Summer Diet of Northern Bobwhite in Eastern Mississippi: Implications for Habitat Management

Leonard A. Brennan, *Tall Timbers Research Station, Route 1, Box 678, Tallahassee, FL 32312*

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

Abstract: Potential dietary differences between adult female and male northern bobwhites (*Colinus virginianus*) during the breeding season may influence habitat use and thus require special habitat management. The bobwhite literature contains only meager quantitative information, and no statistical evaluation, of adult female and male bobwhite diets during the breeding season. Therefore, we collected bobwhites and quantified their food use to test the null hypothesis that diets of male and female bobwhites were similar during the breeding season. In 41 female and 47 male bobwhites collected in eastern Mississippi from April–September 1968–1978, we found that females consumed greater ($P < 0.001$) numbers and biomass of animal matter (primarily arthropods and snails) than males. There was no difference ($P > 0.05$) between the sexes in number or biomass of plant material in the diet. Animal foods may play an important, and previously overlooked role in the diet of breeding bobwhites.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 49:516–524

Nearly 30 years ago, Gullion (1966) indicated that much work on foods eaten by North American game birds had limited application for galliform management and conservation. One of his primary concerns was that most studies of galliform diets were based on hunter-harvested samples taken in fall when food is most abundant. He argued that dietary relations during other critical periods (such as the breeding season) may have been overlooked regarding their influence on annual population productivity.

Our understanding of the diet of the northern bobwhite (*Colinus virginianus*) is relatively limited despite it being one of the most studied birds in the world (Scott 1985). Most information on bobwhite diet is from analyses of crop contents of birds collected by hunters during fall and winter and may represent a biased assessment of foods eaten. For example, 23 of 26 (89%) published bobwhite food studies from the southeastern United States were based entirely on

information from quail collected during fall and winter (Landers and Johnson 1976).

Curtis et al. (1990) reviewed the literature on summer diets of adult bobwhites and identified records of only 475 summer crop samples. Adding information from Eubanks and Dimmick (1974) (124 summer crops) to the 88 samples in Curtis et al. (1990), this total is increased to 687, and is still meager compared to the thousands of fall and winter crop samples analyzed throughout this bird's geographic range. Lack of information on breeding season diets of game birds can potentially result in misguided or inappropriate habitat management priorities (Gullion 1966).

Although proportion of animal foods increases in the diet of bobwhites during the breeding season (Cottam 1931, Handley 1931), data on between-sex food differences during the breeding season are scant. Stoddard (1931:41) commented that ". . . grasshoppers and other insects caught by the cock are more frequently eaten by the hen. . . ." Laessle (1944) reported that breeding female bobwhites ingested an unusually high proportion of animal matter, but this was based on a small sample ($N = 4$). Additionally, Landers and Mueller (1989) speculated that hens ate more insects than males to meet increased needs for protein and minerals associated with egg formation; however, they did not provide quantitative evidence to support this assertion. Furthermore, none of the summer bobwhite diet studies cited by Curtis et al. (1990) nor Eubanks and Dimmick (1974) statistically tested the hypothesis that female and male bobwhite diets do not differ during the breeding season.

Our objective was to use a tabulation of foods eaten by wild bobwhites during their breeding season in eastern Mississippi to provide an example that supports a key aspect (potential importance of between-sex differences in diet during a critical period of the year, the breeding season) of Gullion's (1966) viewpoint about game bird diet studies.

Funding for this study was provided by the Mississippi Department of Wildlife, Fisheries and Parks. B. Herring and R. Griffin deserve thanks for coordinating research support. We thank R. Brown, H. Jacobson, R. Kaminski, B. Leopold, and W. Rosene for their helpful reviews of this manuscript; B. Cross, M. Cross, and D. Moore for identification of bobwhite foods, and J. Stys for computerization of data. K. Gainey and T. Pruden provided helpful editorial comments and proof-reading.

