Arthropod Response to Strip Disking in Old Fields Managed for Northern Bobwhites

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Abstract: In the southeastern United States northern bobwhite (*Colinus virginianus*) populations have declined rapidly during the past 3 decades. Deterioration of suitable habitat conditions has been suggested as a major cause of this decline. Habitat management efforts typically focus on production of fall/winter foods (i.e., seeds). Management efforts are seldom directed at production of breeding season foods (i.e., arthropods) for bobwhites. Therefore, we used a D-Vac insect vacuum to measure effects of strip disking on arthropod resources in old fields managed for northern bobwhites during the 1992 and 1993 breeding seasons. Disked fields contained greater arthropod biomass than undisked fields. Greater arthropod biomass was supported primarily by increases in phytophagous insects. Arthropod biomass did not differ between years. We recommend strip-disked areas be incorporated into old field management plans for northern bobwhites to provide elevated levels of proteinaceous food resources required by laying females and growing chicks.

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Northern bobwhite populations have significantly declined over most of its geographic range since the 1960s (Droege and Sauer 1990, Brennan 1991, Church et al. 1993). This decline has been most pronounced in the southeastern United States, which is the center of the bobwhite's range and which has histori-

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cally supported abundant populations (Rosene 1969:17–25, Gutierrez et al. 1983).

Many agricultural areas in the Southeast have been abandoned or left idle. Such areas are typically not quality agricultural lands (i.e., small field size, poor soil conditions, and/or susceptibility to erosion), but often contain habitat components (e.g., nesting cover, feeding areas for adults and broods) potentially important to northern bobwhites. Old fields provide bobwhites optimal habitat for 3–5 years after abandonment (Stoddard 1931, Rosene 1969, Roseberry and Klimstra 1984), after which they generally become sub-optimal for bobwhites (Stoddard 1931, Byrd 1956, Rosene 1969).

Old field habitat manipulations such as controlled burning and disking retard plant succession and are recommended habitat management practices for bobwhites (Stoddard 1931, Cushwa et al. 1969, Rosene 1969, Buckner and Landers 1979, Landers and Mueller 1986, Lewis and Harshbarger 1986). Success of these manipulations is attributed to production of early successional vegetation communities rich in fall and winter food resources (i.e., seeds). This perspective has developed from diet studies based on samples collected during the hunting season (Gullion 1966). Such studies provide incomplete information about factors regulating or limiting game bird populations because food resources during other times of the year, such as the breeding season, also may be critical (Gullion 1966, Potts 1986, Sotherton et al. 1993).

Fall populations of northern bobwhites are typically composed of >70% subadults hatched the previous summer (Marsden and Baskett 1958, Roseberry and Klimstra 1984:136, Pollock et al. 1989), signifying the importance of the reproductive period. Subadult bobwhites have yet to exploit fall and winter resources. Their survival and recruitment into the fall population hinges on availability of appropriate habitat conditions and dietary resources during summer (Gullion 1966).

Northern bobwhite chicks require proteinaceous foods for reproduction and growth (Nestler et al. 1944, Nestler 1949, Rosene 1969:108). Arthropods supply this important resource (Handley and Cottam 1931, Hurst 1972, Eubanks and Dimmick 1974, Jackson et al. 1987). Although arthropods play an important role during the bobwhite's reproductive period, information on how commonly applied habitat manipulations (i.e., controlled burning, disking) influence these resources are limited. Therefore, we studied effects of strip disking on arthropod resources in old fields at 3 sites in Mississippi during the 1992 and 1993 bobwhite breeding seasons.

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Methods

This study was conducted at 3 sites. Copiah County Wildlife Management Area (CCWMA), managed by MDWFP, is located in the Lower Thin Loess physiographic region of south Mississippi (see Pettry (1977) for description of soil resource areas). The area is composed of pine (*Pinus* spp.), upland hardwoods, and old fields. Fields were used primarily for hay production prior to 1988, and left idle until this study began in 1991. Noxubee National Wildlife Refuge (NNWR), managed by the USFWS, is located primarily within the Interior Flatwoods physiographic region of east Mississippi. The area is composed of upland pines and hardwood drains, with fields interspersed throughout. Fields were maintained by burning and mowing prior to 1987, and left idle until this study began. Trim Cane Wildlife Demonstration Area (TCWDA), managed by MDWFP, is located within an alluvial floodplain between the Interior Flatwoods and Blackland Prairie physiographic regions in northeast Mississippi. The area is composed of field and wooded hedgerow habitats. Fields were last farmed in 1986 and left idle until this study began. Woody and herbaceous vegetation dominated old fields at all study areas. Prior to initiation of experiments, fields were composed of approximately 55%, 35%, and 50% woody vegetation at CCWMA, NNWR, and TCWDA, respectively. For detailed description of study areas see Fuller (1994), Lee (1994), and Manley (1994).

