Wilson Bull., 113(4), 2001, pp. 384–387

KIRTLAND'S WARBLER DIET AS DETERMINED THROUGH FECAL ANALYSIS

CHRISTIE M. DELORIA-SHEFFIELD,[1,4] KELLY F. MILLENBAH,[1,7]
CAROL I. BOCETTI,[2,5] PAUL W. SYKES, Jr.,[3] AND CAMERON B. KEPLER,[3,6]

ABSTRACT.—The endangered Kirtland's Warbler (*Dendroica kirtlandii*) nests primarily in large (>32 ha) stands of young (5- to 25-yr-old) jack pine (*Pinus banksiana*) which grow on Grayling sand soil. These specific habitat requirements restrict the Kirtland's Warbler breeding range to only 13–16 counties in the northern lower peninsula of Michigan. Although the nature of the species' affinity for this habitat is poorly understood, one theory suggests that higher prey abundance in young jack pine may play a role. To explore further the hypothesis that Kirtland's Warblers choose nesting habitat due to prey abundance, a more thorough knowledge of the warblers' diet is needed. To better understand the diet, we identified arthropod and plant fragments found in 202 Kirtland's Warbler fecal samples, collected from June to September, 1995–1997. The major food items recorded were spittlebugs and aphids (Homoptera; found in 61% of all samples), ants and wasps (Hymenoptera; 45%), blueberry (*Vaccinium augustifolium*; 42%), beetles (Coleoptera; 25%), and moth larvae (Lepidoptera; 22%). *Received 17 April 2001, accepted 30 Nov. 2001.*

The Kirtland's Warbler (*Dendroica kirtlandii*) is a primarily insectivorous, ground-nesting bird that was federally listed as an endangered species in 1973 (Byelich et al. 1976). It is one of the largest members of the wood-warbler family, Parulidae. Kirtland's Warblers have strict breeding habitat requirements: nests are restricted to large (>32 ha) stands of young (5- to 25-yr-old) jack pines (*Pinus banksiana*) that grow on Grayling sand and other similarly well-drained sandy soils found only in the northern lower peninsula of Michigan (Byelich et al. 1976).

For effective management of an endangered species such as the Kirtland's Warbler, it is important to understand why the species chooses a particular habitat. Although the evolution of Kirtland's Warbler habitat specificity is poorly understood, Fussman (1997) hypothesized that younger jack pine stands may provide a greater prey base for the warbler. Fussman (1997) began exploring the importance of prey abundance to habitat selection by Kirtland's Warblers by studying the arthropod abundance in jack pine stands of various age. However, arthropod abundance is not always equivalent to prey abundance. Bibby (1979) found that certain invertebrates, such as ants and woodlice, were avoided by Dartford Warblers (*Sylvia undata*) in Great Britain even when they were abundant. Although the Kirtland's Warbler has been the subject of considerable research (Mayfield 1960, 1992; Walkinshaw 1983; Probst 1986, 1988; Probst and Weinrich 1993; Bocetti 1994; Kepler et al. 1996; Fussman 1997; Houseman 1998), no previous studies have provided detailed quantitative information about its diet. To explore further the hypothesis that Kirtland's Warblers choose nesting habitat based on prey abundance, a thorough knowledge of the warbler's diet is needed.

As the Kirtland's Warbler is an endangered species, killing specimens for gut content analysis or other potentially harmful dietary assessment methods are not feasible. However, fecal analysis has proven to be an effective and nonintrusive method to determine the diet of other insectivorous bird species (Bibby 1979, 1981; Greig-Smith and Quicke 1983; Ormerod 1985; Ralph et al. 1985; Moreby 1987; Green and Tyler 1989; Van Horne and Bader 1990; Burger et al. 1999). Davies (1976, 1977a, 1977b) found close agreement

[1] Dept. of Fisheries and Wildlife, Michigan State Univ., East Lansing, MI 48824-1222, USA.

[2] USGS Patuxent Wildlife Research Center, 11510 American Holly Dr., Laurel, MD 20708-4019, USA.

[3] USGS Patuxent Wildlife Research Center, Warnell School of Forest Resources, Univ. of Georgia, Athens, GA 30602-2152, USA.

[4] Current address: U.S. Fish and Wildlife Service, 1250 South Grove Rd., Suite 103, Barrington, IL 60010, USA.

[5] Current address: USGS Patuxent Wildlife Research Center, 10 Oakridge Ln., Hickory, PA 15340, USA.