Methods

Data Collection

Hurst opportunistically collected crops from female ($N = 41$) and male ($N = 47$) bobwhites found dead on roads (DOR) in eastern Mississippi between April and September 1968–1978. Most (88%) samples were collected during 1968–1970; the balance were obtained during 1973, 1977, and 1978. Proportions of females and males in each yearly sample were not different ($P = 0.11$, df =

1, Mantel-Haenszel Chi-square test, Norusis 1990). We analyzed only intact crops from fresh, identifiable DOR specimens. Crop contents were sorted in a petri dish, identified to the lowest taxonomic group practicable, dried for 7 hours at 83 C, and weighed to 0.001 g on a top-loading analytical balance.

Sample Size Evaluation

We evaluated sample-size requirements for 4 response variables: 1) dry mass of plant foods, 2) dry mass of animal foods, 3) number of plant food items/crop, and 4) number of animal food items/crop. We used Stein's 2-stage technique to estimate precision of available number of samples (Steele and Torrie 1980:120). Calculations for each response variable indicated that 40 samples provided ≥90% confidence that sample data were within 5% of their respective means.

Hypothesis Tests

We tested the hypotheses that mean ranks for the above response variables did not differ between female and male bobwhites. Variances of all response variables were unequal [$P < 0.001$, Bartlett's Test, (Steele and Torrie 1980:471)]. Additionally, distributions of the 4 response variables were not normally-distributed. Therefore, we used the non-parametric Mann-Whitney *U*-test (Zar 1974:112) for between-sex comparisons.

We did not perform statistical tests for between-group contrasts of individual food items for 2 reasons. First, 9 of 33 (27%) food items were not contained in the diet of both sexes (Appendix). Second, collections were made throughout eastern Mississippi during the 6-month bobwhite breeding period. Thus, we could not control confounding effects of phenology, geographic distribution, and availability of specific plant and animal foods.

Results

We rejected the overall hypothesis that composition of female and male bobwhite diets did not differ during the breeding season (Fig. 1, Table 1). Females consumed more animal food than males, both with respect to mean ranks of dry mass and number of food items/crop ($P < 0.05$, Mann-Whitney *U*-test, Fig. 1). Mean ranks of plant food items, and biomass of plant foods did not differ ($P > 0.05$) between sexes. Average dry biomass of animal food in female crops was 20% of the average mass of crop contents, while in males it was 4%.

The most important animal foods consumed by females were snails, shorthorn grasshoppers, crickets, stinkbugs, spittlebugs, and beetles. Spiders occurred in the greatest number (24%) of female crops (Appendix).

Seeds from vetch (*Vicia* spp.) comprised the largest proportion of dry mass of foods eaten by either sex. When combined with Johnson grass (*Sorghum halpense*) seeds, these 2 species comprised 47% of the dry mass of female crop contents, and 44% of male crop contents, respectively (Appendix).

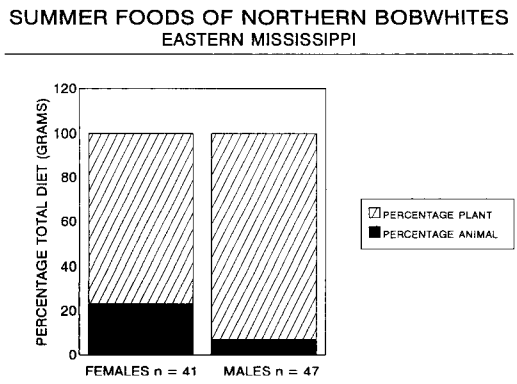

Figure 1. Relative abundance of plant and animal foods (on a percent dry mass basis) in crops of adult bobwhites collected in eastern Mississippi (April–September 1968–1978). Statistics are reported in Table 1.

Discussion

Our results support Gullion's contention that only studying diet during fall and winter may provide misleading information if used for management or conservation. Female bobwhites clearly ate more arthropod foods than males during the breeding season. Research on galliforms in Europe also supports the pattern we observed.

Researchers in Europe identified a link between spatial and temporal abundance of arthropods and productivity of partridge (*Perdix perdix*) (Rands 1985, Sotherton et al. 1985, Potts 1986, Hudson and Rands 1988), and capercaillie (*Tetrao urogallus*) (Storch et al. 1991). A similar relationship for northern bobwhites may exist but has not been established (Roseberry and Klimstra 1984). Potts (1986:154) hypothesized that "there may be a premium on insect food for hens if they are feeding partly to restore a protein balance." While there is presently little empirical support for this hypothesis in the galliform literature, it is important to note that studies of waterfowl diet and nutrition provide considerable support (Aliauskas and Ankney 1992, Krapu and Reinecke 1992).

