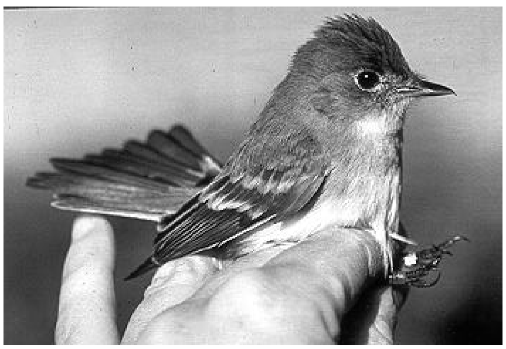
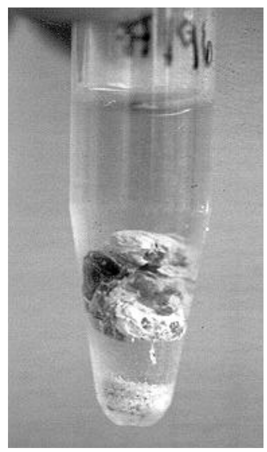
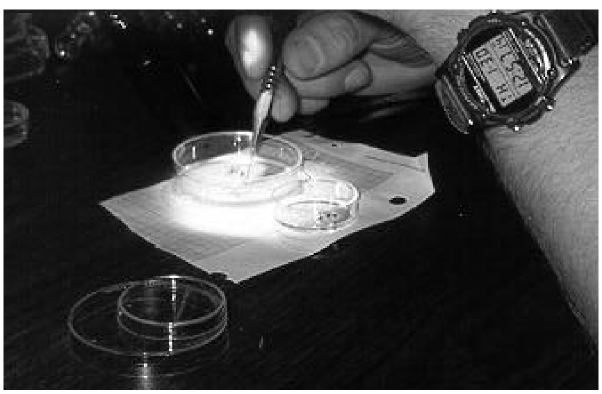
Food Habits of the Endangered Southwestern Willow Flycatcher







Final Report to the U.S. Bureau of Reclamation, Salt Lake City

January 2001

Charles A. Drost[1], Eben H. Paxton[1], Mark K. Sogge[1] and Mary J. Whitfield[2]

[1]USGS Forest and Rangeland Ecosystem Science Center, Colorado Plateau Field Station, Flagstaff, AZ
[2]Southern Sierra Research Station, Weldon, CA

Food Habits of the Endangered Southwestern Willow Flycatcher

Abstract:

The food habits and prey base of the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*) are not well known. We analyzed prey remains in 59 fecal samples from an intensively-studied population of this flycatcher at the Kern River Preserve in southern California. These samples were collected in 1996 and 1997 from adults caught in mist nets, and from nestlings temporarily removed from the nest for banding. A total of 379 prey individuals were identified in the samples. Dominant prey taxa, both in total numbers and in frequency of occurrence, were true bugs (Hemiptera), flies (Diptera), and beetles (Coleoptera). Leafhoppers (Homoptera: Cicadellidae), spiders, bees and wasps (Hymenoptera), and dragonflies and damselflies (Odonata) were also common items. There was not a significant difference in diet composition between years (1996 and 1997) nor between months. However, there was a significant difference between the diet of young and adults, with the diet of young birds having significantly higher numbers of flies, bugs, and leafhoppers. There was also a trend toward differences between the diet of males and females, but this was not significant at the p=0.05 level. We compared the Kern River diet data with data for Southwestern Willow Flycatchers at Tonto Creek and Salt River in south-central Arizona. There were significant differences in the diet composition of the populations at the three sites, which may be primarily due to differences in habitat among the sites. We do not see any indication that available food is limiting these populations, but we do discuss differences between habitats and other management implications of these data.

Introduction

The Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is a neotropical migrant bird that breeds in the southwestern United States, from southern California to New Mexico and west Texas. It is a subspecies of the widespread Willow Flycatcher, and breeds in riparian habitats along rivers and streams (Unitt 1987). Like some other riparian-breeding species in the southwest, the numbers and distribution of the Southwestern Willow Flycatcher have been significantly reduced (e.g. Sogge et al. 1997, Unitt 1987), and in 1995, this subspecies was added to the Federal Endangered Species list (USFWS 1995). With the listing of the Southwestern Willow Flycatcher, conservation and management of this bird and its habitat have become important concerns for state and federal agencies. Intensive research has been undertaken, including studies of the current distribution and numbers of flycatchers, their habitat characteristics, breeding ecology, population genetics, and impacts of nest parasitism by Brown-headed Cowbirds (*Molothrus ater*).

One aspect of the ecology of the Southwestern Willow Flycatcher that has received relatively little study is its diet and feeding ecology. Earlier studies (e.g. Beal 1912, Bent 1942, McCabe 1991) provided information on diet of the Willow Flycatcher across its entire North American range, but did not present any specific data on the Southwestern subspecies. In addition, they presented diet information in only very general terms, such as percentage of prey by different insect orders. Drost et al. (1998) recently completed a diet study based on fecal samples collected from flycatchers captured in mist nets, providing specific information on the diet of *E. t. extimus*. This study drew on samples from a range of sites in Arizona and southern Colorado, described flycatcher diet during the breeding season, and made preliminary comparisons of the diet of birds using different habitats, particularly mixed native riparian vs. non-native tamarisk habitat.

The Arizona / Colorado study was based on samples from a single year (1996), so it could not evaluate potential year-to-year differences in diet. Also, though the study included samples from a wide range of sites, the sample sizes at most sites were quite small, seriously limiting comparisons or analyses of differences among sites and habitats. Other comparisons that are potentially of interest, such as between adults and young, were similarly limited. Our current study was undertaken to extend diet data on the Southwestern Willow Flycatcher to other parts of the subspecies range, and to provide intensive, site-specific data for comparisons of year-to-year variation in diet, seasonal comparisons, and other analyses. Taken together with earlier work, these data provide a more complete picture of flycatcher food habits. We discuss important prey species of the Southwestern Willow Flycatcher, and how food habits and prey species relate to native vs. non-native (tamarisk) habitat. We conclude with a discussion of implications for conservation and management.

Objectives

This project had three main objectives:

1) Conduct a more detailed analysis of Southwestern Willow Flycatcher food habits and prey species.

The earlier study included samples from a wide range of locations in Arizona and Colorado, but the largest number of samples from any one location was only 11 (from the Salt River site in Arizona). By focusing in this project on a large, intensively studied population (the Kern River site in southern California), we were able to obtain a larger sample size, providing a more reliable picture of overall diet composition, and allowing the comparisons described in objective 2. In addition to increasing sample size to improve precision and reliability of the data, this analysis also included finer resolution in the identification of some prey species.

2) Compare food habits of the Willow Flycatcher between years, at different times of the nesting season, and among different sites within the subspecies' range.

The increased sample size provided by this study allowed comparisons that further our understanding of Willow Flycatcher diet. For example, the 1996 and 1997 nesting seasons of the flycatchers were quite different, both in rainfall pattern and also with respect to flycatcher breeding effort and phenology. A comparison between years should show whether patterns observed in 1996 are robust. A between-year comparison also provides an indication of how food habits may vary over time. We were also able to analyze differences among different months (to evaluate seasonal variation), and between adults and young. The large sample size also allowed for contrasts of flycatcher diet at different sites (the Kern River in California, and the Salt River and Tonto Creek in Arizona).

3) Evaluate composition of diet, and differences among sites and habitats, in relation to conservation implications for the Southwestern Willow Flycatcher.

The final objective of this study was to place the results of this analysis in a conservation context, and provide discussion on how the patterns recorded relate to protection and management of Southwestern Willow Flycatchers. By identifying important categories of prey, the breadth of the diet, and differences among sites, we can better understand this part of the flycatcher's ecological requirements, and what factors may negatively affect the bird's prey base.

Study Areas

One of the largest and best-studied populations of the Southwestern Willow Flycatcher is at the Kern River Preserve in southern California (Whitfield et al. 1999; Figure 1). The Kern River Preserve is comprised of approximately 500 ha of native cottonwood–willow riparian habitat along the Kern River in the southern San Joaquin Valley; it is managed by the National Audubon Society. Elevation at the site is approximately 750 m.

The breeding flycatcher population at the Kern River Preserve is spread out over several areas within the preserve. These areas form a diverse forest mosaic of predominantly native vegetation (Figure 2), including mature red willow (*Salix laevigata*) and/or Fremont cottonwood (*Populus fremontii*), interspersed with small marshes dominated by cattail (*Typha* sp.), tules (*Scirpus* sp.), and/or bur-reed (*Sparganium eurycarpum*). One large portion of the site is dominated by young Goodding's willows (*Salix gooddingii*) established between 1983 and 1986, after the removal of cattle from the site. This part of the site is periodically inundated by Lake Isabella (from 1996-1998, inundation generally started in June, but varied by 1-3 weeks during those years).