[6] Current address: 400 Snapfinger Dr., Athens, GA 30605-4437, USA.

[7] Corresponding author; E-mail: millenba@msu.edu

among collar (use of neck ligature), emetic, and fecal samples in wagtails and flycatchers. The objective of this study was to determine the diet of Kirtland's Warblers during the breeding season using fecal analysis.

METHODS

We collected Kirtland's Warbler fecal samples from June through September, 1995–1997, at 47 banding sites located within the breeding areas (44° 33′ N, 84° 29′ W; approximate center of sites). Sites were located on U.S. Forest Service, Michigan Dept. of Natural Resources, and Michigan Dept. of Defense property in the following counties of Michigan: Alger, Alcona, Crawford, Delta, Iosco, Kalkaska, Marquette, Montmerency, Ogemaw, Oscoda, Otsego, and Schoolcraft. Overstory vegetation at the banding sites was primarily jack pine between 6- and 20-yr-old. Jack pine on these sites were regenerated either by seedling planting or by natural wildfire events. Secondary overstory vegetation included northern pin oak (*Quercus ellipsoidalis*), big-toothed aspen (*Populus grandidentata*), black cherry (*Prunus serotina*), and pin cherry (*P. pensylvanica*). Understory vegetation was comprised mainly of blueberry (*Vaccinium augustifolium*), bearberry (*Arctostaphylus uva-ursi*), sand cherry (*P. pumila*), sweet fern (*Comptonia peregrina*), bracken fern (*Pteridium aquilinum*), and sedge (*Carex pensylvanica*). Jack pine stands ranged in size from 81–4047 ha with soils primarily of Grayling or Kalkaska sand.

We obtained fecal samples incidentally during a Kirtland's Warbler banding study (C.I.B. unpubl. data). Birds were extracted from mist nets and placed individually in clean cotton bags for transport and holding. Birds were processed in <15 min and returned, in the bags, to the nets for release. If at any time during this procedure the birds defecated, we collected the droppings and stored them in buffered 10% formalin. We analyzed a total of 202 fecal samples. Each vial of fecal material was poured into a gridded petri dish and viewed under a dissecting microscope. Arthropod fragments sufficiently large to be identified, such as fragments of appendages, exoskeleton, or wings, were removed from the formalin and mounted with eupharal fixative on labeled glass microscope slides. We keyed arthropod fragments to order or family, the lowest taxonomic category possible, with arthropod keys (Borror and White 1970, Borror et al. 1989) and a jack pine arthropod reference collection (Fussman 1997, Deloria 2000). For each arthropod taxon, we calculated percent occurrence by dividing the number of samples in which a taxon was observed by the total number of samples examined.

RESULTS

We identified 10 orders and 16 families of arthropods, as well as blueberry seeds (Table 1). Taxa most frequently observed in samples were Homoptera (found in 61% of all samples), Hymenoptera (ants and wasps; 45%), blueberry (42%), Coleoptera (beetles; 25%), and Lepidoptera (moth caterpillars; 22%). Nearly all identified specimens of Homoptera were spittlebugs (*Aphrophora cribrata*, Cercopidae; 36%) or aphids (Aphididae; 21%), most identified Hymenoptera were ants (Formicidae; 18%), and all the Lepidoptera were larvae.

TABLE 1. Taxa identified in 202 Kirtland's Warbler fecal samples collected June through September, 1995–1997, Michigan.

Order	Family	Number of samples	Percent occurrence
Arthropods			
Homoptera		123	61
	Cercopidae	72	36
	Aphididae	43	21
	Nabidae	1	0
	Unknown	7	3
Hymenoptera		90	45
	Formicidae	36	18
	Ichneumonidae	3	1
	Braconidae	1	0
	Chalcididae	1	0
	Unknown	49	24
Coleoptera		51	25
	Curculonidae	6	3
	Unknown	45	22
Lepidoptera	Unknown	45	22
Araneae		40	20
	Salticidae	3	1
	Unknown	37	18
Diptera		36	18
	Agromyzidae	1	0
	Asilidae	1	0
	Therevidae	1	0
	Unknown	33	16
Hemiptera		13	6
	Tingidae	2	1
	Lygaeidae	1	0
	Unknown	10	5
Collembola	Sminthiridae	1	0
Neuroptera	Unknown	1	0
Blueberry			
Magnoliopsida	Pyrolaceae	85	42

DISCUSSION

The array of taxa identified from fecal samples in this study was similar to the taxa identified from observations of foraging Kirtland's Warblers in previous qualitative studies. During May through early July, Fussman (1997)

observed Kirtland's Warblers consuming Hymenoptera and Lepidoptera larvae, Coleoptera, grasshoppers (Orthoptera), ants, aphids, and spittlebugs. Walkinshaw (1983) reported that Kirtland's Warblers fed on Hymenoptera or Lepidoptera larvae, small beetles, cicadas (Homoptera) and blueberries. Mayfield (1960) reported warblers eating mainly on sawfly (Hymenoptera) adults and larvae, grasshopper nymphs, flying moths, and flies (Diptera).

