Abundance and Selection of Invertebrates by Northern Bobwhite Chicks

John R. Jackson, *Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762*

George A. Hurst, *Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762*

Ernest A. Gluesing,[1] *Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762*

Abstract: Invertebrate density and biomass, northern bobwhite (*Colinus virginianus*) chick invertebrate selection, and vegetation stem density and biomass were studied in old field (OF), fertilized old field (FOF), and fertilized kobe lespedeza (FKL) (*Lespedeza striata* var. *kobei*) plots, in the summers of 1985 and 1986. Total invertebrate density and biomass were not different ($P > 0.05$) among treatments. Coleoptera (beetles) density and biomass were greatest ($P < 0.05$) in FKL plots in 1986. Coleoptera, Lepidoptera larvae, and Hemiptera were most preferred ($P < 0.05$) by 3-, 7-, 14-, 21-, and 28-day-old bobwhite chicks. Kobe lespedeza plots contained a greater stem density ($P < 0.05$) of Fabaceae (legumes) than OF plots in 1985 and 1986 and FOF plots in 1986. In both years, FOF plots contained a greater ($P < 0.05$) plant biomass than FKL and OF plots. Kobe lespedeza strips and burning can be used for management of bobwhite nest and brood habitat.

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Northern bobwhite brood habitat and chick invertebrate selection may be the least understood aspects of this extensively studied species. Although chick nutritional and energetic requirements for growth and survival are known (Nestler 1949), knowledge about invertebrates consumed by bobwhite chicks and the ability of these invertebrates to meet nutritional requirements is limited (Handley 1931, Hurst 1972, Dunaway 1976, Gluesing and Field 1982).

Invertebrates can constitute over 80% of a bobwhite chick's diet during the first 2 weeks of life, but gradually decrease to 20% to 30% by the sixth to eighth week (Handley 1931, Nestler 1940). Invertebrates provide essential proteins and vitamins

[1] Deceased.

needed for growth and survival (Nestler et al. 1945). Abundance and availability of invertebrates may be a major factor determining chick survival (Rosene 1969, Hurst 1972). The objectives of this study were to determine invertebrate abundance and bobwhite chick invertebrate selection in old field (OF), fertilized old field (FOF), and fertilized kobe lespedeza (FKL) communities.

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Study Area

The study was conducted in an old field dominated by grasses and forbs (Jackson 1987) on Noxubee National Wildlife Refuge, Mississippi. During spring 1983 the field was disked and seeded with rye grass (*Lolium* sp.). Previously, burning or disking was used to maintain the area as an old field. The field was divided into 9 (0.33 ha) square plots. Soil samples were collected in each plot to test for possible heterogeneity in pH, P, K, Ca, Mg, S, Zn, and organic matter among plots. A randomized complete block design was used based upon soil and vegetative similarities.

Each plot within a block was randomly assigned to 1 of 3 treatments: (1) OF, (2) FOF, and (3) FKL. Plots assigned to FOF were fertilized in early March 1985 and 1986 at a rate of 160 kg/plot with 8–24–24. Plots assigned to FKL were tilled to a depth of 5 cm, fertilized as above, and seeded with kobe lespedeza (12 kg/plot) in early March 1985 and 1986.

Total precipitation for January–April 1985 and 1986 was 38.0 and 19.8 cm, respectively. Average total precipitation for January–April is 66.2 cm. The soil type is a Urbo-Mantachie association which is nearly level and poorly drained (Brent 1986).

Methods

Vegetation was sampled in each plot at 2-week intervals between 8 June and 3 August 1985, and 15 June and 8 July 1986. Four sample periods were completed in 1985 and 2 in 1986. A numbered grid system was used to randomly locate 10 (20 × 50 cm) sample frames in each plot. Within each frame, plant stems were identified to family and tallied. Biomass was measured by clipping all above-ground live vegetation within each frame, oven-drying samples at 60° C for 24 hours, and weighing to 0.1 g.

Invertebrates were collected with a back-mounted vacuum machine (D-Vac) in each plot during each period of vegetative sampling. Samples were collected along 3 randomly located transects (54 m/transect) per plot. A slow walking rate was used along the length of each transect while holding the D-Vac 15 cm above and perpendicular to the ground. Samples were collected between 1400 and 1800 hours. Each sample was placed in a round tray, mixed, and separated into quarters. One quarter of the tray was randomly selected for identifying (to family or order), enumerating, and estimating biomass of invertebrates. A sample of 10 individuals from each family or order was randomly selected and oven-dryed at 60° C for 24 hours. Individuals were weighed to 0.0001 g. Mean biomass for each family or order was then multiplied by the number of individuals in the D-Vac sample.