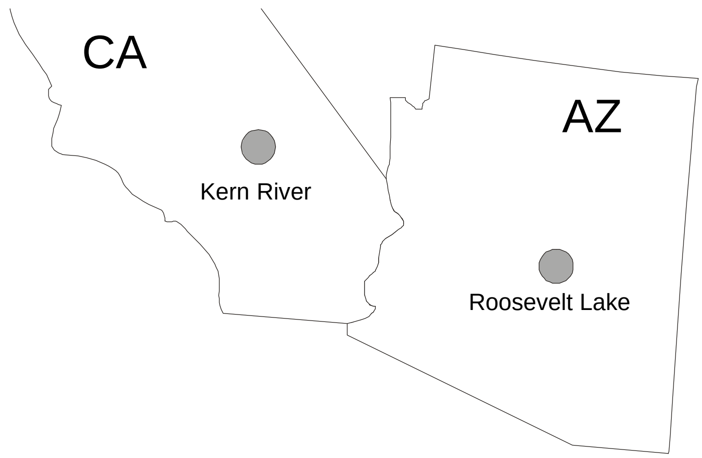


Figure 1. General locations of study sites for a diet study of the Southwestern Willow Flycatcher in southern California and Arizona. Roosevelt Lake, Arizona, includes two different sites: the Salt River inflow at the east end of the lake, and the Tonto Creek inflow, from the north.

Roosevelt Lake is formed by Roosevelt Dam at the confluences of the Salt River and Tonto Creek in central Arizona, approximately 87 km northeast of Phoenix. Willow flycatchers breed at 640 m elevation at the inflows of the Salt River and Tonto Creek, nesting in the mature riparian vegetation found in the flood basins near the average lake level shoreline. The breeding sites are anywhere from several meters to 350 m from the water depending on annual and seasonal changes in lake level and creek and river flows. The Salt River Inflow breeding site consists of a large monotypic stand of dense tamarisk (*Tamarix ramosissima*) that stretches for 2 km along the Salt River (Figure 2). The stand's core is mature tamarisk forming a canopy averaging 10 - 12 m high, with little or no understory vegetation. Edges of the mature tamarisk core consist of younger tamarisk in various stages of growth. Willow flycatchers breed 10-150 m from the Salt River in the mature tamarisk. The Tonto Creek Inflow breeding site is comprised of mature tamarisk (10-12 m tall) with mature Goodding's willow (15-20 m tall) and Fremont cottonwood interspersed at varying densities. The portion of the Tonto Creek site from which diet samples were obtained for this report is dominated by tamarisk, interspersed with a few tall cottonwoods (Figure 2). A perennial seep runs on the west side of the site, 10-500 m from the flycatcher territories.

Kern River Preserve, from the north

Salt River Inflow, looking east (upriver)

"Tamarisk Island" at Tonto Creek

Tamarisk at Salt River Inflow

Dense tamarisk at Tonto Creek

Figure 2. General appearance and habitat at study sites for the Southwestern Willow Flycatcher diet study in southern California and Arizona.

Methods

Collection and handling of samples

We analyzed samples collected during the 1996 and 1997 field seasons at the Kern River site. Fecal samples were collected by field crew members at Kern River, when birds "voluntarily" provided them. Samples were obtained both from adult birds caught in mist-nets, and from nestlings that were handled during weighing and banding. Fecal samples were collected into small plastic vials containing 70% ethanol, and the vials were then labeled with area name, date, and identifying reference to the bird that provided the sample (usually the number from the USGS Federal bird band). Sample vials were stored temporarily at the Kern River site facilities, then sent to the Colorado Plateau Field Station (CPFS). Samples were sorted and organized at CPFS, and alcohol levels topped off as needed. Each sample was assigned a unique, sequential number, and then sample number, date, site, band number, age and sex of bird (if known), and any explanatory notes were entered into a database (see Appendix 1).

Sorting, identification, and quantification

All samples were analyzed at the CPFS. Paxton carried out the sorting, dissecting, and initial identification on almost all of the new samples. Individual samples were transferred to microscope dishes containing 70 % ethanol, then teased apart under a variable-power (7 – 40x) dissecting microscope. Body fragments, wings or wing fragments, legs, head capsules, and sometimes whole invertebrates were sorted, grouped, and identified to the finest taxonomic level possible (generally order or family level) with the aid of standard invertebrate taxonomy literature, and insect reference collections. Important general references used were Arnett (1993), Borror et al. (1976), Kaston (1978), and Thorp and Covich (1991). Specialized references for particular groups included: Merritt and Cummins (1996) for aquatic invertebrates; Osborn (1912) for leafhoppers; Arnett (1973) for beetles; Cole (1969) and McAlpine (1981) for flies; and Goulet & Huber (1993), Michener et al. (1994), and Stephen et al. (1969) for bees, wasps and other hymenopterans. Brodsky (1994) and Grodnitsky (1999) were useful for wings and wing venation. In addition to using literature references for identification, we also compared some food sample fragments with reference invertebrate collections housed at Northern Arizona University.

Fragments from each sample were sorted into groups that were recognizably from the same invertebrate taxon. This aided in the identification process, and also facilitated counting the number of each prey taxon. For each group of fragments, we tabulated the number of individuals represented. This tabulation was based on the minimum number of individuals required to account for the fragments present in the sample. The count was generally based either on head capsules, wings, terminal abdominal segments / genitalia (for Homopterans) or chelicerae (for spiders). As examples of the method of counting, for a fly, one head capsule and three wings would be counted as two individuals (based on the wings); however, three head capsules and three wings would be counted as three individuals (based on the head capsules). The volume of the fragments was also estimated, based on the area of a square grid covered by the fragments. Photographs or sketches were made of characteristic remains for future reference to other samples or identification manuals.

We entered the following information into a database for each prey taxon identified in each sample: sample number; identification of prey (including order, family, and lower level identification, where applicable); number of individuals of that taxon; percent of total sample volume represented by the taxon, description of remains, including notes on identification (e.g. "exoskeleton, partial head capsule – metallic green," or "Calyptrate muscoid fly – leg, abdomen, calypter, antennae"). All samples were returned to alcohol vials after identification and saved, both for future reference for similar samples, and for further study or more precise identification of problematic fragments. Wings were generally permanently mounted on microscope slides for careful examination. All such slides were labeled with the sample number, and saved for future reference.

We examined most of the samples a second time, after we had gone through the entire series of samples. This reexamination included all samples where question marks were noted by the identification, and all samples containing invertebrate taxa that were generally difficult to identify. Any questions on identification were resolved during this reexamination, either confirming the original identification or correcting it. We were conservative on all final identifications: if we could not positively identify fragments as belonging to a particular taxon, they were recorded at the level we could be certain of (e.g. "unidentified insect").

Statistical analysis

We identified prey in the food samples to different taxonomic levels, depending on the amount and completeness of prey remains, and available references on particular taxonomic groups. Generally identification was to order or family level, but in a few cases prey were identified to genus level. Since many small categories at different taxonomic levels are confusing to present and interpret, we assigned each prey taxon to an "Analysis" category for purposes of summary statistics and comparative statistical tests. These "Analysis" categories (hereafter referred to as "prey taxa") were generally order or family taxonomic level, based on the level that the majority of prey items in that group could be assigned to (e.g. some spiders were identified to family or genus, but most spiders could only be identified as far as the spider order, Araneae, so we used Araneae as the prey taxon in the "Analysis" field).

Summary statistics included the number of prey individuals per sample, the number of different, identified taxa per sample (i.e. the prey diversity per sample), overall breakdowns of the number of each prey taxon across all samples, and the percent occurrence of each prey taxon in the samples. Percent occurrence (frequency) was calculated as the number of samples in which a prey taxon was found, divided by the total number of samples.

For comparative purposes, we categorized samples by age of bird from which the sample was obtained, year, month, and geographic location. Age was categorized as nestling and adult. Year for all samples was 1996 or 1997, and calendar month was either June, July, or August. We had adequate sample sizes from three locations – Kern River, Tonto Creek, and Salt River – to include them in comparative analyses. We used non-parametric median tests (Daniel 1990) for comparisons of number of prey individuals per sample (as between number of prey individuals in samples from adults, vs. samples from young). For all other comparisons, we used multivariate analysis of variance (MANOVA).

We used the same procedures for examining, identifying, and quantifying samples, and for statistical analysis, at the Kern River Preserve and in the earlier study in Arizona (Drost et al. 1998). In particular, the taxonomic categories used in the analyses (e.g. flying Hymenoptera, Diptera, Araneae) were the same in the two studies. Overall sample size in the Arizona study was the same as in the Kern study, however only those Arizona sites with the largest sample sizes were used in the between-site comparisons in this report.

