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Loren W. Burger Jr.
University of Missouri

Eric W. Kurzejeski
Missouri Department of Conservation

Thomas V. Dailey
Missouri Department of Conservation

Mark R. Ryan
University of Missouri

RELATIVE INVERTEBRATE ABUNDANCE AND BIOMASS IN CONSERVATION RESERVE PROGRAM PLANTINGS IN NORTHERN MISSOURI

LOREN W. BURGER Jr., The School of Natural Resources, 112 Stephens Hall, University of Missouri, Columbia, MO 65211

ERIC W. KURZEJESKI, Missouri Department of Conservation, 1110 South College Avenue, Columbia, MO 65201

THOMAS V. DAILEY, Missouri Department of Conservation, 1110 South College Avenue, Columbia, MO 65201

MARK R. RYAN, The School of Natural Resources, 112 Stephens Hall, University of Missouri, Columbia, MO 65211

Abstract: We measured relative invertebrate abundance, biomass, and diversity in Conservation Reserve Program (CRP) fields planted to red clover (*Trifolium pratense*)/timothy (*Phleum pratense*), timothy, orchard-grass (*Dactylis glomerata*), tall fescue (*Festuca pratensis*), warm-season grasses (big bluestem [*Andropogon gerardi*]/switch grass [*Panicum virgatum*]), orchard-grass/Korean lespedeza (*Kummerowia stipulacea*), and conventionally-tilled soybeans, to assess brood habitat quality for northern bobwhite (*Colinus virginianus*). We sampled invertebrate populations by vacuuming along 3 15-m transects (4.56 m^2/sample) within 4 fields of each planting type, at 2-week intervals from 1 July to 15 August 1990 and 1991. Invertebrate abundance and biomass were lowest in early August ($P < 0.05$). The CRP fields planted to a red clover/timothy mixture, and dominated by red clover, had the highest levels of invertebrate abundance and biomass ($P < 0.05$). Conventionally-tilled soybeans had lower invertebrate abundance and biomass than all CRP covertypes ($P < 0.05$). Mean invertebrate abundance and biomass in CRP fields were 4 times that of soybean fields. In northern Missouri, CRP fields could provide quality brood habitat if structural characteristics are also consistent with brood foraging needs. Incorporation of a legume in CRP plantings may produce higher invertebrate densities and improve the value of these fields as brood habitat.

Key words: brood ecology, brood habitat, *Colinus virginianus*, Conservation Reserve Program, insect, invertebrate, northern bobwhite.

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Invertebrates are the primary component in the diet of galliform chicks during the first 6 weeks after hatching (Handley 1931, Southwood and Cross 1969, Hurst 1972, Healy 1985, Erpelding et al. 1987). Invertebrates are critical to growth and survival of chicks, providing essential amino acids and high concentrations of protein, water, and energy (Nestler et al. 1942, 1945, Almquist 1952, Savory 1977, Wise 1982, Potts 1986, Dahlgren 1990).

Studies of willow ptarmigan (*Lagopus lagopus*), ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), and red-legged partridge (*Alectoris rufa*) have reported positive relationships between invertebrate densities and brood survival (Green 1984, Erikstad 1985, Hill 1985, Sotherton and Robertson 1990). Dahlgren (1990) reported that consumption of invertebrates by juvenile gray partridge affected not only juvenile growth rate, but also ultimate adult body size, egg size and quality, and reproductive success.

Hayfields, small grains, forage legumes, and old fields have been reported to support rich invertebrate communities (Hurst 1972, Hill 1976, Whitmore 1982, Jackson et al. 1987) and provide quality brood habitat (Hurst 1972, Warner 1979, Enck 1987). However, as agricultural landscapes have shifted toward intensive rowcrop monocultures, availability of these habitats has declined throughout the Midwest (Vance 1976, Taylor et al. 1978, Miller 1980). As brood habitat has become more limiting, northern bobwhite broods may have necessarily become more dependent on rowcrops for foraging. However, rowcrop fields treated with pesticides support low invertebrate populations and provide poor brood habitat (Whitmore 1982, Green 1984, Warner et al. 1984, Hill 1985, Rands 1985, Sotherton and Robertson 1990). Warner et al. (1984) and Nelson et al.

(1990) have reported evidence linking increased amount of rowcrops and diminished amounts of small grain and forage crops to reductions in invertebrates and declining brood survival. Broods foraging in cropland move more and have lower survival than those foraging in diverse grasslands (Warner 1984, Enck 1987, L. W. Burger Jr., Univ. of Missouri, Columbia, unpubl. data).