Our results indicate that invertebrates may play an important and previously overlooked role in nutrition of breeding female bobwhites. These results also indicate that limiting breeding season diet analyses to crop samples from males (e.g., Curtis et al. 1990) may result in arthropods being underrepresented as an important dietary component of breeding adult bobwhites.

It is important to note that our results indicate only that there is a statistical, sex-related difference in breeding season bobwhite diets. Experimental research will be necessary to establish if there is a biological difference in such a dietary pattern.

Even when sampling bias from differential digestibility of soft vs. hard-bodied arthropods is considered (Lifjeld 1983), the apparent importance of animal material (arthropods and snails) in diet of females indicates that management efforts to enhance these food resources (e.g., Hurst 1972) may have a positive influence on bobwhite populations. Clearly, research is needed to assess

Table 1. Descriptive statistics of foods eaten by female ($N = 41$) and male ($N = 47$) northern bobwhites collected in Mississippi during the breeding season (April–September 1968–1978).

	Female			Male				Female			Male			
Food type[a]	$\overline{X}$ dry mass (g)[b]	*SE*	$\overline{X}$ rank	$\overline{X}$ mass (g)	*SE*	$\overline{X}$ rank	*P*[c]	$\overline{X}$ per crop[d]	*SE*	$\overline{X}$ rank	$\overline{X}$ per crop	*SE*	$\overline{X}$ rank	*P*[c]
Seeds and plant material	0.45	0.06	43.3	0.44	0.06	45.5	0.69	115.3	24.2	38.9	189.9	30.7	49.3	0.06
Arthropods and animal material	0.12	0.03	54.7	0.02	0.04	36.3	<0.001	11.6	3.6	52.8	2.8	1.2	37.2	<0.001

[a]See appendix for listing of food items.
[b]Average dry mass in grams.
[c]Probability of between-sex differences in mean ranks based on Mann-Whitney *U*-tests.
[d]Average number of plant or animal food items per crop.

relationships between: 1) abundance of animal foods used by bobwhites during breeding, 2) bobwhite habitat use, and 3) productivity of bobwhite populations. Such research could be designed with controls and used in conjunction with management actions on public wildlife areas that are managed for bobwhite.

Our understanding of specific factors that influence bobwhite habitat use and regulate population productivity are poorly understood. When one considers the widespread declines of bobwhite populations (Brennan 1991), it is clear that we should reassess what we know about the diet of this bird.

Literature Cited

Aliauskas, R. T. and C. D. Ankney. 1992. The cost of egg laying and its relationship to nutrient reserves in waterfowl. Pages 30–61 in B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu, eds. Ecology and management of breeding waterfowl. Univ. Minn. Press, St. Paul. 635pp.

Brennan, L. A. 1991. How can we reverse the northern bobwhite population decline? Wildl. Soc. Bull. 19:544–555.

Cottam, C. 1931. Animal food. Pages 158–159 and 521–533 *in* H. L. Stoddard, The bobwhite quail: its habits, preservation, and increase. Charles Scribners' Sons, New York, N.Y. 559pp.

Curtis, P. D., T. L. Sharpe, and P. D. Doerr. 1990. Early summer diet of male northern bobwhite in the North Carolina sandhills. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 44:250–259.

Eubanks, T. R. and R. W. Dimmick. 1974. Dietary patterns of bobwhite quail on Ames Plantation: implications for management. Tenn. Agric. Exp. Sta. Bull. 534. 38pp.

Gullion, G. W. 1966. A viewpoint concerning the significance of studies of game bird food habits. Condor 68:372–376.

Handley, C. O. 1931. The food and feeding habits of bobwhites. Pages 113–157 and 509–521 *in* H. L. Stoddard, ed. The bobwhite quail: its habits, preservation, and increase. Charles Scribners' Sons, New York, N.Y. 559pp.