Strip-Disk Manipulations

The study areas contained 8, 7, and 13 fields at CCWMA, NNWR, and TCWDA, respectively. Strip disking was applied to half of the fields, which were selected at random. In disked fields, 40% of the soil was disturbed, approximately 15 ($\pm$ 5) cm deep, in alternating strips (12–15 m wide) each year. Efforts were made to disk soil consistently within and among study areas. Fields used in this study were of similar size, approximately 6 ha. We intended to strip-disk fields on a predetermined schedule; October–November 1991 and 1992. However, strip disking for October–November 1992 was delayed until May 1993 at NNWR and TCWDA due to wet weather conditions.

Data Collection

We estimated relative arthropod biomass in disked and unmanipulated fields using a D-Vac insect vacuum (intake cone diameter = 310 cm^2). The D-vac produces similar results as other sampling techniques when estimating relative arthropod biomass (Marston et al. 1976, Smith et al. 1976) and selects for small insects consumed by bobwhite chicks (Hurst 1972). In disked fields, sampling was restricted to strips that were <1 year old. Sampling occurred during mid-day (1400) when most diurnal insects undergo a cessation of feeding activity, concentrate at the base of vegetation, and are most available for collection (Dumas et al. 1962).

Data collection occurred during the bobwhite's peak brood rearing period (i.e., late June to early August [Rosene 1969:59]). Sampling was conducted in strip-disked and unmanipulated fields at 1-week intervals, for 8 consecutive weeks. Fields were sampled at random with replacement. During each sampling interval, 5 sub-samples per field (15 m transects, 75 m total) were pooled to estimate arthropod biomass.

Sampling followed a systematic random design. In each field a random starting point was located ≥25 m into the field. The vacuum was then lowered to ground level at full throttle, held at a 45° angle, and traversed along a 15-m transect. Four additional transects (sub-samples) were spaced at 25-m intervals along a random bearing. These intervals correspond to the average distance between disked strips. If necessary, we adjusted distance between transects to assure sampling was conducted within disked strips.

Samples were sorted to order and identified according to Borror et al. (1989). Samples were dried at 87 C, and weighed (±0.1 mg) on an analytical balance. Individual arthropods ≥0.035 g were discarded because they were considered too large to be ingested by bobwhite chicks (Hurst 1972).

Data Analyses

Pre-existing differences in woody vegetation coverage, physiographic location, and prior land-use practices were present at each study area. Therefore, we used analysis of variance (ANOVA) (SAS Inst. Inc. 1988), in a randomized complete block design, to test effects of strip disking on arthropod biomass. We considered year and treatment as fixed effects, and blocked on study areas. We assumed that estimates of arthropod biomass were independent among the 8 weeks because they were separated temporally and/or spatially. We tested the null hypothesis that arthropod biomass, averaged over the 8-week brood rearing period, did not differ among strip-disked and unmanipulated fields.

Results

Total biomass of arthropods did not differ significantly ($F = 2.47$, df = 1,90 $P = 0.119$) between years and there was no year by treatment interaction ($F = 0.37$, df = 1,90 $P = 0.547$). Therefore, data from 1992 and 1993 were pooled. Total biomass of arthropods was greater ($F = 15.82$, df = 1,90 $P < 0.001$) in strip-disked fields than in unmanipulated fields. This trend was evident at each study site each year, except for NNWR in 1993 (Table 1). Increased biomass was due primarily to increases of phytophagous insects (e.g., Orthoptera, Homoptera, Coleoptera, Fig. 1). Arthropod biomass did not differ significantly between study areas ($F = 2.57$, df = 2,90 $P = 0.082$).

Table 1. Data summary presenting means[a] of arthropod biomass (g) from experimental old fields at 3 study areas in Mississippi, June–August 1992–1993.

	Copiah County Wildlife Management Area		Noxubee National Wildlife Refuge		Trim Cane Wildlife Demonstration Area	
Order[b]	Control (N = 8)	Disked (N = 8)	Control (N = 8)	Disked (N = 8)	Control (N = 8)	Disked (N = 8)
1992						
Total[c]	0.174	0.265	0.331	0.780	0.143	0.398
Orthoptera	0.011	0.033	0.215	0.591	0.078	0.213
Homoptera	0.039	0.042	0.026	0.060	0.017	0.064
Coleoptera	0.029	0.041	0.012	0.018	0.010	0.043
Hemiptera	0.040	0.043	0.020	0.029	0.008	0.024
Araneae	0.020	0.027	0.033	0.051	0.013	0.025
Diptera	0.021	0.047	0.009	0.019	0.011	0.008
Hymenoptera	0.013	0.029	0.006	0.012	0.005	0.016
Miscellaneous[d]	0.001	0.004	0.009	0.001	0.001	0.006
1993	(N = 8)	(N = 8)	(N = 8)	(N = 8)	(N = 8)	(N = 8)
Total[c]	0.151	0.619	0.225	0.200	0.104	0.247
Orthoptera	0.020	0.299	0.072	0.043	0.016	0.095
Homoptera	0.025	0.086	0.033	0.067	0.024	0.070
Coleoptera	0.010	0.048	0.008	0.010	0.010	0.010
Hemiptera	0.049	0.041	0.045	0.014	0.005	0.015
Araneae	0.020	0.058	0.048	0.016	0.032	0.032
Diptera	0.013	0.039	0.009	0.029	0.008	0.010
Hymenoptera	0.014	0.035	0.006	0.012	0.008	0.008
Miscellaneous[d]	0.002	0.012	0.004	0.010	0.002	0.007

[a]Means computed across 8 sampling periods.
[b]*Only the orders comprising ≥1.0% of the pooled total biomass are noted.*
[c]Total arthropod biomass (g/sample) summed across all orders.
[d]Miscellaneous orders include Acarina, Blattaria, Mantodea, Neuroptera, Odonata, and Phasmida.

