (*Melanoplus* spp.) in 2015 and 2016. Spider numbers were greatest in OWB–alfalfa in 2015, but relative rankings of forage types varied among years. Ant lion (Neuroptera: Myrmeleontidae), green lacewing (Neuroptera: Chrysopidae), damselfly (Odonata: Lestidae), and thrips (Thysanoptera: Thripidae) were found only in one or two forage types. Abundances were greatest ($P < 0.05$) in 2015 (a relatively high rainfall year) for all orders except Hymenoptera (year means not shown). All taxa had forage × year interactions ($P < 0.01$).

Table 1. List of taxa, functional groups, and abundances of arthropods summed over three transects per pasture and averaged over four forage treatments, three replications, and 3 yr.

Order	Family	Common name	Functional group	Abundance
				no. pasture^{-1}
Coleoptera	Coccinellidae	ladybird beetle	Predator	2.0
	Melyridae	soft-winged flower beetle	Herbivore	1.8
	Mordellidae	tumbling flower beetle	Herbivore	1.7
	Curculionidae	weevil	Herbivore	0.8
	Cerambicydae	long-horned beetle	Herbivore	0.6
	Chrysomelidae	leaf beetle	Herbivore	0.2
	Cleridae	checkered beetle	Herbivore	0.2
	Elateridae	click beetle	Herbivore	<0.1
	Unidentified	–	Herbivore	1.7
Diptera	Muscidae	house fly	Herbivore	2.2
	Agromyzidae	leaf minor fly	Herbivore	1.8
	Dolichopodidae	long-legged fly	Herbivore	0.9
	Sarcophagidae	flesh fly	Herbivore	0.7
	Calliphoridae	blow fly	Herbivore	0.3
	Chironomidae	midge	†	0.2
	Culicidae	mosquito	†	0.2
	Tachinidae	tachinid fly	Herbivore	0.1
	Tabanidae	horse fly	Herbivore	<0.1
Hemiptera	Cicadellidae	potato leafhopper	Herbivore	8.9
	Miridae	lygus bug	Herbivore	6.1
	Aphididae	sugarcane aphid	Herbivore	3.8
	Anthocoridae	minute pirate bug	Herbivore	3.7
	Rhopalidae	scentless plant bug	Herbivore	3.0
	Membracidae	buffalo treehopper	Herbivore	2.1
	Pentatomidae	stink bug	Herbivore	0.9
	Berytidae	stilt bug	Herbivore	0.7
	Reduviidae	assassin bug	Herbivore	0.7
	Alydidae	broad-headed bug	Herbivore	0.3
	Lygaeidae	seed bug	Herbivore	0.3
Hymenoptera	Formicidae	fire ant	Predator	3.8
	Halictidae	sweat bee	Pollinator	1.0
	Ichneumonidae	ichneumon wasp	Predator	0.9
	Pompilidae	spider hawk wasp	Predator	0.9
	Apidae	honey bee	Pollinator	0.3
	Braconidae	braconid wasp	Predator	0.3
	Colletidae	fork-tongued bee	Pollinator	0.3
	Megachilidae	leafcutter bee	Pollinator	0.3
	Vespidae	yellowjacket	Predator	0.2
	Siricidae	horntail	Predator	<0.1
Lepidoptera	Noctuidae	moth	Herbivore	2.0
	Pyralidae	pyralid moth	Herbivore	1.6
	Lycaenidae	blues and hairstreaks	Herbivore	0.7
	Unidentified	–	Herbivore	2.1
Neuroptera	Chrysopidae	green lacewing	Predator	0.3
	Myrmeleontidae	ant lion	Predator	0.1
Odonata	Lestidae	damselfly	Herbivore	0.1
Orthoptera	Acrididae	spur-throated grasshopper	Herbivore	10.8
Thysanoptera	Thripidae	thrips	Herbivore	<0.1
Araneae	Araneidae‡	spider	Predator	13.1

† Midge and mosquito can be assigned as detritivore or predator depending on species.
‡ Other minor unidentified families within Araneae are included.