Results

Sample data

We analyzed a total of 59 samples from the Kern River Willow Flycatcher breeding site. Samples were collected from adult birds and nestlings, in June, July, and August of 1996 and 1997. Table 1 provides a breakdown of the Kern River samples, by year, month, age, and sex (note that limited data were recorded for some samples, so the totals for the different classification factors (year, month, age) in Table 1 have different sums, ranging from 50 to 58). Comparison of diet between males and females was limited to birds foraging on their own (i.e. not including nestlings). Sex was determined by genetic analysis of blood samples (Griffiths et al. 1996), with 12 birds determined to be females and five determined to be males.

Table 1. Breakdown of food samples from Willow Flycatchers from the Kern River nesting site in California by year, month, and age of bird. N = number of samples for each category; A = adult; and Y = nestling.

		N
Year	1996	18
	1997	40
Month	June	8
	July	43
	August	1
Age	A	16
	Y	34
Sex	F	12
	M	5

Comparisons were made with other data from Willow Flycatcher breeding sites in Arizona (Drost et al. 1998). The two sites with sufficiently large sample sizes for statistical comparison were the Tonto Creek inflow into Roosevelt Lake, and the Salt River inflow into Roosevelt Lake. All of these samples were from adult birds captured in mist nets in 1996. There were 11 samples from the Salt River site, all from tamarisk habitat. At Tonto Creek, there were nine samples from tamarisk and six from mixed riparian habitat. Because there appear to be differences in diet composition between tamarisk and mixed riparian habitat (Drost et al. 1998), we did not lump the Tonto Creek samples, instead using only the nine samples from tamarisk habitat in comparative analyses (the six from mixed habitat were not included because of the small sample size).

Overall diet composition

In the results and discussion that follow, we first present overall data for all of the Kern samples combined. Following this, the samples are broken down according to variables that may affect diet composition (year, age, etc.), for tests of differences among subgroups of the samples. Figure 3 shows the overall composition of the diet, in terms of numbers of prey individuals, for all samples. The most numerous prey recorded in the samples were true bugs (order Hemiptera), followed by flies (Diptera), and beetles (Coleoptera). The next most numerous groups in the samples (in order of abundance) were termites (order Isoptera), leafhoppers (family Cicadellidae in the order

Homoptera), spiders (order Araneae), bees and wasps (order Hymenoptera), and dragonflies and damselflies (order Odonata). Taken together with bugs, flies, and beetles, these groups comprised 85% of the prey recorded in the samples.

Percent occurrence of prey taxa is shown in Figure 4. Flies were the most common prey taxon, with one or more flies being present in nearly 75% of the samples. True bugs and beetles were both present in over half of the samples. These prey taxa were followed (in order) by dragonflies and damselflies, bees and wasps, leafhoppers, and spiders.

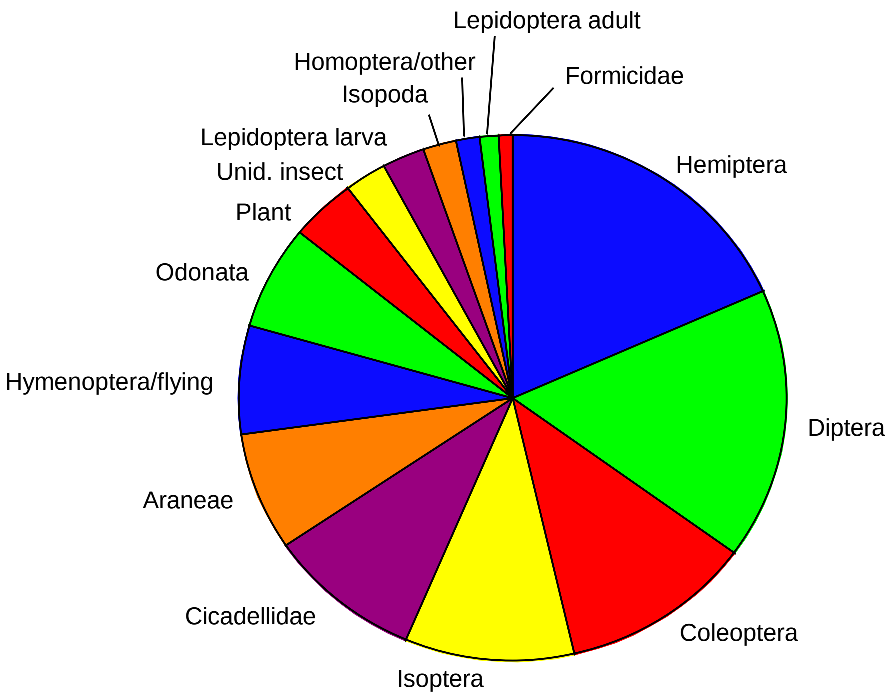


Figure 3. Proportions of different prey taxa (based on total numbers of prey) in diet samples from Southwestern Willow Flycatchers at the Kern River Preserve in southern California, by major prey taxa. Taxa are graphed clockwise from most numerous to least numerous. See text for further explanation.

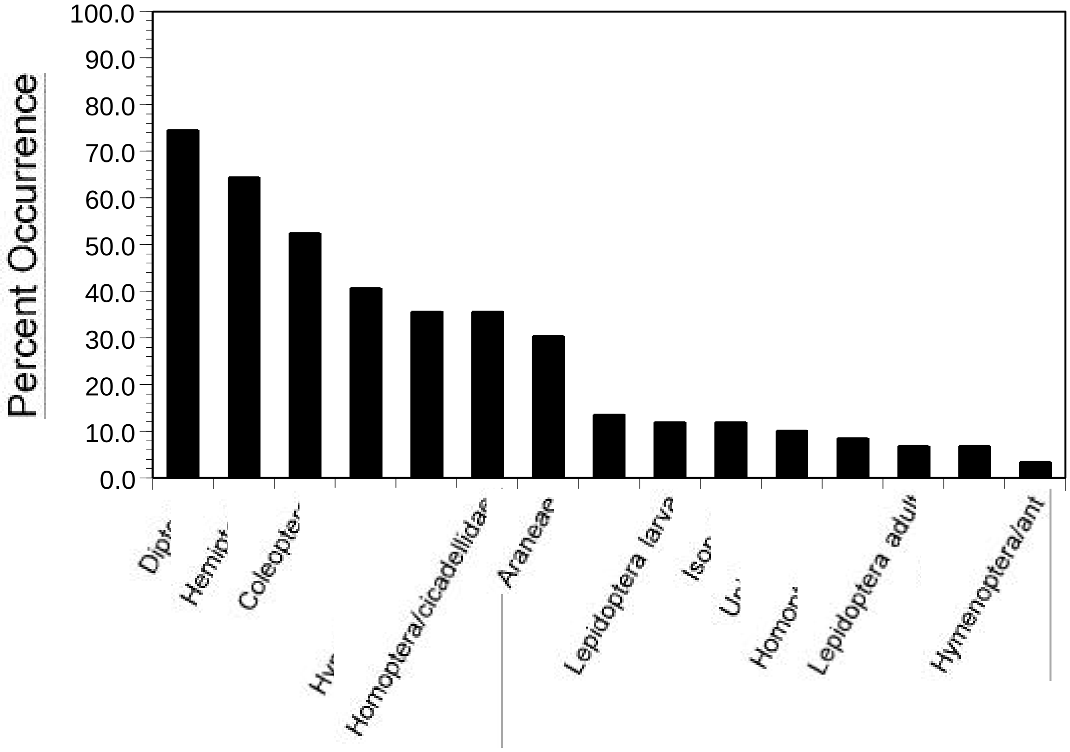


Figure 4. Percent occurrence of major prey taxa in diet samples from Southwestern Willow Flycatchers at the Kern River Preserve in southern California. Taxa are graphed from greatest occurrence to lowest. 100% occurrence would indicate that a prey taxon was found in every sample examined.

Comparisons

Year, Month, Age

We analyzed differences in numbers of major prey taxa in the diet samples between years, among months during the breeding season, and between adult and nestling birds at the Kern River (Table 2). For this analysis, we used the the seven most common invertebrate taxa in the samples (Diptera; Hymenoptera; Hemiptera; Homoptera: Cicadellidae; Odonata; Coleoptera; and Araneae), with remaining food items grouped in an “other” category. There was not a significant difference between samples from 1996 and 1997, nor were there significant differences among months (June, July, August). There was a statistically significant difference in diet based on age (adults vs. nestlings) and in the Month * Age interaction (Table 2). Among the variables included in the MANOVA, the number of flies (Diptera), bugs (Hemiptera), and leafhoppers (Homoptera: Cicadellidae) showed strong differences between adults and nestlings (Table 3). Figure 5 compares the composition of the diet (numbers of major prey taxa) of nestling and adult flycatchers at the Kern River site.

Table 2. Southwestern Willow Flycatcher diet: MANOVA results for differences between years (1996 vs. 1997), calendar months (June vs. July), and age of bird (adult vs. nestling). Lines shown in bold are significant at the p=0.05 level.