The relative proportions of taxa identified in fecal samples differed somewhat from those suggested by observations of foraging birds. Fussman (1997), Walkinshaw (1983), and Mayfield (1960) observed Kirtland's Warblers feeding on Lepidoptera and Hymenoptera larvae and adults, and Orthoptera adults and nymphs, whereas this study detected little or no occurrence of larval Hymenoptera, adult Lepidoptera, or Orthoptera.

The discrepancy between observational and fecal sample data probably is not due to an inability to identify arthropods in fecal samples. Orthoptera have many hard parts (especially mandibles, present in both nymphs and adults) which likely would be identifiable after passing through the gut. Adult Lepidoptera have few large hard parts, but are easily identified by the presence of wing scales in fecal samples (Whitaker 1988, Ralph et al. 1985). Lepidopteran wing scales, however, were not observed in any of the fecal samples.

The inconsistencies are more likely due to temporal differences between the field observations and fecal sample collection. Most observational data were collected from May to July, while the majority of fecal samples reported here were collected from July to September. Some arthropods, especially larvae, would be more abundant during spring and early summer, and would likely be consumed more by Kirtland's Warblers at that time.

Another possible explanation for the discrepancies between observational and fecal sample data could be possible biases associated with observing foraging behavior in the field. Grasshoppers and adult Lepidoptera may be ingested less frequently than smaller prey items, but due to their large size, they are more easily identified in free-ranging birds. Bierman and Sealy (1982) suggested that their observational data on Yellow Warblers (*Dendroica petechia*) was biased toward relatively large insects. Large insects that protruded from the parent's bill could be identified, but smaller items could not (Bierman and Sealy 1982). Perhaps this bias played a role in studies by Mayfield (1960) and Walkinshaw (1983), both of whom suggested that large-sized grasshoppers and Lepidoptera made up a large proportion of the Kirtland's Warbler diet.

The present study was exploratory in nature and was meant to contribute to our understanding of the diet of Kirtland's Warblers. Although not presented in this study, further analysis of Kirtland's Warbler fecal samples by sex, age, and jack pine stand characteristics (stand age, size, location, and regeneration type) proved inclusive, due to low sample sizes that precluded statistical tests of significance (Deloria 2000). This study sets the stage for future field studies that focus on determining if prey abundance influences the affinity of Kirtland's Warblers for young jack pine habitat.

ACKNOWLEDGMENTS

We are very grateful to C. Smith, Univ. of Georgia, who helped us identify arthropod fragments. O. Taboata and G. Parsons were very helpful in the identification of whole arthropods. We offer special thanks to lab. volunteers B. Rock and C. Downing. Funding for this project was provided by Michigan State Univ. Dept. of Fisheries and Wildlife, USFWS East Lansing Field Office, and Michigan Dept. of Natural Resources Natural Heritage Program. We sincerely thank the reviewers of this manuscript for greatly improving the quality of this paper.

LITERATURE CITED

BIBBY, C. J. 1979. Foods of the Dartford Warbler *Sylvia undata* (Aves: Syliviidae) on southern English heathland. J. Zool. 188:557–576.

BIBBY, C. J. 1981. Food supply and diet of the Bearded Tit. Bird Study 28:201–210.

BIERMAN, G. C. AND S. G. SEALY. 1982. Parental feeding of nestling Yellow Warblers in relation to brood size and prey availability. Auk 99:332–341.

BOCETTI, C. I. 1994. Density, demography, and mating success of Kirtland's Warblers in managed and natural habitats. Ph.D. diss., The Ohio State Univ., Columbus.

BORROR, D. J., C. A. TRIPLEHORN, AND N. F. JOHNSON. 1989. An introduction to the study of insects, 6th ed., Saunders, Fort Worth, Texas.

BORROR, D. J. AND R. E. WHITE. 1970. A field guide to the insects. Houghton Mifflin, Boston, Massachusetts.