One-day-old northern bobwhite chicks, obtained from a local quail breeder, were placed with and allowed to imprint on domestic bantam chickens. Broods are easier to control using chickens, and invertebrates eaten by gamebird chicks have been found to be the same as those eaten by wild chicks (Hurst 1972). Prior to feeding trials, broods were conditioned to search for food by being placed in an enclosed grassy area. Feeding trials were conducted at chick ages 3, 7, 14, 21, and 28 days. Two broods per age class were used for each treatment. Each brood (5–20 chicks/hen) was placed in a plot to feed from 1600 to 1800 hours. After each feeding trial, chicks were immediately killed, and their crop contents identified to order.

Analysis of variance (split-plot on time, randomized complete block) was used to test for differences among treatments for vegetation stem density, vegetation biomass, invertebrate density, and invertebrate biomass. Johnson's (1980) method was used to test if use of invertebrate orders by chicks differed from their availabilities.

Results

Vegetation

Kobe lespedeza plots contained a greater stem density of Rubiaceae, primarily *Diodia teres,* than either OF or FOF plots and a greater stem density of Fabaceae, primarily *Lespedeza striata* and *Cassia fasiculata,* than OF plots in 1985 (Table 1). In 1986, FKL plots contained a greater stem density of Asteraceae (primarily *Ambrosia artemisiifolia, Bidens* spp., *Helianthus angustifolius,* and *Solidago* spp.), Fabaceae, and Rubiaceae than OF and FOF plots. This same year FKL plots contained less Poaceae, primarily *Andropogon* spp. and *Panicum* spp., than OF and FOF plots, and less Cyperaceae (primarily *Cyperus* spp., *Eleocharis* spp. and *Scirpus* spp.), and Verbenaceae, primarily *Verbena brasilensis,* than OF plots. In 1985 and 1986, FOF plots produced a greater plant biomass than FKL and OF plots.

Invertebrates

Total invertebrate density and biomass were not different among treatments (Tables 2, 3). Coleoptera (beetles) density and biomass were greatest in FKL plots in 1986. Biomass of Acari (mites) in 1985 and 1986, and Diptera (flies) in 1986 were greater in FKL plots than OF plots.

Northern Bobwhite Chick Selection

Coleoptera and Lepidoptera larvae were the most preferred orders, followed by Hemiptera (true bugs) by 3-day-old chicks in 1985 and 1986 (Tables 4, 5).

Table 1. Mean stem density (0.1 m^2) of major families and total oven-dry biomass (g) of vegetation found in old field, fertilized old field, and fertilized kobe lespedeza plots, Noxubee National Wildlife Refuge, Mississippi, 1985 and 1986.

Family		Old field	Fertilized old field	Fertilized Kobe lespedeza	Pooled SE
Asteraceae	1985	5.7 A[a]	6.9 A	6.6 A	0.81
	1986[b]	4.4 A	5.7 A	10.5 B	1.16
Cyperaceae	1985	6.7 A	6.4 A	1.5 A	0.84
	1986	1.8 A	0.5 B	0.1 B	0.41
Fabaceae	1985[b]	8.9 A	12.0 AB	24.0 B	2.30
	1986	2.8 A	1.5 A	9.9 B	0.99
Poaceae	1985[b]	14.0 A	16.5 A	5.6 B	1.38
	1986	11.4 A	12.6 A	2.1 B	1.15
Rubiaceae	1985	1.0 A	0.1 A	5.9 B	0.75
	1986	0.2 A	0.0 A	5.9 B	0.62
Verbenaceae	1985	5.1 A	3.0 A	0.7 A	0.78
	1986	2.9 A	0.5 B	0.1 B	0.57
Biomass	1985	24.3 A	44.9 B	26.6 A	1.76
	1986	26.3 A	36.1 B	25.6 A	2.71

[a]Means followed by an unlike letter differ ($P < 0.05$), LSD.
[b]Interaction between treatment effect and sample period.

Table 2. Mean density (MD, $N/2.2\ m^2$) and mean biomass (MB, mg) of invertebrates collected in old field, fertilized old field, and fertilized kobe lespedeza plots during 4 (2-week) sample periods, Noxubee National Wildlife Refuge, Mississippi, June and July 1985.