Hudson, P. J. and M. R. W. Rands. 1988. Ecology and management of gamebirds. Blackwell Sci. Publ., Oxford, U.K. 263pp.

Hurst, G. A. 1972. Insects and bobwhite brood habitat management. Proc. Natl. Bobwhite Quail Symp. 1:65–82.

Krapu, G. L. and K. J. Reinecke. 1992. Foraging ecology and nutrition. Pages 1–29 *in* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec and G. L. Krapu, eds. Ecology and management of breeding waterfowl. Univ. Minn. Press, St. Paul. 635pp.

Laessle, A. M. 1944. A study of quail food habits in peninsular Florida. Proc. Fla. Acad. Sci. 7:155–171.

Landers, J. L. and A. S. Johnson. 1976. Bobwhite quail food habits in the southeastern United States with a key to important foods. Misc. Publ. 4. Tall Timbers Res. Sta., Tallahassee, Fla. 90pp.

——— and B. S. Mueller. 1989. Bobwhite quail management: a habitat approach. Second ed. Quail Unlimited and Tall Timbers Res. Sta. Tallahassee, Fla. 39pp.

Lifjeld, J. 1983. Stomach content analyses of the dunlin *Calidris alpina:* bias due to differential digestibility of prey items. Fauna Norvegica Series C, Cinclus 6:43–46.

Norusis, M. J. 1990. SPSS/PC+ 4.0 Base manual. SPSS inc., Chicago, Ill.

Potts, G. R. 1986. The partridge: pesticides, predation, and conservation. Collins, London, U.K. 274pp.

Rands, M. R. W. 1985. Pesticide use on cereals and the survival of partridge chicks: a field experiment. J. Appl. Ecol. 22:49–54.

Roseberry, J. L. and W. D. Klimstra. 1984. Population ecology of the bobwhite. South. Ill. Univ. Press. Carbondale. 259pp.

Sotherton, N. W., M. R. W. Rands, and S. J. Moreby. 1985. Comparison of herbicide treated and untreated headlands on the survival of game and wildlife. Proc. British Crop Prot. Conf. 3:991–998.

Scott, T. G. 1985. Bobwhite thesaurus. Internatl. Quail Found. Edgefield, S.C. 306pp.

Steele, R. G. D. and J. H. Torrie. 1980. Principles and procedures of statistics: a biometric approach. McGraw-Hill, New York, N.Y. 633pp.

Stoddard, H. L., Sr. 1931. The bobwhite quail: its habits, preservation, and increase. Charles Scribners' Sons, New York, N.Y. 559pp.

Storch, I., C. Schwarzmuller, and D. von den Stemmem. 1991. The diet of the capercaillie in the Alps: a comparison of hens and cocks. Trans. Internatl. Union Game Biol. Congr. 20.

Zar, J. H. 1974. Biostatistical analysis. Prentice Hall, Englewood Cliffs, N.J. 620pp.

Appendix. Plant and animal foods eaten by female ($N = 41$) and male ($N = 47$) northern bobwhites collected in Mississippi during the breeding season (April–September; 1968–1978).