Herbaceous vegetation available in CRP fields could provide quality brood habitat for bobwhite in intensively farmed areas. This USDA cropland diversion program has retired 12.6 million ha of highly erodible cropland nationally. In the CRP, fields are taken out of production for 10 years and planted to a permanent covercrop. In Missouri, 607,000 ha of cropland have been enrolled in the CRP and planted primarily in grasses or grass/legume mixtures. These idle grasslands could provide brood foraging habitat that is otherwise limiting in intensively cultivated portions of Missouri.

Invertebrate densities have been estimated for a variety of agricultural habitats (Hurst 1972, Whitmore 1982, Basore et al. 1987, Enck 1987, Jackson et al. 1987), but documentation of invertebrate densities in cropland diversion program fields is lacking. In 1990 and 1991, we documented the relative abundance of invertebrates in 6 CRP cover plantings and conventionally-tilled soybeans in northern Missouri as an index to northern bobwhite brood habitat quality. We tested the hypotheses of no differences in relative invertebrate abundance, biomass, and diversity among cover plantings.

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METHODS

Study fields were on private land in Knox and Macon counties, northcentral Missouri. Soils in this area are predominantly Mexico-Putnam, Armstrong-Leonard, or Lindley-Keswick associations. These are somewhat poorly to moderately well-drained, deep soils occurring on gently to moderately sloping uplands (Watson 1979). In 1991, 18% of Macon County and 30% of Knox County were planted to rowcrops (corn, soybeans, or milo), and 9.6% of Macon County and 15.3% of Knox County were enrolled in the CRP (USDA Agr. Stat. Serv., Columbia, MO, unpubl data).

We sampled invertebrates in CRP fields planted to red clover, timothy, orchard grass, fescue, warm season grass (big bluestem or switch grass) or orchard grass/Korean lespedeza, and conventionally tilled soybeans. Contract guidelines of the CRP require that planting mixtures contain a perennial grass, therefore pure red clover was not an accepted planting option. Timothy/clover plantings, a common mixture in northern Missouri, were often dominated by nearly pure stands of clover during the first 2 years after establishment. Consequently, we sampled recently established stands of timothy/red clover that were totally dominated by red clover. We refer to these fields as "red clover." The warm-season grass fields were planted to either switchgrass or big bluestem (2 fields each). The CRP plantings were 2-5 years old. Fields selected for sampling were dominated (75% cover) by the specified planting type, but typically contained a diverse complement of volunteer annual and perennial weeds and Korean lespedeza (Burger et al. 1990). Soybean fields all received herbicide treatment at planting, were not cultivated, and were relatively weed-free. Specific types and rates of herbicide application are unknown. Insecticides are not typically used on soybeans in northern Missouri. Four replicate fields of each planting type were selected. Study fields were 8-48 ha in size. Ten fields sampled in 1990 were not sampled in 1991 because of changes in land use or dominant vegetation. In 1991, we replaced these fields with fields of the appropriate planting type.

We sampled invertebrate populations by vacuuming (D-Vac insect sampler) 15 cm above the ground along 3 15-m transects (4.56 m^2/sample) at 25-m intervals along a randomly selected transect within each field (Hurst 1972). All samples were collected 25 m from a field edge. We sampled each field 4 times, at 2-week intervals, from 1 July to 15 August in 1990 and 1991. Insects were sorted, identified to order, counted, dried for 24 hrs at 70 C and weighed. The mean weight of an individual invertebrate was determined for each order, within each cover planting, and for each time interval by cumulatively weighing all of the invertebrates within that group and dividing by the number of individuals being weighed. Biomass of each invertebrate order was calculated for each sample by multiplying the number of individuals of that order in the sample by the mean order- specific weight per individual during that time interval, in that cover planting. We used the mean number of invertebrate orders per sample as an index to invertebrate diversity.

