BREEDING BIOLOGY OF LUCY'S WARBLER IN SOUTHWESTERN NEW MEXICO

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ABSTRACT: We found Lucy's Warblers breeding abundantly in mid-elevation broadleaf riparian forests in the lower Gila River valley of southwestern New Mexico. They arrived *en masse* in the third week of March. Patterns of singing suggested that Lucy's Warblers might raise two broods. Few were heard or seen after late July. Estimated population densities ranged from 1.7 to 3.3 territories per ha, and Lucy's Warblers constituted up to 10% of the total bird territories in our study plots. We found 24 nests placed in cavities or behind loose bark. Large cottonwoods and willows were the preferred nesting substrates. Nesting success was high (83%). We found only two nests that had been parasitized by cowbirds but observed five pairs feeding fledgling cowbirds.

Lucy's Warbler (*Vermivora luciae*) is the smallest and probably the least known of North American wood warblers. It shares with the Prothonotary Warbler (*Protonotaria citrea*) the trait, unusual for parulids, of cavity nesting. Most of what is known about Lucy's Warbler, summarized by Johnson et al. (1997), relates to the lowland (<1000 m elevation) of Arizona, where it is considered a specialist of mesquite (*Prosopis* spp.) bosques. It also occurs in cottonwood–willow, sycamore (*Platanus wrightii*), tamarisk (*Tamarix ramosissima*), and mixed broadleaf riparian communities, and in lesser numbers in mesquite-dominated upland scrub (Szaro and Jakle 1985, Curson et al. 1994, Johnson et al. 1997). Although most abundant at lower elevations, the species ranges up to 1700 m or more.

Lucy's Warbler is assumed to be a recent arrival to New Mexico, being first recorded in the state in 1907 (Gilman 1908). It was first noted in the San Francisco River valley in 1926 (Hubbard 1978) and the lower Gila valley in 1928 near Redrock, where a nest was found (Ligon 1961). From 1929 to 1937, several additional New Mexico specimens were collected along the Gila River (Mellinger and Stewart 1940), including some near our study sites. Currently it breeds commonly along watercourses in the southwestern quadrant of the state (Ligon 1961, Hubbard 1971, Baltosser 1986, American Ornithologists' Union 1998). Almost all of its habitat in the state lies at middle elevations (1000–2000 m), where mesquite constitutes only a minor component of riparian bosques (Dick-Peddie 1991).

Johnson et al. (1997: 12) stated "Population numbers are diminishing throughout breeding range because of losses of riparian habitat from water projects and cutting of mesquites throughout sw U.S." However, Breeding Bird Survey results suggest that although some portions of its range have experienced population declines, others have shown stable or increasing trends (Sauer et al. 1997). Although not formally recognized as threatened, the species is on the watchlist of Partners in Flight (http://www.audubon.org/

bird/watch). Effective management requires a sound knowledge base, but the lack of information on this species from habitats other than mesquite highlights the need for basic natural history information from such areas. In this paper we present information on the arrival and departure dates, population trends, timing of breeding, population density, and nest sites of Lucy's Warblers from mid-elevation riparian woodlands on the Gila River in southwestern New Mexico.

METHODS

Study Sites

We studied Lucy's Warbler in two portions of the Gila River valley in Grant County, New Mexico. The Cliff–Gila study site lies between the towns of Cliff and Gila, at an average elevation of 1380 m. Most of this valley is privately owned agricultural land used primarily for grazing and irrigated hay farming. The river and nearby earthen irrigation ditches are flanked by corridors of mostly mature (canopy 16–35 m tall) riparian forest. The Gila National Forest study site (GNF), elevation 1326 m, is located about 13.5 km downstream from Cliff and consists of a corridor along the Gila River that varies from about 0.4 km to 1.2 km in width. The river at this site is bordered by riparian communities of various ages and hillside woodland (Rea 1972).