Effect	F	Significance
Year	1.127	0.369
Month	0.985	0.482
Age	**3.475**	**0.005**
Year * Month interaction	not calculated	
Year * Age interaction	1.488	0.196
Month * Age interaction	**3.433**	**0.005**
Year * Month * Age	not calculated	

Table 3. Differences in major prey taxa in diet samples from adult and nestling Southwestern Willow Flycatchers at the Kern River Preserve in southern California: MANOVA results from a comparison using year (1996 vs. 1997), calendar month (June vs. July), and age of bird (adult vs. nestling) as factors. Lines shown in bold are significant at the p=0.05 level.

Dependent Variable	F	Significance
Diptera	**14.125**	**0.001**
Hymenoptera	0.166	0.686
Hemiptera	**4.055**	**0.050**
Cicadellidae	**10.850**	**0.002**
Odonata	1.743	0.194
Coleoptera	1.094	0.301
Araneae	2.043	0.160
Other taxa	0.796	0.377

Adults and nestlings were also significantly different in the total numbers of identifiable prey individuals per fecal sample, as well as in the number of identifiable taxa per sample. Diet samples from nestling birds contained significantly higher numbers of prey than diet samples from adults (Median Test, ? ^{2} = 11.8, $p < 0.005$). Samples from nestlings also contained more prey taxa per sample than samples from adults (Median Test, ? ^{2} = 10.6, $p < 0.005$). Table 4 lists summary statistics for diet samples from adult and nestling birds.

Table 4. Differences in number of prey individuals per sample, and number of major prey taxa per sample, in diet samples from adult and nestling Southwestern Willow Flycatchers at the Kern River Preserve in southern California. Range is the minimum and maximum per sample for each category, and 'n' is sample size.

	Mean	Median	Range	n
Total prey per sample				
Adults	3.7	4	1 – 12	16
Nestlings	7.2	7	2 – 24	33
Prey taxa per sample				
Adults	3.3	3.5	1 – 7	16
Nestlings	5.0	5	2 – 9	33

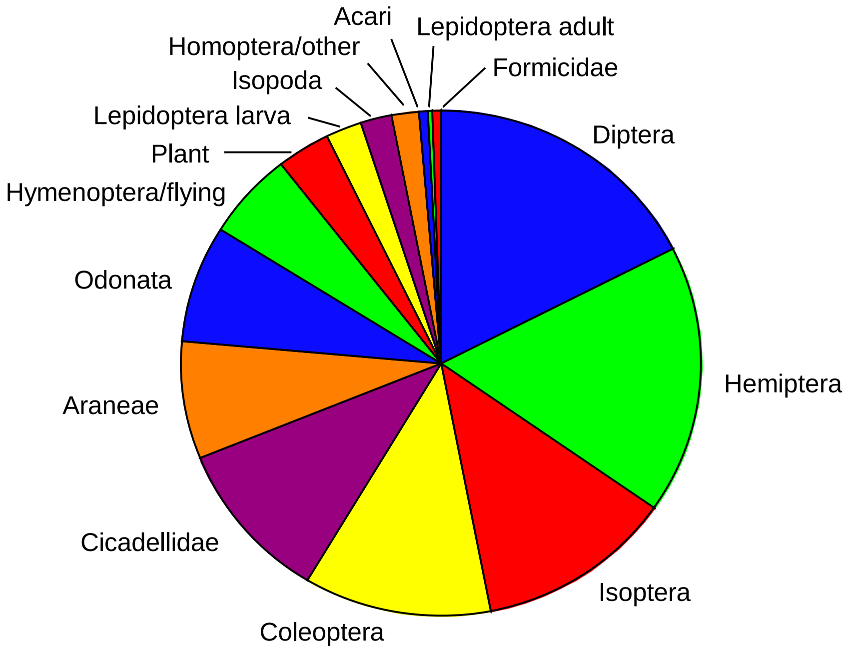
Sex

Male and female Willow Flycatchers at the Kern River Preserve showed a trend toward differences in diet composition. Both the overall MANOVA results, and individual comparisons for Diptera and Hymenoptera, had p-values between 0.05 and 0.10 (overall MANOVA results: F=3.186, p=0.061). Table 5 provides a breakdown of the MANOVA results by major prey taxa for males vs. females.

Table 5. MANOVA results for a comparison of the diet of male and female Southwestern Willow Flycatchers at the Kern River Preserve in California. Table shows statistics for the different major invertebrate taxa used as dependent variables in the test. Lines in bold have $0.05 < p < 0.10$.

Taxon	F	Significance
True flies (Diptera)	**4.344**	**0.055**
Bees & Wasps (Hymenoptera)	**3.151**	**0.096**
True bugs (Hemiptera)	0.876	0.364
Leafhoppers (Cicadellidae)	2.109	0.167
Dragonflies & Damselflies (Odonata)	1.471	0.244
Beetles (Coleoptera)	1.218	0.287
Araneae	2.508	0.134
Other orders	**3.433**	**0.084**

a. Nestlings



b. Adults

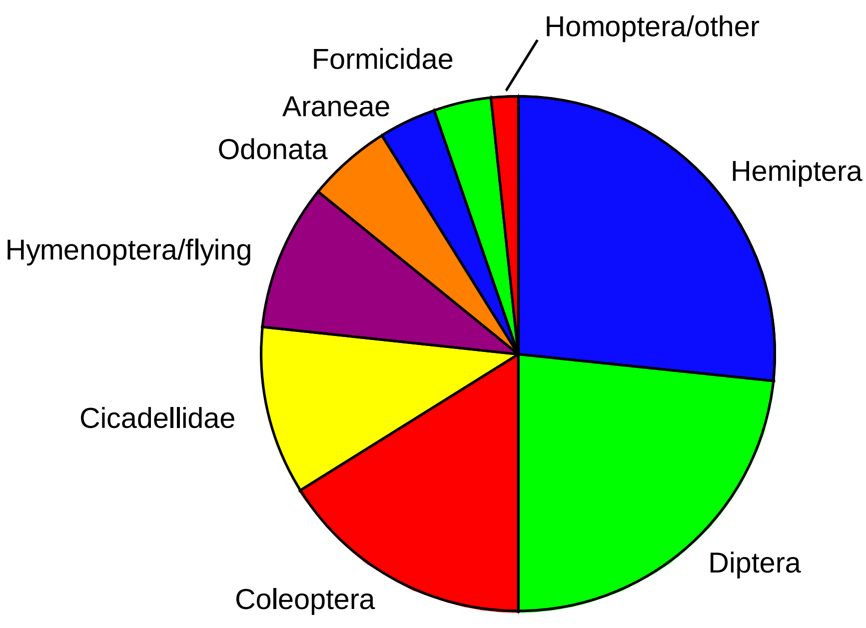


Figure 5. Diet composition (based on total number of prey individuals in different major prey taxa) of (a.) nestling and (b.) adult Southwestern Willow Flycatchers, from the Kern River Preserve in southern California. n=33 nestlings and 16 adults.

Site

We compared Southwestern Willow Flycatcher diet at three sites: the Kern River Preserve (n=16), the Salt River inflow to Roosevelt Lake (n=11), and the Tonto Creek inflow to Roosevelt Lake (n=9). These comparisons were based on fecal samples from adult birds occupying uniform habitats at the three sites (Cottonwood – Willow at Kern River, and Tamarisk at Salt River and Tonto Creek). There were significant differences in prey composition by major taxa among the sites (F=4.130, p<0.001). Table 6 lists the MANOVA results for the major prey taxa included in the analysis, and Figure 6 compares proportions of prey taxa included in the diet at each of the three sites.

Table 6. Table showing MANOVA results for the different variables (different insect orders) included in the test evaluating differences among sites (Kern River vs. Salt River vs. Tonto Creek). Lines shown in bold are significant at the p=0.05 level.