Order		Old field	Fertilized old field	Fertilized Kobe lespedeza	Pooled SE
Acari	MD	37.8 A[a]	18.0 AB	11.0 B	4.5
	MB	0.4 A	0.2 AB	0.1 B	0.1
Araneae	MD	44.4 A	48.1 A	34.4 A	2.6
	MB	37.3 A	40.4 A	28.9 A	2.1
Coleoptera	MD	8.9 A	11.9 A	10.9 A	1.2
	MB	13.8 A	17.5 A	15.4 A	2.0
Diptera	MD	29.7 A	43.2 A	36.7 A	3.0
	MB	21.1 A	30.7 A	26.1 A	6.8
Gastropoda	MD	0.1 A	0.1 A	[b]	0.0
	MB	0.0 A	0.0 A		0.0
Hemiptera	MD[c]	17.4 A	25.4 A	17.8 A	1.3
	MB[c]	27.1 A	40.2 A	25.9 A	2.5
Homoptera	MD	45.9 A	65.1 A	51.7 A	9.5
	MB	71.2 A	101.1 A	82.1 A	16.9
Hymenoptera	MD[c]	58.8 A	55.4 A	41.2 A	4.5
	MB[c]	15.1 A	14.2 A	10.6 A	1.2
Lepidoptera	MD	1.6 A	2.2 A	0.7 A	0.2
	MB	5.6 A	8.1 A	2.4 A	1.0
Orthoptera	MD	2.1 A	2.8 A	2.1 A	0.4
	MB	11.2 A	15.3 A	11.5 A	2.1
Total	MD	246.7 A	272.2 A	206.6 A	16.0
	MB	202.8 A	267.6 A	203.1 A	20.6

[a]Means followed by an unlike letter differ ($P < 0.05$), LSD.
[b]Order not found in D-Vac samples.
[c]Interaction between treatment effect and sample period.

Table 3. Mean density (MD, $N/2.2$ m^2) and mean biomass (MB, mg) of invertebrates collected in old field, fertilized old field, and fertilized kobe lespedeza plots during 2 (2-week) sample periods, Noxubee National Wildlife Refuge, Mississippi, June and July 1986.

Order		Old field	Fertilized old field	Fertilized Kobe lespedeza	Pooled SE
Acari	MD	6.5 A[a]	10.5 B	16.4 B	2.5
	MB	0.1 A	0.1 A	0.2 B	0.0
Araneae	MD[c]	41.6 A	39.5 A	43.8 A	4.1
	MB	35.0 A	33.2 A	36.8 A	3.5
Coleoptera	MD	9.3 A	8.7 A	15.7 B	1.3
	MB	12.3 A	12.8 A	21.0 B	2.0
Diptera	MD	27.1 A	37.0 A	49.3 A	4.3
	MB	19.2 A	26.3 AB	35.0 B	3.0
Gastropoda	MD	0.1 A	[b]		0.0
	MB	0.0 A			0.0
Hemiptera	MD[c]	13.9 A	18.9 A	17.7 A	1.6
	MB	20.9 A	27.3 A	24.3 A	2.3
Homoptera	MD	27.8 A	26.6 A	28.0 A	2.4
	MB	50.5 A	40.5 A	46.0 A	3.8
Hymenoptera	MD	47.1 A	57.0 A	64.6 A	9.7
	MB	12.2 A	14.7 A	16.7 A	2.5
Lepidoptera	MD	0.6 A	0.6 A	0.7 A	0.2
	MB	2.1 A	2.5 A	2.6 A	0.8
Orthoptera	MD	6.5 A	6.7 A	2.0 A	1.3
	MB	37.1 A	35.8 A	10.9 A	7.6
Total	MD	180.4 A	205.5 A	238.3 A	18.2
	MB	189.5 A	193.2 A	193.6 A	11.3

[a]Means followed by an unlike letter differ ($P < 0.05$), LSD.
[b]Order not found in D-Vac samples.
[c]Interaction between treatment effect and sample period.

Table 4. Rankings of invertebrates selected by northern bobwhite chicks (N) feeding in old field, fertilized old field, and fertilized kobe lespedeza plots, Noxubee National Wildlife Refuge, Mississippi, 1985.

	Age (days)				
Order	3 (N = 25)	7 (N = 24)	14 (N = 29)	21 (N = 17)	28 (N = 23)
Araneae	4[a]A[b]	4 A	5 AD	4 A	4 A
Coleoptera	1 B	1 B	1 B	1 B	1 B
Diptera	[c]	6 C	6 AD		5 A
Hemiptera	3 A	2 D	3 C	2 B	2 C
Homoptera	6 C	7 C	7 D	5 C	6 D
Hymenoptera	5 C	5 AC	4 A	3 A	3 A
Lepidoptera (Larvae)	2 B	3 D	2 C		

[a]A value of 1 is the most preferred order.
[b]Ranks followed by an unlike letter differ ($P < 0.05$).
[c]Order not found in northern bobwhite chicks' crops.