Invertebrate abundance and biomass data from 1990 and 1991 were analyzed separately because we did not sample all of the same fields in both years. Furthermore, we observed differences in overall invertebrate abundance between years that may have been due to differences in precipitation patterns. Counts of invertebrates per sample were square-root transformed to improve normality and reduce heteroscedascity (Sokal and Rohlf 1981:423). Transects within a field were treated as subsamples; fields were treated as replicates. We used 2-way ANOVA to test for main effects of sampling week and cover planting on total invertebrate biomass and abundance, and biomass and abundance in 5 selected orders reported to be important bobwhite chick foods (Handley 1931, Hurst 1972, Jackson et al. 1987). We used Tukey's HSD multiple comparison to test for differences among treatments (week or cover planting) following a significant ($P < 0.05$) ANOVA F-test (Day and Quinn 1989). This test controls experiment-wise error rate at alpha = 0.05.

RESULTS

Sampling periods by covertype interactions were generally not significant for invertebrate abundance (1990: $F = 1.77$, df = 18, $P = 0.11$; 1991: $F = 1.46$, df = 18, $P = 0.21$), biomass (1990: $F = 4.31$, df = 18, $P = 0.0009$; 1991: $F = 1.12$, df = 18, $P = 0.39$), or diversity (1990: $F = 1.72$, df = 18, $P = 0.12$; 1991: $F = 0.79$, df = 18, $P = 0.69$); therefore, we report only main effects.

We observed differences among sampling periods for 1990 and 1991 in total invertebrate abundance (1990: $F = 8.62$, df = 3, $P = 0.0006$; 1991: $F = 4.42$, df = 3, $P = 0.01$), diversity (1990: $F = 8.83$, df = 3, $P = 0.0006$; 1991: $F = 3.06$, df = 3, $P = 0.05$), and biomass (1990: $F = 17.17$, df = 3, $P = 0.0001$; 1991: $F = 3.07$, df = 3, $P = 0.05$). Invertebrate abundance, biomass, and diversity varied widely across sampling periods during 1990 and 1991. In both years, invertebrate abundance, biomass, and diversity were lowest during early August (Table 1).

In both years, total invertebrate abundance differed among cover plantings (1990: $F = 12.44$, df = 6, $P = 0.0001$; 1991: $F = 7.19$, df = 6, $P = 0.0003$) and was greatest in red clover (Table 2). Soybeans had the lowest numbers of invertebrates, although not significantly so in 1991. Homopterans were the most common invertebrate during both years.

During 1990 and 1991, total invertebrate biomass differed among cover plantings (1990: F

Table 1. Mean[a] relative invertebrate abundance, biomass (mg), and diversity in Conservation Reserve Program fields in northern Missouri during 1 July-22 August 1990-91.

		Sampling period[b]			
		1	2	3	4
1990					
	Abundance[c]	130.8 A[d]	107.7 B	36.7 D	77.9 C
	Biomass[e]	72.3 B	133.1 A	41.5 C	53.9 C
	Diversity[f]	7.5 A	7.6 A	6.5 B	6.6 B
1991					
	Abundance[c]	63.9 A	46.2 B	32.6 B	65.8 A
	Biomass[e]	48.4 AB	51.2 A	25.2 C	39.5 B
	Diversity[f]	6.9 AB	6.5 BC	6.2 C	7.1 A

[a]Means computed across 7 cover plantings, 4 fields/cover planting, and 3 D-Vac subsamples/field; $n = 84$.
[b]Period 1: 1-7 July; period 2: 15-22 July; period 3: 1-7 August; period 4: 15-22 August.
[c] Mean number of invertebrates/sample.
[d] Means within rows with the same letter are not different, Tukey's HSD, $P > 0.05$.
[e] Mean invertebrate biomass (mg)/sample.
[f] Mean number of invertebrate orders/sample.

Table 2. Mean[a] number of invertebrates/sample in 6 Conservation Reserve Program cover plantings and soybean fields in northern Missouri, 1 July-15 August 1990-91.