Taxon	F	Significance
True flies (Diptera)	0.917	0.409
Bees & Wasps (Hymenoptera)	**11.456**	**<0.001**
True bugs (Hemiptera)	1.756	0.188
Leafhoppers (Cicadellidae)	1.936	0.159
Dragonflies & Damselflies (Odonata)	**6.235**	**0.005**
Beetles (Coleoptera)	0.526	0.595
Other orders	2.445	0.101

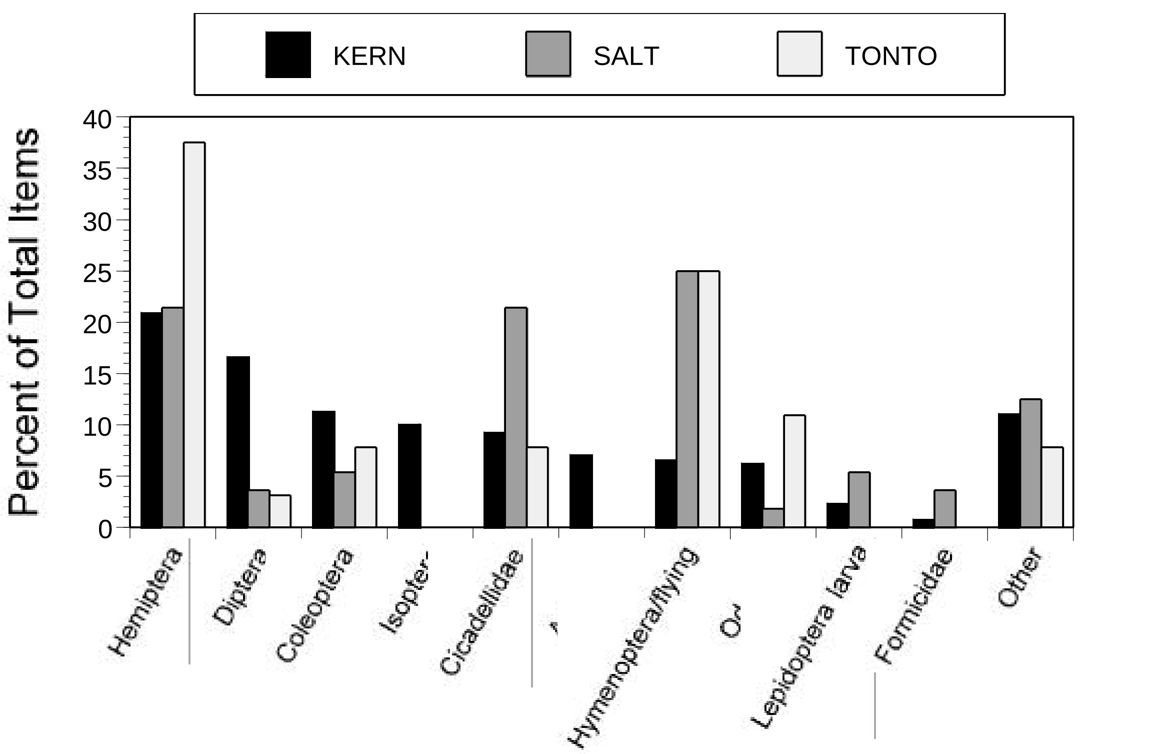


Figure 6. Relative contribution of major prey taxa to Southwestern Willow Flycatcher diet at three sites: the Kern River Preserve in southern California, and the Salt River and Tonto Creek sites in Arizona. Because of differences in sample size, numbers for each site are expressed as a percentage of the total at that site.

Discussion

Overall diet composition

We analyzed 59 samples from the Kern River Preserve, doubling the total number of diet samples that have been examined for the Southwestern Willow Flycatcher. All of these samples were from one population, in native willow and cottonwood-willow habitat, and were collected over a two-year period (1996 and 1997). Earlier work (Drost et al. 1998) provided a broad overview of flycatcher diet over the range of the subspecies, but the small sample sizes at a number of different sites, along with the different habitats, different months when the samples were collected, and other potentially confounding factors, all made comparisons difficult (e.g. among habitats or sites, or between adults and young). The large number of samples from the Kern River site are valuable in providing a clear picture of the diet of a population at a single site, and in allowing comparisons between years, between sexes, between adults and young, and with other sites across the subspecies' range.

Total numbers of prey

The total numbers of prey from all samples combined provide a picture of the overall diet of a population, showing the numeric contribution of each prey taxon to the diet, averaged over any individual diet preferences. Particularly with a small sample size, total numbers of prey can be biased by one or a few individuals consuming large numbers of a single prey taxa. For the Kern samples, three orders –true bugs, flies, and beetles – made up close to half of the total number of prey items (Figure 3; see also Table 7). Of these, numbers of bugs and flies were relatively close; since flies were generally more fragmented in the samples and more difficult to enumerate, the two taxa may contribute about equally to the diet. Termites, which had not been recorded in earlier samples (Drost et al. 1998) ranked fourth in terms of total numbers in the Kern samples. All of the termites examined in the samples were winged individuals, presumably captured during one of their large, swarming mating flights.

Farther down the list of prey numbers, but still occurring in moderate abundance were (in order): leafhoppers, spiders, bees and wasps (i.e. Hymenoptera excluding ants), and dragonflies and damselflies. The leafhoppers were not identified below family level, but the remains examined in the diet samples were clearly larger and of one or more different species than the tamarisk leafhoppers that were common in samples from tamarisk habitats in Arizona (Drost et al. 1998). Moderate numbers of spiders were recorded in the diet. Some of these were small spiders that could have been caught while they were "ballooning" (being carried through the air on long strands of their own silk). However, some of the spider remains in the diet samples were from spiders that were too large to be carried through the air. These must have been captured either from vegetation, from the ground, or out of their webs. Also, some of the spiders were of groups – e.g. jumping spiders, family Salticidae – that do not build typical webs, and so must have been captured on either the ground or vegetation.

Bees and wasps ranked relatively low in the Kern River samples, relative to previous studies (cf. Drost et al. 1998). Dragonflies and damselflies were recorded in just slightly lower numbers than bees and wasps. Given the large size of dragonflies and damselflies, and the relatively large size of many of the bees and wasps recorded (bees in the superfamily Apoidea, Vespid wasps, and other moderate-sized species), these groups are probably more important in the diet than simple rank order would indicate. Rare diet items include small seeds from unidentified fruit, which were the only plant remains that we found. Though few in number and infrequent in occurrence, these are interesting from the standpoint of the additional breadth they indicate for the diet.

Many prey items were identified to finer levels than those used to summarize diet, and some of these more specific identifications provide additional insight into the foraging behavior of Southwestern Willow Flycatchers. Two of the flies identified, for example, were species in the suborder Nematocera (the group including midges and gnats). These are small, weakly-flying species. Most of the flies identified, however, were calyptrate muscoid flies (section Calyptratae in the suborder Cyclorrhapha). These are medium-sized, strong-flying species. The largest number of Hymenoptera that were identified were bees in the superfamily Apoidea, which are also strong fliers, and which typically feed from flowers. One whole food item brought by a Willow Flycatcher to a nestling at the Kern site was collected, and identified as a medium-sized soldier fly (Diptera: Stratiomyidae). This is also a flower-visiting group. Leafhoppers, small beetles, and some other groups are probably captured by hover-gleaning (a behavior noted occasionally by Willow Flycatcher field crews), but most prey are evidently captured by active pursuit.

Percent Occurrence

Percent occurrence provides a better indication of the diet of individuals throughout a local population. It is a measure of how prevalent a particular prey taxon is in individual diet samples. The most common prey items, which individuals in the population take most consistently, should approach 100% in percent occurrence. At the other extreme, a prey taxon which is only rarely consumed will have a very low occurrence rate. As noted, total prey numbers may be biased by single individuals taking large numbers of a single prey taxon (either through individual preference, or due to a local or temporary abundance of the prey taxon), and percent occurrence helps to account for this. For example, the relatively large number of termites in the diet of the Kern River birds consisted of a total of 38 termites taken by only four birds (7% of the diet samples examined). By comparison, close to the same number of leafhoppers (35) were included in the diet, but these were distributed through 21 samples (37% of the samples examined).

The three most prevalent (highest percent occurrence) diet items in the Kern River samples were the same three that ranked highest in terms of total prey numbers, except that the order of the first two is reversed. Flies (order Diptera) occurred in three-fourths of all samples, and bugs (order Hemiptera) were present in about 65% of the samples. Table 7 compares the rank order of prey taxa in the Kern River flycatcher diet samples, by total number and by percent occurrence. Termites (Isoptera) are much lower (near the bottom) in percent occurrence compared to total numbers, and bees and wasps (Hymenoptera) and dragonflies and damselflies (Odonata) rank higher in percent occurrence, trading places with leafhoppers (Cicadellidae) and spiders (Araneae). Presumably due to their size, odonates were never found more than one per sample in the fecal samples that we examined, and hymenopterans were usually only one per sample as well (we recorded two individuals in only four samples). In contrast, individual samples often contained two or more leafhoppers or spiders (up to six per sample for leafhoppers). This accounts for the lower total numbers, but higher percent occurrence, of hymenopterans and odonates.

Table 7. Diet composition of Southwestern Willow Flycatchers at the Kern River Preserve in southern California, based on fecal samples collected in 1996 and 1997. First half of table shows total number of prey individuals in major taxonomic groups (order or family), and second half of table shows percent occurrence of prey taxa (as number of samples containing prey item *x*, divided by the total number of samples. n = 59.