Table 5. Rankings of invertebrates selected by northern bobwhite chicks (N) feeding in old field, fertilized old field, and fertilized kobe lespedeza plots, Noxubee National Wildlife Refuge, Mississippi, 1986.

	Age (days)				
Order	3 (N = 15)	7 (N = 30)	14 (N = 25)	21 (N = 11)	28 (N = 6)
Araneae	5[a]A[b]	5 A	5 A	[d]	[d]
Coleoptera	2 BD	1 B	1 B	[d]	[d]
Diptera	6 C		6 C	[d]	[d]
Hemiptera	3 B	2 C	2 D	[d]	[d]
Homoptera	[c]	3 A	3 E	[d]	[d]
Hymenoptera	4 AB	4 A	4 F	[d]	[d]
Lepidoptera (Larvae)	1 D			[d]	[d]

[a] A value of 1 is the most preferred order.
[b] Ranks followed by an unlike letter differ ($P < 0.05$).
[c] Order not found in northern bobwhite chicks' crops.
[d] Sample size too small for analysis.

Coleoptera (beetles) was also the most preferred order by 7-, 21-, and 28-day-old chicks in 1985 and 7- and 14-day-old chicks in 1986. Hemiptera and Coleoptera were most preferred orders by 14-day-old chicks in 1985. Hemiptera ranked either second or third for all other age classes in 1985 and 1986. Most of the beetles eaten were either ground beetles (Carabidae) or leaf beetles (Chrysomelidae, primarily flea beetles). Most beetles eaten were small (1–5 mm long).

Discussion

Legumes in old fields are major seed producers for bobwhites and are thought to attract or produce more insects than non-leguminous plants (Stoddard 1963). Webb (1963) found a greater density of insects on clover (*Trifolium* spp.) than on native grasses, and Dunaway (1976) reported that mean number and mean biomass of arthropods, mostly insects, were greater on kobe lespedeza strips than on burned or unburned native grasses/forbs in pine (*Pinus* spp.) forests. In our study, invertebrate mean density and mean biomass on FKL plots were not greater than on OF or FOF plots in either year. Invertebrate mean density and mean biomass were 24% greater on FOF plots than FKL plots in 1985. This difference might have resulted from the abundance of a legume, partridge pea (*Cassia fasiculata*), on FOF plots in 1985. In 1986, partridge pea was scarce on FOF plots and total plant biomass declined 20%. In addition, invertebrate mean density and biomass declined 24% and 28%, respectively. The winter and spring of 1986 were dry. Lack of moisture may have inhibited germination and thus affected partridge pea abundance (D. H. Arner, pers. commun.).

The FKL plots were reduced to bare ground by tilling, and in just 3 months had total plant biomass similar to OF and FOF plots. In addition, FKL plots had a similar number of invertebrates available to chicks. The fact that FKL plots had vegetation averaging only 25 cm tall, and FOF plots had vegetation 1 m tall in July was important. The FKL plots low stature may have concentrated invertebrates in the chicks' feeding zone, near the ground.

Two other features of FKL plots should be noted. First, plots were tilled each year prior to planting. Plots would have reseeded naturally the second year. Thus, tilling to mineral soil the second year was not necessary. Invertebrates may have repopulated the FKL plots faster if the plots had not been tilled. Secondly, managers should plant kobe lespedeza in narrow (2.4–3.7 m) meandering strips (Rosene 1969), not large blocks like those planted in this study. The former arrangement places a luxuriant growth of vegetation next to old field vegetation, which should attract nearby invertebrates.

Northern bobwhite chicks of all ages preferred beetles. Handley (1931), Hurst (1972), and Dunaway (1976) also found beetles to be the most important food of chicks. Beetle mean density and mean biomass were slightly, but not significantly, greater on FKL than OF plots in 1985, and in 1986 beetle mean density and mean biomass were greater on FKL plots than OF and FOF plots.

Kobe lespedeza is planted to provide a food (seed) source for bobwhites in the winter and provide nesting edge (Rosene 1969). Strips should not be tilled each year but should be allowed to reseed to kobe. New kobe strips can be created as needed. Managers can maintain an old field by late winter burning. Parts of the field should be burned each year, and a patchy, rather than a large-block burning pattern, is recommended (Stoddard 1963). Population densities and biomass of herbivorous insects were found to be greater on burned versus unburned old field habitat (Hurst 1972). In addition, Arner et al. (1976) found that fertilizing after a winter burn promoted legume production. Managers could improve brood habitat by sowing kobe lespedeza directly on a newly burned old field. This technique would create a multi-layer plant community (Kobe lespedeza and native grasses/forbs) and thereby provide invertebrates, seeds, and overhead, protective cover.

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