		Cover plantings						
Year	Order	Red clover	Warm-season grass	Orchard-grass/ lespedeza	Tall fescue	Timothy	Orchard-grass	Soybeans
1990	Homoptera	109.0 A[b]	35.7 B	13.5 DE	39.9 B	24.7 C	16.7 CD	8.3 E
	Hemiptera	10.7 A	4.4 B	3.7 BC	0.7 D	3.9 BC	2.7 C	4.2 BC
	Orthoptera	1.2 C	1.0 C	2.4 B	3.4 B	5.6 A	3.1 B	0.9 C
	Coleoptera	18.4 A	10.9 B	4.0 C	3.1 C	5.0 BC	2.6 CD	0.6 D
	Diptera	61.0 A	27.4 B	12.0 D	12.6 DE	32.1 BC	15.6 CD	4.4 E
	Total[c]	226.8 A	93.7 B	53.9 CD	68.2 BCD	81.3 BC	49.1 D	20.8 E
1991	Homoptera	43.7 A	30.6 A	12.4 B	7.6 BC	6.2 C	8.3 BC	8.4 BC
	Hemiptera	11.2 A	4.7 B	2.0 CD	0.6 D	3.5 BC	2.0 CD	2.4 BC
	Orthoptera	2.5 A	1.4 A	1.4 A	1.8 A	1.8 A	1.7 A	0.1 B
	Coleoptera	24.6 A	3.0 DE	11.2 B	5.7 CD	7.2 BC	10.6 BC	0.9 E
	Diptera	12.5 A	8.4 AB	14.2 A	4.7 BC	2.7 C	4.2 C	10.0 A
	Total[c]	105.9 A	73.2 B	58.7 B	37.3 C	32.4 C	35.3 C	25.1 C

[a] Means computed across 4 sample periods, 4 fields/cover planting, and 3 D-Vac subsamples/field; $n = 48$.
[b] Means within rows with the same letter are not different, Tukey's HSD, $P < 0.05$.
[c] Total number of invertebrates/sample, summed across all orders.

Table 3. Mean[a] invertebrate biomass (mg)/sample in 6 Conservation Reserve Program cover plantings and soybean fields in northern Missouri, 1 July-15 August 1990-91.

		Cover plantings						
Year	Order	Red clover	Warm-season grass	Orchard-grass/ lespedeza	Tall fescue	Timothy	Orchard-grass	Soybeans
1990	Homoptera	96.1 A[b]	24.5 C	10.3 DE	50.5 B	23.3 CD	15.6 CDE	3.8 E
	Hemiptera	22.5 A	7.8 B	6.0 BC	0.7 D	6.7 BC	2.0 CD	4.1 BCD
	Orthoptera	16.1 BC	6.3 C	16.3 BC	25.7 AB	34.2 A	32.0 A	7.8 C
	Coleoptera	8.9 A	9.3 A	2.3 B	0.8 B	2.2 B	1.0 B	1.8 B
	Diptera	7.5 AB	5.5 BC	2.1 D	1.7 D	8.9 A	2.3 CD	1.3 D
	Total[c]	178.2 A	61.3 BC	44.1 CD	84.7 B	86.4 B	56.1 C	22.3 D
1991	Homoptera	28.4 A	19.7 B	9.8 C	9.0 C	6.1 C	8.2 C	3.1 C
	Hemiptera	17.6 A	7.4 B	2.3 CD	0.5 D	7.0 BC	1.4 D	1.8 D
	Orthoptera	23.2 A	7.9 BC	10.4 B	11.3 B	10.1 B	10.6 B	0.4 C
	Coleoptera	11.6 A	2.1 BC	5.2 B	1.5 C	2.7 BC	3.4 BC	1.3 C
	Diptera	1.6 BCD	1.7 BC	2.6 AB	0.6 D	0.8 CD	0.7 CD	2.8 A
	Total[c]	90.4 A	50.3 B	39.2 BC	34.7 BC	35.4 BC	27.0 CD	12.3 D

[a] Means computed across 4 sample periods, 4 fields/cover planting, and 3 D-Vac subsamples/field; $n = 48$.
[b] Means within rows with the same letter are not different, Tukey's HSD, $P < 0.05$.
[c] Total invertebrate biomass (mg)/sample, summed across all orders.

Table 4. Mean[a] number of invertebrate orders/sample in 6 Conservation Reserve Program cover plantings and soybean fields in northern Missouri, 1 July-15 August 1990-91.

	Cover plantings						
Year	Red clover	Warm-season grass	Orchard-grass/ lespedeza	Tall fescue	Timothy	Orchard-grass	Soybeans
1990	7.9 A[b]	7.6 AB	7.1 B	7.3 AB	7.2 AB	6.8 B	4.9 C
1991	7.1 ABC	6.9 ABC	7.5 A	6.7 BC	7.4 AB	6.4 C	4.8 D

[a]Means computed across 4 sample periods, 4 fields/cover planting, and 3 D-Vac subsamples/field; $n = 48$.
[b]Means within rows with the same letter are not different, Tukey's HSD, $P < 0.05$.

= 11.52, df = 6, P 0.0001; 1991: $F = 7.51$, df = 6, $P = 0.0002$) and was greatest in red clover plantings and lowest in soybean fields (Table 3).