Discussion

Phytophagous insects (e.g., Orthoptera, Homoptera, Coleoptera) that forage on the host plant community are the most important arthropod food resources for bobwhites (Handley and Cottam 1931, Hurst 1972, Eubanks and Dimmick 1974, Jackson et al. 1987). Several authors have reported greater densities of these arthropods in herbaceous early successional habitats. Hurst (1972) observed greater arthropod biomass in burned versus unburned old fields. Nelson et al. (1990) reported greater biomass of arthropods in cool-season grass plantings than in monotypic stands of switchgrass or warm-season grasses. Webb (1963) reported higher invertebrate density in clover than in native grasses. Similarly, Whitmore (1982) observed >3 times the biomass of arthropods in clover stands than in bluegrass stands. Lastly, Burger et al. (1993), reported greater arthropod biomass in clover compared to other various Conservation Reserve Program plantings.

Responses of phytophagous insects to early successional herbaceous habitats may be governed in part by increased quality of available forage. Disking increases annual grasses and forbs (Stoddard 1931, Buckner and Landers 1979,

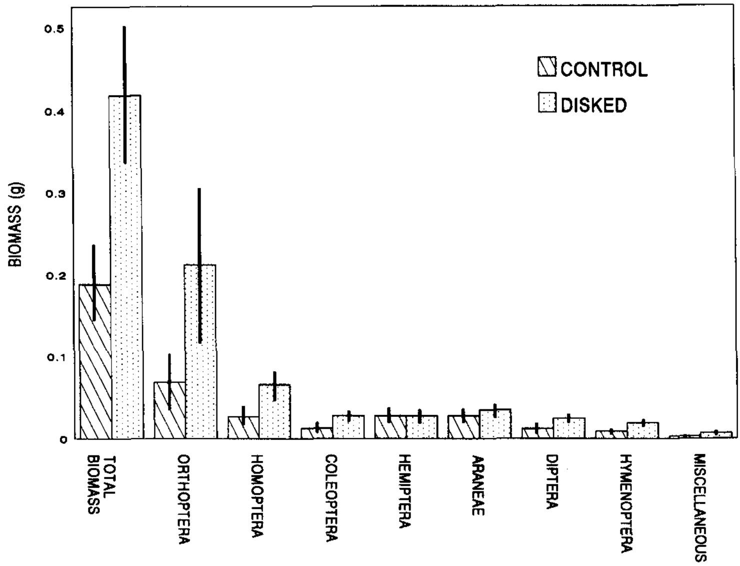

Figure 1. Relative biomass (g) of arthropods pooled from experimental plots at 3 sites in Mississippi, June–August 1992 and 1993. Bars represent means and lines represent 95% confidence intervals.

Landers and Mueller 1986, Manley 1994). These plants provide more palatable and nutritious food resources (Menhinick 1967, Schowalter 1985). As nutritional values of host plants increase, assimilation and growth efficiencies of associated arthropods improve (McNeill and Southwood 1978, Mattson 1980). Concomitantly, rates of arthropod growth, survival, and reproduction increase, resulting in significantly greater populations (Onuf 1978, Prestidge 1982).

Diversity in the vegetation community also plays an important role in determining population responses of arthropods. Structural diversity, with respect to both plant shape and size, has been associated with abundant insect populations (Southwood et al. 1979, Lawton 1983, Schowalter 1985). Mosaic arrangements of different successional stages, such as those created by strip disking, are also associated with abundant and diverse insect communities (Duelli et al. 1990). Lastly, greater floristic diversity may increase arthropod populations as there are more host plants, each with their own associated arthropod hosts (Murdoch et al. 1972, Southwood et al. 1979).

Management and Research Implications

Although old fields were different with respect to woody vegetation cover, physiographic region, and prior land-use practices, strip disking was effective in creating habitat patches that were relatively rich in the arthropod resources required by breeding bobwhites. Disking in October–November produced consistent increases in arthropod biomass. Disking in May produced greater arthropod biomass at TCWDA in 1993, but not at NNWR. Therefore, we encourage fall disking and recommend late spring disking only if there is an apparent lack of early successional habitat available to supply arthropods for breeding season bobwhites.

Our study focused on disked patches <1 year old. It is possible that these patches produced greater arthropod resources than control areas for additional years after manipulation. Information on longevity of disked patches would provide guidelines for managers who use strip disking on a rotation bases. We hypothesize that elevated arthropod resources may result in better reproduction in female bobwhites and higher survival rates of broods. However, this hypothesis was not tested and other factors may be more important. Therefore, we recommend future research evaluate bobwhite reproductive performance in habitats with varying arthropod resources.

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