	Female					Male				
Food item	% occurrence[a]	% dry mass (g)[b]	$\overline{X}$ dry mass (g)[c]	$\overline{X}$ per crop[d]	Range[e]	% occurrence	% dry mass (g)	$\overline{X}$ dry mass (g)	$\overline{X}$ per crop	Range
Foxtail grass										
Setaria sp.	—[e]	—	—	—	—	4.3	0.25	0.029	1.02	35
Bahia grass										
Paspalum sp.	—	—	—	—	—	8.5	6.12	0.029	4.87	148
Crab grass										
Digitaria sp.	9.8	0.50	0.003	8.58	200	12.7	2.95	0.014	28.12	600
Panic grass										
Panicum sp.	21.9	2.05	0.011	1.92	17	11.9	4.71	0.022	4.21	68
Johnson grass										
Sorghum halpense	14.6	17.0	0.088	15.26	450	8.5	11.25	0.053	19.15	400
Wheat										
Triticum aestivum	2.4	0.29	0.002	0.29	12	2.1	0.21	0.001	0.04	10
Sedges										
Carex spp.	2.4	0.12	0.0006	0.24	10	31.9	5.22	0.025	43.38	675
Hackberry										
Celtis sp.	2.4	1.53	0.008	0.24	10	—	—	—	—	—
Pokewood										
Phytolacca americana	—	—	—	—	—	2.1	0.01	0.0004	0.02	1
Chickweed										
Stellaria sp.	7.3	0.83	0.004	9.6	300	2.1	0.59	0.003	1.59	75
Blackberries										
Rubus spp.	29.2	8.87	0.051	34.95	523	23.4	9.72	0.046	33.27	600
Vetch										
Vicia sp.	41.4	30.0	0.170	15.97	170	38.2	33.01	0.156	18.08	140
Cowpea										
Vigna unguiculata	2.4	2.08	0.110	0.10	4	—	—	—	—	—
Wood Sorrel										
Oxalis sp.	19.5	0.44	0.002	8.48	250	17.0	3.55	0.017	9.16	200
Cranesbill										
Geranium sp.	7.3	1.12	0.003	0.34	35	10.6	3.00	0.14	7.34	270
Grape										
Vitis sp.	—	—	—	—	—	6.6	2.29	0.011	0.78	15
Mallow										
Sida sp.	—	—	—	—	—	2.1	0.04	0.0001	0.27	13

Unidentified Seeds[g]	42.8	10.26	0.064	18.60	253	55.3	10.11	0.052	20.53	450
Snails *Gastropoda*	19.0	2.73	0.018	2.33	75	2.1	0.04	0.0001	0.021	1
Spiders *Aranea*	23.8	0.83	0.005	0.97	41	6.4	0.07	0.0003	0.06	1
Flies *Diptera*	7.1	0.11	0.0007	0.09	2	8.5	0.63	0.003	0.10	2
Shorthorn grasshoppers *Acrididae*	14.2	2.26	0.014	0.47	10	4.3	0.79	0.004	0.04	2
Crickets *Gryllidae*	2.4	3.83	0.013	0.40	17	6.4	0.43	0.002	0.06	1
Stink bugs *Pentatomidae*	14.2	1.79	0.011	1.61	28	12.7	0.27	0.001	0.23	5
Other true bugs *Hemiptera*	7.1	0.13	0.0008	0.19	6	4.3	0.15	0.0007	0.06	2
Cicadas *Cicadidae*	10.6	0.43	0.003	0.50	7	10.6	0.06	0.0004	0.15	2
Spittlebugs *Cercopidae*	19.0	1.56	0.010	1.05	24	4.3	0.06	0.001	0.19	8
Moth larvae *Lepidoptera*	2.4	0.003	0.00002	0.02	1	—	—	—	—	—
Ground Beetles *Carabidae*	14.6	1.07	0.006	0.66	14	4.3	0.01	0.0007	0.17	6
Weevils *Curculionidae*	7.3	0.23	0.001	0.34	11	4.3	0.01	0.00005	0.09	3
Other beetles *Coleoptera*	41.4	1.96	0.010	1.65	14	17.0	1.98	0.009	1.91	42
Ants *Formicidae*	7.3	0.04	0.0002	0.14	4	8.5	0.05	0.0002	0.19	3
Unidentified arthropods[h]	41.46	4.13	0.22	0.63	5	19.1	1.12	0.005	0.62	15
Unidentified debris[i]	46.34	2.0	0.17	na[j]	0.8[g]	53.2	1.0	0.52	na	0.4[g]

[a]Percentage of crops that contained each taxonomic group.
[b]Percentage total dry mass of all foods.
[c]Average dry mass in grams.
[d]Average number of food items per crop.
[e]Maximum number of food items per crop. Minimum number was 0 for all taxonomic groups.
[f]Dashes indicate taxonomic group not present.
[g]Also includes unidentified seed parts and miscellaneous plant material.
[h]Also includes unidentified arthropods and miscellaneous arthropod parts.
[i]Unidentified material, exclusive of grit.
[j]Not applicable for this variable.