In general, the greatest numbers of major insects were among pastures containing alfalfa and least were among OWB pastures (Table 2). A similar trend was detected with total pollinator numbers, which were less in OWB than in alfalfa in 2 out of 3 yr when collected in bee bowls (Bhandari et al., 2018d). The greater number of canopy-dwelling insects in alfalfa is in line with that reported by Sulc and Lamp (2007), in which a wide range of insect communities including pests are expected in alfalfa. No taxa showed significantly greater abundances in OWB than in other forage types except spiders in 2015. Jabbour and Noy (2017) reported that the most problematic pests of alfalfa in Wyoming are alfalfa weevil [*Hypera postica* Gyllenhal (Coleoptera: Curculionidae)] followed by grasshopper (Orthoptera). No feeding damage by weevil or grasshopper was observed in these pastures during collection times, probably attributable to a small abundance of weevil in all pastures (Table 1) and low abundance of grasshopper in alfalfa (Table 2). The OWB treatment had a tendency of lower abundances of total canopy-dwelling arthropods, including pestiferous insects such as potato leafhopper, sugarcane aphids (*Melanaphis sacchari*; Hemiptera: Aphididae), and ants. Numbers of ladybird beetle, an important predator of aphids, were not depressed in OWB relative to numbers in alfalfa, but they were found in very low numbers in all pastures. Therefore, there is no evidence that the beneficial ladybird beetles were suppressed by OWB relative to other forages.

The forage types were not all managed the same but were managed according to best practices consistent with the species make-up and environment. For example, the native mix was not irrigated or fertilized, in accordance with management of local rangeland. Care was taken to conduct sampling

Table 2. Abundance of total arthropods, four insect orders and one order of spider (Araneae) by pasture type and year, summed over three transects per pasture replicate and averaged over three replications.

Taxon	Pasture type	2014	2015	2016	Mean
		no. pasture^{-1}			
Total	OWB†	40 b‡	70 b	61	57 c
	OWB–alfalfa	52 b	171 a	63	95 ab
	Alfalfa	109 a	153 a	61	108 a
	Native mix	59 b	171 a	49	93 b
	Forage effect	$P < 0.001$	$P < 0.01$	$P = 0.59$	$P < 0.001$
	Forage × year		$P < 0.001$		
Hemiptera	OWB	13 b	12 b	12 c	12 b
	OWB–alfalfa	25 b	32 b	14 bc	24 b
	Alfalfa	56 a	69 a	24 a	50 a
	Native mix	26 b	86 a	17 b	43 a
	Forage effect	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$
	Forage × year		$P < 0.001$		
Hymenoptera	OWB	5	1 b	1	2 b
	OWB–alfalfa	6	9 b	3	6 b
	Alfalfa	5	6 b	22	11 a
	Native mix	10	18 a	10	13 a
	Forage effect	$P = 0.69$	$P = 0.01$	$P = 0.10$	$P < 0.001$
	Forage × year		$P < 0.01$		
Lepidoptera	OWB	2 b	2 b	1 bc	2 c
	OWB–alfalfa	2 b	15 a	2 ab	7 b
	Alfalfa	22 a	22 a	3 a	16 a
	Native mix	1 b	4 b	0 c	2 c
	Forage effect	$P < 0.01$	$P < 0.01$	$P = 0.01$	$P < 0.001$
	Forage × year		$P < 0.01$		
Orthoptera	OWB	4	2 b	9 bc	5 b
	OWB–alfalfa	6	43 a	23 a	24 a
	Alfalfa	5	7 b	4 c	5 b
	Native mix	7	7 b	13 b	9 b
	Forage effect	$P = 0.16$	$P = 0.01$	$P < 0.01$	$P < 0.001$
	Forage × year		$P < 0.01$		
Araneae	OWB	2 b	25 b	26 a	18 a
	OWB–alfalfa	4 ab	44 a	5 b	18 a
	Alfalfa	7 a	23 b	2 b	11 b
	Native mix	<1 b	14 b	4 b	6 b
	Forage effect	$P = 0.03$	$P = 0.03$	$P = 0.01$	$P < 0.01$
	Forage × year		$P < 0.001$		

† OWB, 'WW-B.Dahl' old world bluestem.

‡ Means within columns followed by similar letters are not different at $\alpha = 0.05$.

in adequately developed canopies before intense grazing or haying events. There was no clear inhibitory effect of OWB on canopy-active beneficial insects, namely, pollinators or predators. The lower abundances of arthropods in OWB relative to alfalfa may be explained by a combination of greater attractiveness of alfalfa for insects and low habitat suitability of OWB. Further arthropod assessments on larger commercial pastures are desirable to minimize possible edge effects that experimental pastures may have induced.

Conclusions

The previous discovery of deterrence of ground-dwelling ants by OWB (Bhandari et al., 2018c) prompted us to document the effects of OWB on arthropod abundance and population structure in other pasture niches. The strong depression of ant communities did not carry over to a comparable suppression of canopy-dwelling arthropods. Inhibition by OWB of canopy arthropods reported herein and by pollinators (Bhandari et al., 2018d) indicate that multiple collection sites should be surveyed for a comprehensive assessment of the ecological impact of wide-scale establishment of OWB.

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