BURGER, J. C., M. A. PATTEN, J. T. ROTENBERRY, AND R. A. REDAK. 1999. Foraging ecology of the California Gnatcatcher deduced from fecal samples. Oecologia 120:304–310.

BYELICH, J., W. IRVINE, N. JOHNSON, W. JONES, H. MAYFIELD, R. RADTKE, AND W. SHAKE. 1976. Kirtland's Warbler recovery plan. U.S. Fish and Wildlife Service, Washington, D.C.

DAVIES, N. B. 1976. Food, flocking and territorial behaviour of the Pied Wagtail *Motacilla alba yarrellii* Gould, in winter. J. Anim. Ecol. 45:235–254.

DAVIES, N. B. 1977a. Prey selection and social behaviour in wagtails (Aves: Motacillidae). J. Anim. Ecol. 46:37–57.

DAVIES, N. B. 1977b. Prey selection and the search strategy of the Spotted Flycatcher (*Muscicapa striata*): a field study in optimal foraging. Anim. Behav. 25:1016–1033.

DELORIA, C. M. 2000. Kirtland's Warbler (*Dendroica kirtlandii*) diet and its relationship to warbler age, sex, and jack pine stand characteristics. M.Sc. thesis, Michigan State Univ., East Lansing.

FUSSMAN, J. L. 1997. Foraging ecology of Kirtland's Warblers in managed and natural breeding habitat. M.Sc. thesis, The Ohio State Univ., Columbus.

GREEN, R. E. AND G. A. TYLER. 1989. Determination of the diet of the Stone Curlew (*Burhinus oedicnemus*) by faecal analysis. J. Zool. 217:311–320.

GREIG-SMITH, P. W. AND D. L. J. QUICKE. 1983. The diet of nestling Stonechats. Bird Study 30:47–50.

HOUSEMAN, G. R. 1998. Effects of various management practices in jack pine plantations on ground cover preferred by Kirtland's Warblers. M.Sc. thesis, Illinois State Univ., Normal.

KEPLER, C. B., G. W. IRVINE, M. E. DECAPITA, AND J. WEINRICH. 1996. The conservation management of Kirtland's Warbler *Dendroica kirtlandii*. Bird Cons. Internat. 6:11–22.

MAYFIELD, H. F. 1960. The Kirtland's Warbler. Cranbrook Inst. Sci. Bull. 40., Bloomfield Hills, Michigan.

MAYFIELD, H. F. 1992. Kirtland's Warbler (*Dendroica kirtlandii*). No. 19 *in* The birds of North America (A. Poole, P. Stettenheim, and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania, and the American Ornithologists' Union, Washington, D.C.

MOREBY, S. J. 1987. An aid to the identification of arthropod fragments in the faeces of gamebird chicks (Galliformes). Ibis 130:519–526.

ORMEROD, S. J. 1985. The diet of breeding dippers *Cinclus cinclus* and their nestlings in the catchment of the River Wye, mid-Wales: a preliminary study by faecal analysis. Ibis 127:316–331.

PROBST, J. R. 1986. A review of factors limiting the Kirtland's Warbler on its breeding grounds. Am. Midl. Nat. 116:87–100.

PROBST, J. R. 1988. Kirtland's Warbler breeding biology and habitat management. Pp. 28–35 *in* Integrating forest management for wildlife and fish (T. W. Hoelstra and J. Capp, Eds.). USDA Forest Service Rep. NC-122, Rhinelander, Wisconsin.

PROBST, J. R. AND J. WEINRICH. 1993. Relating Kirtland's Warbler population to changing landscape composition and structure. Landscape Ecol. 8: 257–271.

RALPH, C., S. E. NAGATA, AND C. J. RALPH. 1985. Analysis of droppings to describe diets of small birds. J. Field Ornithol. 56:165–174.

VAN HORNE, B. AND A. BADER. 1990. Diet of nestling Winter Wrens in relationship to food availability. Condor 92:413–420.

WALKINSHAW, L. H. 1983. Kirtland's Warbler: the natural history of an endangered species. Cranbrook Inst. Sci. Bull. 58, Bloomfield Hills, Michigan.

WHITAKER, J. O., JR. 1988. Food habits analysis of insectivorous bats. Pp. 171–189 *in* Ecological and behavioral methods for the study of bats (T. H. Kunz, Ed.). Smithsonian Inst. Press, Washington, D.C.