Taxon	Number	Taxon	% Occurr.
Hemiptera	69	Diptera	74.6
Diptera	63	Hemiptera	64.4
Coleoptera	43	Coleoptera	52.5
Isoptera	38	Odonata	40.7
Cicadellidae	35	Hymenoptera/flying	35.6
Araneae	27	Cicadellidae	35.6
Hymenoptera/flying	25	Araneae	30.5
Odonata	24	Plant	13.6
Plant	15	Lepidoptera larva	11.9
Unid. insect	10	Isopoda	11.9
Lepidoptera larva	9	Unid. insect	10.2
Isopoda	7	Homoptera/other	8.5
Homoptera/other	6	Lepidoptera adult	6.8
Lepidoptera adult	4	Isoptera	6.8
Formicidae	3	Formicidae	3.4
Acari	1	Acari	1.7

Comparisons

Year – Month – Age

There was no significant difference in the diet samples from 1996 compared to 1997, nor any evident trend. This indicates that the diet of the Kern River population was relatively consistent between years. Likewise, there was no indication of seasonal differences in the comparison of diet between months (June vs. July; only one sample was available for August). However, the sample size for June was only eight, so we do not place much weight on this analysis. Given the marked changes that may occur in invertebrate communities over the course of a season, it would not be surprising to see corresponding shifts in the diet of insectivorous birds.

There were significant differences between adults and nestlings, however. This included both differences in composition (prey taxa and relative numbers; Table 3) and differences in quantity (total numbers of prey per sample, and numbers of identified taxa per sample; Table 4). Table 8 lists mean number of different taxa in fecal samples from adults and nestlings. Nestlings averaged higher numbers of all prey taxa, with the mean number per sample more than twice that of adults for many taxa. Among the most common prey taxa, these differences were statistically significant for flies (Diptera), true bugs (Hemiptera), and leafhoppers (Homoptera: Cicadellidae).

Table 8. Mean numbers of different prey taxa in diet samples from adult and nestling Southwestern Willow Flycatchers at the Kern River Preserve in southern California: Value listed under 'Adult' and 'Nestling' is the mean number of each prey taxon per sample. Lines in bold indicate individual taxa that were significantly different at the 0.05 level in a MANOVA incorporating year, month, and age of bird.

Prey Taxon	Adults	Nestlings
Diptera	**0.81**	**1.24**
Hymenoptera	0.31	0.41
Hemiptera	**0.94**	**1.32**
Cicadellidae	**0.37**	**0.74**
Odonata	0.19	0.53
Coleoptera	0.56	0.85
Araneae	0.13	0.56

Numbers of prey individuals, as well as prey diversity (number of prey taxa) in samples from nestlings were substantially larger than in samples from adults (Table 4). Both mean and median numbers of prey in samples from nestlings were close to twice the numbers in samples from adults. We do not specific evidence to explain the conspicuously higher number of prey per sample among nestlings. It may simply reflect longer time intervals between defecating in the young, or it may be due to higher feeding rates for nestlings as compared to adults. Mean and median number of prey taxa per sample among nestlings is about 1.5 times as great as in samples from adults. As with number of prey individuals per sample, the difference in prey diversity per sample between nestlings and adults is conspicuous, but the reason for the difference is not clear. It may simply be correlated with the greater number of prey per sample for the nestlings. However, it may also reflect a wider selection of prey by adult birds that are feeding hungry nestlings (i.e. prey that birds might pass up when foraging on their own, are captured when the birds are feeding young), or a broader availability of different prey during the nesting period. Further analyses may suggest explanations for these trends (e.g. if prey fed to young average smaller in size than prey consumed by adults, then the young may need higher numbers of prey to meet their needs).

Sex

There is a strong trend toward a difference in diet between males and females, but the MANOVA is not significant at the 0.05 level (p=0.061). We restricted this analysis to adult males and females, assuming that any differences between the sexes would arise from birds foraging on their own, as opposed to nestlings being fed by their parents. Limiting the analysis to adult birds left us with a small samples size (n=5 males and n=12 females), and relatively low power (ß=0.341). The strongest trends toward differences between the sexes among major prey taxa were for flies, and bees and wasps (Table 5). Given that there are potential behavioral explanations for differences in diet between males and females during the nesting season (e.g. foraging in proximity to the nest vs. farther away, or differences in roles between the sexes in feeding the young), this comparison would be worth further examination in future considerations of Willow Flycatcher diet.

Site

Previous work (Drost et al. 1998) provided information on the general diet characteristics of Southwestern Willow Flycatchers at a number of sites across the range of the subspecies. Of the sites included in that study, we had a sufficient number of samples from two sites to make comparisons with the Kern River samples. These two sites were both in tamarisk habitat, at the Salt River inflow to Roosevelt Lake (11 samples) and at the Tonto Creek inflow to Roosevelt Lake (9 samples). There were significant differences in prey composition among these three sites (Table 6). Table 9 compares mean numbers of major prey taxa at the three sites. There were significant differences in numbers of bees and wasps in the diet at the three sites, with numbers at Kern River being much lower than in the tamarsik at Salt River and Tonto Creek. There were also significant differences in numbers of dragonflies and damselflies, with relatively high numbers at Tonto Creek, and low numbers at both Kern River and Salt River. Among some of the other prey taxa, there were trends toward more bugs (Hemiptera) at Tonto Creek, and more leafhoppers at Salt River. Kern River had the highest mean number of other orders, based in part on relatively high numbers of spiders and termites.

Table 9. Mean numbers of different major prey taxa in Southwestern Willow Flycatcher diet samples from three sites: Kern River, California, and Salt River and Tonto Creek, Arizona. Lines in bold were significantly different in a MANOVA comparing prey taxa at the three sites.

Taxon	Kern River	Salt River	Tonto Creek
True flies (Diptera)	0.81	0.18	2.09
Bees & Wasps (Hymenoptera)	**0.31**	**1.27**	**1.91**
True bugs (Hemiptera)	0.94	1.09	2.36
Leafhoppers (Cicadellidae)	0.37	1.09	0.45
Dragonflies & Damselflies (Odonata)	**0.19**	**0.09**	**0.73**
Beetles (Coleoptera)	0.56	0.27	0.55
Other orders	1.25	0.64	0.73

Habitat at the Kern River Preserve is native willow, while both the Salt River and Tonto Creek have large amounts of non-native tamarisk (the Salt River site is monotypic tamarisk, whereas Tonto Creek has scattered cottonwoods mixed in with extensive tamarisk). Hence the differences in diet in this comparison among sites may actually be primarily a function of habitat differences. Our earlier work (Drost et al. 1998) showed strong patterns in comparisons of native and non-native habitats. Food resources are less diverse in tamarisk habitat, based both on studies of invertebrate communities in tamarisk habitat (DeLoach et al. 1996, Liesner 1971) and on the earlier analyses of flycatcher diet in native vs. tamarisk habitat. In the earlier study (Drost et al. 1998), the diet of birds in tamarisk habitats was dominated by three groups: true bugs (Hemiptera); bees and wasps (Hymenoptera); and leafhoppers (Homoptera: Cicadellidae). Many of the bees and wasps were pollinating species, evidently attracted by the profuse flowering of the tamarisk. All or most of the leafhoppers were a non-native species, imported with and quite abundant on the tamarisk.

Further comparing the results of this study to earlier work (Beal 1912, Bent 1942, Drost et al. 1998, McCabe 1991), bugs, various hymenopterans, and flies are reported by all sources as prominent food items. We found leafhoppers to be a prominent prey item in tamarisk, but other studies have found significant numbers in native habitats as well (Beal 1912). Various species of flies (Diptera) make up a consistently high portion of the diet at Kern and in other areas. The Kern River samples had higher numbers of some taxa (compared to earlier studies), including beetles and spiders. The spiders (and possibly some of the beetles) are of interest because many of them are probably taken by gleaning. Large numbers of termites (Isoptera) were found in samples from Kern, and were not seen at all in the samples from Arizona and Colorado (however, these were all from a few individual samples; see below).

On the other hand, the observed diet at Kern included relatively low numbers of flying hymenoptera (bees and wasps), which are a major contributor to the diet in all previous reports (cf. Table 9). This paucity of hymenoptera in the diet may be due to the relative scarcity of flowering shrubs at this site. Tamarisk and mesquite, which bloom heavily and are abundant at some other Willow Flycatcher sites, are virtually absent at Kern. Willows at the Kern site flower by early May, and so insects attracted to flowering willows are not represented in our samples. Malaise trap samples for flying insects at the Kern River site support this idea, being heavily dominated by flies, with few hymenoptera (Whitfield unpublished data). The Kern diet samples also contained relatively few lepidoptera larvae (caterpillars) which make up a moderate part of the diet in Arizona and Colorado. Very few ants were present in the diet at Kern, relative to the Arizona and Colorado data.