Invertebrate diversity differed among cover plantings in both years (1990: $F = 13.64$, df = 6, $P = 0.0001$; 1991: $F = 8.05$, df = 6, $P = 0.0001$). Soybean fields had the lowest invertebrate diversity (Table 4).

DISCUSSION

Herbaceous vegetation available in CRP fields may provide quality habitat for upland game species in intensively farmed areas. Most studies focusing on the habitat value of the CRP (Farmer et al. 1988, Hays et al. 1989) and earlier federal cropland diversion programs (Joselyn and Warnock 1964, Edwards 1984, Berner 1988) have discussed the value of these programs in terms of nesting and winter habitat for wildlife. Burger et al. (1990) suggested that vegetative structure in Missouri CRP fields could be conducive to bobwhite brood foraging. Structure only partially determines brood habitat quality; invertebrate abundance is a primary determinant of brood habitat quality (Hurst 1972, Jackson et al. 1987). We observed that abundance, biomass, and diversity of selected invertebrates tended to be greater in CRP plantings than in conventionally-tilled soybeans. This suggests that CRP fields could provide brood habitat superior to that available in rowcrops if structural characteristics are also consistent with brood foraging needs.

Burger et al. (1990) further suggested that the potential value of CRP fields as brood habitat could differ among cover plantings and management practices. We observed differences in invertebrate abundance and biomass among different CRP cover plantings with the highest insect abundance and biomass in red clover. The importance of legumes in producing invertebrates has been suggested by others (Stoddard 1963, Jackson et al. 1987). Webb (1963) observed higher invertebrate density in clover than in native grasses. Dunaway (1976) reported greater abundance and biomass of invertebrates in kobe lespedeza (*Lespedeza striata*) strips than in native grass/forb communities in pine (*Pinus* spp.) forests. In 1 of 2 years, Jackson et al. (1987) observed higher abundance and biomass of coleopterans in fertilized kobe lespedeza fields than in old fields or fertilized old fields. Others have recommended the inclusion of legumes in plantings as a means of improving brood habitat quality for selected galliforms (Whitmore et al. 1986). Our findings suggest that the addition of a legume component to grass plantings on CRP acres may increase invertebrate abundance and biomass, thereby improving brood habitat quality for bobwhite.

Nelson et al. (1990) reported that dense monotypic stands of switchgrass and mixed warm-season grass plantings had lower invertebrate abundance and biomass than cool-season grass plantings. Furthermore they suggested that the structure of warm-season grass plantings was less conducive to brood foraging needs. They concluded that "...native warm-season grasses, commonly recommended as nesting cover for pheasants and waterfowl, do not provide quality brood-rearing habitat for game bird chicks" (Nelson et al. 1990:110). In contrast, we observed relatively high invertebrate abundance and biomass in 2-5 year old CRP fields planted to warm-season grass, typically being exceeded only by red clover plantings. The differences in their findings and ours may be related to age of plantings, diversity of annual weeds, and management practices. We believe that diverse (weedy) warm-season grass plantings can provide habitat structure and invertebrate populations consistent with bobwhite brood foraging needs.

Many studies have suggested that galliform chicks selectively feed on certain groups of invertebrates. Beetles (Coleoptera), leafhoppers (Homoptera), true bugs (Hemiptera), flies (Diptera), and small grasshoppers and crickets (Orthoptera) have all been reported to be "preferred" foods in the diets of galliform chicks (Handley 1931, Hurst 1972, Healy et al. 1985, Whitmore et al. 1986, Erpelding et al. 1987, Jackson et al. 1987). These orders commonly occurred in invertebrate samples from the grass and grass/legume habitats that we sampled. Relative abundance of invertebrates in these 5 orders was typically lower in soybean fields than in any of the CRP plantings that we studied.

We also observed greater diversity of invertebrate orders in CRP fields than in soybean fields. Such invertebrate diversity could provide a buffer against short-term environmental change and provide a more reliable food base for galliform chicks than that occurring in rowcrop monocultures.

In intensively cultivated portions of the Midwest, both the quality and quantity of brood habitat may limit brood survival and upland bird populations (Warner et al. 1984, Enck 1987, Nelson et al. 1990). In northern Missouri, CRP fields do provide structural characteristics (Burger et al. 1990) and invertebrate densities consistent with brood foraging needs and can provide brood habitat superior to that available in croplands.

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