The results for percent occurrence of major prey taxa in the diet largely follow those of prey numbers, with the exception of termites. Beetles and spiders were much more frequent in the Kern samples, compared to diet samples from Arizona and Colorado. Flying hymenoptera ranked relatively low in the Kern samples, compared to the Arizona / Colorado samples, where they were the most prevalent prey group. Lepidoptera larvae and ants were also infrequent at Kern compared to Arizona / Colorado. Winged termites were taken in relatively large numbers but were only taken by a few birds, so their percent occurrence in the diet is low. This probably represents a chance occurrence of these flycatchers feeding in the vicinity of a termite mating flight, where large numbers of flying termites are in the air.

Conservation and Management Implications

The results of this study lead to the following points regarding conservation implications for the Southwestern Willow Flycatcher:

1) Southwestern Willow Flycatchers take a wide range of invertebrate prey, including both insects and spiders, and flying insects and ground and vegetation-dwelling species. Taken together with the significant differences recorded among sites and the variety of foraging techniques used by the birds (and suggested by the food data), this indicates significant flexibility in the diet. Such flexibility and range in the diet should be advantageous in the face of variable conditions (e.g. site to site and year to year). Under normal conditions, we would not expect food shortage, in and of itself, to significantly limit flycatcher populations.

On the other hand, the wide variety of invertebrate prey taken by Willow Flycatchers provides many potential avenues for accumulating environmental toxins. The variety of prey taken includes strong-flying species (some of the bees, wasps, flies, and dragonflies) which may come from relatively long distances away from flycatcher sites. It also includes species of terrestrial (the majority of prey individuals) and aquatic (dragonflies) origins, so pesticides and other potentially harmful compounds may be acquired from either of these sources. Chemical toxins are one possible explanation of deformities observed in Southwestern Willow Flycatchers (Paxton et al. 1997), and exposure to pesticides and other harmful chemicals is a particular threat at sites surrounded by intensive agriculture and along lowland riparian sites downstream from pollution sources.

2) We did not see significant differences in diet between years, or even a trend toward differences. This is in spite of significant environmental variation from year to year. It is critical, of course, to directly evaluate differences in flycatcher population characteristics between years, but the diet data do not give any evidence of significant problems associated with food availability from one year to the next.

3) We did find significant differences in Willow Flycatcher diet in different habitats, in this and earlier work (Drost et al. 1998). Diet differences included both composition of major prey taxa and prey diversity. This leads to questions about whether there are concomitant differences in flycatcher behavior and/or population characteristics (e.g. density, reproductive effort, survivorship) among the habitats. The simple fact of differences in diet between different habitats, however, does not mean that one habitat type is necessarily better or worse than another from a food availability perspective. On the one hand, the greater variety of prey in native willow or mixed riparian may offer some buffer against a temporary shortage of any particular prey species. On the other hand, the large number of pollinator species attracted to flowering tamarisk appears to provide a very good source of prey in this habitat. Given that tamarisk flowers during much of the flycatcher breeding season at our study sites, abundance of large prey items (e.g., pollinators) may more than compensate for reduced diversity of available prey types.

This latter point is particularly important, given the current effort to introduce biocontrol agents for the purpose of reducing tamarisk habitat in the Southwest (DeLoach et al. 1996, Tracy and DeLoach 1999). Proponents of tamarisk control make the argument that the lower insect diversity (and thus potential flycatcher prey base) observed in tamarisk habitats compared with native habitats suggests that tamarisk is inferior or suboptimal for Southwestern Willow Flycatchers. Although superficially logical in the absence of information on flycatcher food habits, our diet data suggest there is little ecological basis to support this argument. Flycatcher diet does differ between tamarisk and native habitats. However, the types of insects that are attracted in large numbers to flowering tamarisk (primarily medium to large-sized hymenopterans) are important prey of Willow Flycatchers and the birds at our study sites evidently responded by taking proportionately greater numbers of these insects in these dense, relatively mesic tamarisk habitats.

Furthermore, the presence of some tamarisk may actually enhance flycatcher prey availability in mixed native-tamarisk riparian habitats. In some flycatcher breeding sites, such as the Kern River Preserve, flowering of the dominant tree/shrub vegetation (e.g., willows) ends early in the breeding season. Thus, pollinating insects that can provide a ready food source may be scarce within the breeding patch during the incubation and nestling periods. If tamarisk, which flowers later in the summer, is also present in the habitat, pollinating insects will be present during a longer part of the breeding season, enhancing the available flycatcher prey base.

Another consideration with regard to flycatcher diet is the nature of habitats and land uses adjacent to the riparian breeding site. This is particularly true where flycatchers breed in dense tamarisk, and where most of the available prey species attracted to the flowering tamarisk are produced in or supported by other nearby habitat types. Adjacent invertebrate-rich habitats such as mesquite or wetlands may provide good source areas for “tourist” species that can travel to the flycatcher’s breeding patch. Adjacent land uses with intensive agriculture may be sources for fewer or different prey taxa, especially if the agriculture includes intensive or extensive invertebrate control efforts (e.g., pesticides). On the other hand, some agricultural activities or crops may actually attract pollinators and other potential prey taxa. Finally, conversion of surrounding habitats to urban use is likely to dramatically alter the local distribution and abundance of the flycatcher’s invertebrate prey, especially where insect control measures are aggressively pursued. It is important to keep in mind that these land-use effects and their ramifications to Willow Flycatcher diet are theoretical, and have yet to be investigated.

Unfortunately, no food habits study will allow us to determine the ecological ramifications (if any) of the observed diet differences. However, our results do point to potential areas of concern and directions of future research. The truest test of the relative value of native versus tamarisk habitats would be based on comparison of flycatcher survivorship, reproductive success and/or physiological condition in these differing habitats. Such studies are currently being conducted by several agencies and research groups in the Southwest. The food habits data reported herein should be useful in interpreting the results of this ongoing research.

Acknowledgments

Funding for analysis of diet samples was provided by the U.S. Bureau of Reclamation, Upper Colorado Regional Office. The banding and demography work during which the samples were gathered was funded by the California Department of Fish and Game, U.S Army Corps of Engineers, U.S. Bureau of Reclamation (Phoenix Area Office), and U.S. Geological Survey. Our thanks to Christine Karas (U.S. Bureau of Reclamation) for administrative support and scientific consultation regarding this diet study. We also thank Dr. Barbara Kus of the USGS Western Ecological Research Center, and Karen Barnett of the U.S. Bureau of Reclamation Upper Colorado Regional Office, for their careful reading and review comments on the draft version of this report. Our gratitude also to the dedicated and hard working banding staff who collected the samples upon which this study was based.

Literature Cited

Arnett, R. H, Jr. 1973. The beetles of the United States. American Entomological Institute, Ann Arbor, MI.

Arnett, R. H, Jr. 1993. American insects. Sandhill Crane Press, Gainesville, FL.

Beal, F. E. L. 1912. Food of our more important flycatchers. U.S. Bureau of Biological Survey, Bulletin 4. Washington, D.C., 67 pp.

Bent, A. C. 1942. Life histories of North American flycatchers, larks, swallows, and their allies. Bull. 179. U.S. National Museum, Washington, D.C., 555 pp.

Borror, D. J., D. M. DeLong, and C. A. Triplehorn. 1976. An introduction to the study of insects. Holt, Rinehart, and Winston, New York.

Brodsky, Andrei K. 1994. The evolution of insect flight. Oxford University Press, Oxford.

Cole, F. R. 1969. The flies of western North America. University of California Press, Berkeley and Los Angeles.

Daniel. W. W. 1990. Applied nonparametric statistics. PWS – Kent, Boston, MA.

DeLoach, C. J., M. J. Pitcairn, and D. Woods. 1996. Biological control of salt cedar in southern California. pp. 30-31 In: Kunzmann, M. R., R. R. Johnson, and P. S. Bennett (editors). 1989. Tamarisk control in the southwestern United States. U.S.D.I. National Park Service, Special Report No. 9. 144 pp.

Drost, C. A., M. K. Sogge, and E. Paxton. 1998. Preliminary diet study of the endangered Southwestern Willow Flycatcher. Report to U.S. Bureau of Reclamation, Phoenix. USGS / Colorado Plateau Field Station, Flagstaff, AZ.

Goulet, H., and J. T. Huber. 1993. Hymenoptera of the world: an identification guide to families. Research Branch, Agriculture Canada, Publication 1894/E.

Griffiths, R., S. Dean, and C. Dijkstra. 1996. Sex identification in birds using two CHD genes. Proc. R. Soc. Lond. B 263:1251-1256.

Grodnitsky, Dmitry L. 1999. Form and function of insect wings. Johns Hopkins University Press, Baltimore and London.

Kaston, B. J. 1978. How to know the spiders. Wm. C. Brown, Dubuque, Iowa.

Liesner, D. R. 1971. Phytophagous insects of *Tamarix* spp. in New Mexico. M.S. Thesis, New Mexico State University, Las Cruces, NM.

McAlpine, J. F., et al. (coordinators). 1981. Manual of Nearctic diptera. Monograph no. 27, Research Branch, Agriculture Canada.

McCabe, R. A. 1991. The little green bird; ecology of the willow flycatcher. Rusty Rock Press, Madison, Wisconsin.

Merritt, R. W., and K. W. Cummins. 1996. An introduction to the aquatic insects of North America. Kendall / Hunt, Dubuque, Iowa

Michener, C. D., R. J. McGinley, and B. N. Danforth. 1994. The bee genera of North and Central America (Hymenoptera: Apoidea). Smithsonian Institution Press, Washington.

Osborn, Herbert. 1912. Leafhoppers affecting cereals, grasses, and forage crops. U.S.D.A. Bureau of Entomology, Bulletin no. 108. Government Printing Office, Washington, D.C.

Paxton, E. H., S. M. Langridge and M. K. Sogge. 1997. Banding and population genetics of Southwestern Willow Flycatchers in Arizona – 1997 summary report. USGS Colorado Plateau Field Station report to the U.S. Bureau of Reclamation, Phoenix.

Sogge, M. K., R. M. Marshall, S. J. Sferra, and T. J. Tibbitts. 1997. A Southwestern Willow Flycatcher Natural History Summary and Survey Protocol. Technical Report. NPS/NAUCPRS/NRTR-97/12.

Stephen, W. P., G. E. Bohart, and P. F. Torchio. 1969. The biology and external morphology of bees; with a synopsis of the genera of Northwestern America. Oregon State University, Corvallis, OR.

Thorp, J. H., and A. P. Covich. 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego, CA.

Tracy, J. L. and C. J. DeLoach. 1999. Biological control of saltcedar in the United States: Progress and projected ecological effects. Pp. 111-115 in C. E. Bell (ed.). *Arundo* and Saltcedar: the Deadly Duo. Proceedings of the Arundo and Saltcedar Workshop, 17 June 1998, Ontario, CA.

Unitt, P. 1987. *Empidonax traillii extimus* **-** an endangered subspecies. Western Birds 18: 137-162.

U.S. Fish and Wildlife Service. 1995. Endangered and Threatened Wildlife and Plants: Final Rule Determining Endangered Status for the Southwestern Willow Flycatcher. Federal Register 60:10694-10715.

Whitfield, M. J., K. M. Enos and F. P. Rowe. 1999. Is cowbird trapping effective for managing populations of the endangered Southwestern Willow Flycatcher? Studies in Avian Biology 18:260-266.

Appendix 1. Sample data for Southwestern Willow Flycatcher fecal samples included in this study. Arizona and Colorado locations are described in Drost et al. (1997). Abbreviations are: AHY = After hatch year (adult); L = Local (nestling); U = Unknown; F = female; M = male. Territory abbreviations listed under some of the samples are those used by Whitfield (unpublished data).

State: Site name	Habitat type	Date	Sample	Band number	Age	Sex
AZ: Salt	Tamarisk	06/29/96	16	1740-91732	AHY	M
AZ: Salt	Tamarisk	06/29/96	24	1740-91733	AHY	U
AZ: Salt	Tamarisk	06/29/96	25	1740-91731	AHY	F
AZ: Salt	Tamarisk	06/27/96	26	1740-91728	AHY	M
AZ: Salt	Tamarisk	06/29/96	27	1740-91734	AHY	M
AZ: Salt	Tamarisk	06/19/96	30	1740-91727	AHY	M
AZ: Salt	Tamarisk	06/16/96	34	1740-91723	AHY	F
AZ: Salt	Tamarisk	06/19/96	40	1740-91739	AHY	U
AZ: Salt	Tamarisk	06/16/96	46	1740-91723	AHY	F
AZ: Salt	Tamarisk	07/15/96	49	1740-91760	AHY	F
AZ: Tonto-T	Tamarisk	06/01/96	36	1740-91703	AHY	F
AZ: Tonto-T	Tamarisk	06/02/96	41	1740-91705	AHY	F
AZ: Tonto-T	Tamarisk	07/12/96	43	1740-91741	AHY	F
AZ: Tonto-T	Tamarisk	06/14/96	47	1740-91524	AHY	M
AZ: Tonto-T	Tamarisk	06/13/96	52	1740-91705	AHY	F
AZ: Tonto-T	Tamarisk	06/03/96	53	1740-91706	AHY	M
AZ: Tonto-T	Tamarisk	07/12/96	56	1740-91702	AHY	M
AZ: Tonto-T	Tamarisk	06/01/96	57	1740-91701	AHY	M
AZ: Tonto-T	Tamarisk	06/02/96	58	1740-91705	AHY	F
CA: Kern Territory PP4	Willow	07/19/97	77		L	
CA: Kern Territory SC7	Willow	07/11/97	78		L	
CA: Kern	Willow	01/01/97	79			
CA: Kern	Willow	01/01/97	80			
CA: Kern Territory SC19	Willow	07/25/97	81		L	
CA: Kern Territory RCE 2a	Willow	07/31/97	82		L	
CA: Kern Territory WAD3	Willow	07/26/97	83		L	
CA: Kern Territory SC14	Willow	07/21/97	84		L	

State: Site name	Habitat type	Date	Sample	Band number	Age	Sex
CA: Kern Territory PP6	Willow	07/21/97	85	1810-25727	AHY	F
CA: Kern Territory SC5	Willow	08/11/97	86	2110-34934	AHY	F
CA: Kern Territory SC9	Willow	07/13/97	87		L	
CA: Kern Territory SC19	Willow	07/18/97	88	2110-34912	AHY	F
CA: Kern Territory SC7	Willow	07/11/97	89		L	
CA: Kern Territory PP4	Willow	07/19/97	90		L	
CA: Kern Territory SC6a	Willow	07/14/97	91		L	
CA: Kern Territory RCE2a	Willow	07/31/97	92		L	
CA: Kern Territory WAD3	Willow	07/25/97	93	2110-34923	AHY	M
CA: Kern Territory PP2	Willow	07/13/97	94		L	
CA: Kern Territory SC12	Willow	07/16/97	95		L	
CA: Kern Territory SC7	Willow	07/11/97	96		L	
CA: Kern Territory SC6a	Willow	07/14/97	97		L	
CA: Kern Territory SC12	Willow	07/16/97	98		L	
CA: Kern No other data	Willow	01/01/97	99			
CA: Kern Territory SC9	Willow	07/13/97	100		L	
CA: Kern Territory SC1a	Willow	06/30/97	101		L	
CA: Kern Territory SC15	Willow	06/24/97	102	1810-25781	AHY	M
CA: Kern Territory SC13	Willow	06/27/97	103	1810-25681	AHY	M
CA: Kern Territory PP2	Willow	06/13/97	104	1810-25750	AHY	F
CA: Kern Territory SC5	Willow	07/08/97	105	1810-25797	L	

State: Site name	Habitat type	Date	Sample	Band number	Age	Sex
CA: Kern Territory SC1a	Willow	06/30/97	106		L	
CA: Kern Territory SC3	Willow	07/03/97	107	1810-25790	L	
CA: Kern Territory SC3	Willow	07/03/97	108	1810-25788	L	
CA: Kern Territory STAN1	Willow	06/12/97	109	1810-25703	AHY	F
CA: Kern Territory SC5	Willow	07/08/97	110	1810-25796	L	
CA: Kern Territory SC5	Willow	07/08/97	111	1810-25795	L	
CA: Kern Territory SC3	Willow	06/19/97	112	1810-25783	AHY	F
CA: Kern Food collected from adult bird's bill; Territory SC3	Willow	06/19/97	113	1810-25783	AHY	F
CA: Kern Unbanded bird	Willow	01/01/97	114			
CA: Kern Territory SC1a	Willow	06/30/97	115		L	
CA: Kern Territory SC7	Willow	07/05/97	116	1810-25683	AHY	F
CA: Kern Territory SC3	Willow	07/03/97	117	1810-25789	L	
CA: Kern 1 of 3 nestlings	Willow	07/16/96	60	not banded	L	
CA: Kern	Willow	07/07/96	61	1810-25776	AHY	F
CA: Kern	Willow	07/17/96	62	1810-25661	ASY	F
CA: Kern 1 of 3 nestlings	Willow	07/16/96	63	not banded	L	
CA: Kern 1 of 3 nestlings	Willow	07/23/96	64	not banded	L	
CA: Kern	Willow	07/06/96	65	1810-25680	SY	F
CA: Kern	Willow	07/06/96	66	1810-25680	SY	F
CA: Kern 1 of 3 nestlings	Willow	07/18/96	67	not banded	L	
CA: Kern 1 of 3 nestlings	Willow	07/23/96	68	not banded	L	
CA: Kern 1 of 3 nestlings	Willow	07/18/96	69	not banded	L	
CA: Kern No date other than 1996	Willow	01/01/96	70			
State: Site name	Habitat type	Date	Sample	Band number	Age	Sex