Dominant tree species in both areas are Fremont Cottonwood (*Populus fremontii*), Goodding's Willow (*Salix gooddingii*), and Arizona Sycamore (*Platanus wrightii*). Subcanopy species include Boxelder (*Acer negundo*), Arizona Walnut (*Juglans major*), Velvet Ash (*Fraxinus velutina*), Arizona Alder (*Alnus oblongifolia*), Netleaf Hackberry (*Celtis reticulata*), Russian Olive (*Elaeagnus angustifolia*), and Texas Mulberry (*Morus microphylla*). Early successional patches are composed primarily of Seepwillow (*Baccharis glutinosa*) and Coyote Willow (*Salix exigua*). The eastern edge of the GNF census area includes a dry, rocky hillside, intersected by side canyons, supporting scattered piñon pines (*Pinus edulis*), Shrub Live Oak (*Quercus turbinella*), Honey Mesquite (*Prosopis glandulosa*), and One-seeded Juniper (*Juniperus monosperma*).

Census Techniques

Line Transects. To measure the relative abundance of Lucy's Warblers, we conducted simple line transects from 1 January 1997 to 15 October 1999 at the GNF study site (Bibby et al. 1992). We established two 2.5-km variable-width transects (Ralph et al. 1993) by dividing the GNF site in half. Lucy's Warblers were detected along each transect by visual observation, vocalizations, or both. We assumed Lucy's Warblers could be detected up to approximately 200 m from the transects. We censused the upper transect from mid-May 1997 to December 1999, the lower transect from mid-May 1998 to December 1999. Each transect was censused once a week during the breeding season (May to mid-July) and biweekly at other times of the year, except from 1 January to 1 May 1999, when censuses were conducted weekly as well. To minimize variability, all censuses began within 15 minutes of sunrise, followed the same route, were traversed at a constant rate of 0.8 km/

hour, and were conducted by the same observer (Bibby et al. 1992, Ralph et al. 1993). We recorded all birds detected on a field map and recorded number, species, and whether the detection was by sight or sound. Unidentified calls were recorded on a Sony TCM-59V tape recorder for later verification. Singing patterns were characterized by dividing the number of singing Lucy's Warblers by the total number detected on any given census day.

Spot Mapping. We estimated the population density of Lucy's Warbler in six riparian forest patches (average area 4 ha) at the Cliff–Gila site using a combination of spot mapping and nest searches (Bibby et al. 1992). Three patches were adjacent to the Gila River itself, three were adjacent to irrigation ditches. In each patch, we flagged grids of 30.5-m squares that varied in size and configuration with patch size and shape. We mapped each plot 10–12 times during the season, approximately every 2 or 3 days from late May through June 1997–1999. Spot-mapping sessions began within 15 minutes of dawn at a different random corner of the grid each time and lasted 2 to 5 hours (Bibby et al. 1992). All Lucy's Warbler detections were marked on daily maps for later transfer to a master map. We searched for nests on a daily basis after spot-mapping sessions and plotted nests on master maps. From the master maps we estimated the number of breeding territories and density per patch for each year.

Nest Sites. For all nests found, we recorded tree species, size (height and diameter at breast height), condition of tree (alive or dead), nest height and type (cavity or behind bark), and distance to closest surface water and closest edge of habitat patch. To assess whether Lucy's Warblers prefer specific tree species for nesting, we calculated relative abundance of tree species within study patches to compare usage with availability. We counted woody stems within a 0.02-ha plot (radius 8 m) centered on a random selection of 140 spot-mapping grid points. Counts were limited to stems >15 cm diameter, as this was the minimum size warblers used for nesting in our sample. The relative availability of a particular tree species was calculated as the total number of trees of a particular species divided by the total number of all trees. We used chi-square analyses on arcsine-transformed data to compare the proportions of used versus available stems of each tree species. We compared distances to edge and surface water between nests and random points using Mann–Whitney *U* tests.

Nesting Success. Nests were monitored every 5–7 days. We considered nests successful if they fledged one or more young, failed if nests became inactive and no fledglings were sighted in the territory. When possible, we examined failed nests for evidence of depredation or nest parasitism, although direct inspection was not possible for deep cavities.

RESULTS

Temporal Patterns

Lucy's Warbler consistently arrived *en masse* in the lower Gila Valley in the third week of March (Figure 1). Early arrival dates for 1997, 1998, and 1999 were 21, 22, and 24 March, respectively. The number detected peaked early (late April to mid May) and then declined. Few birds were

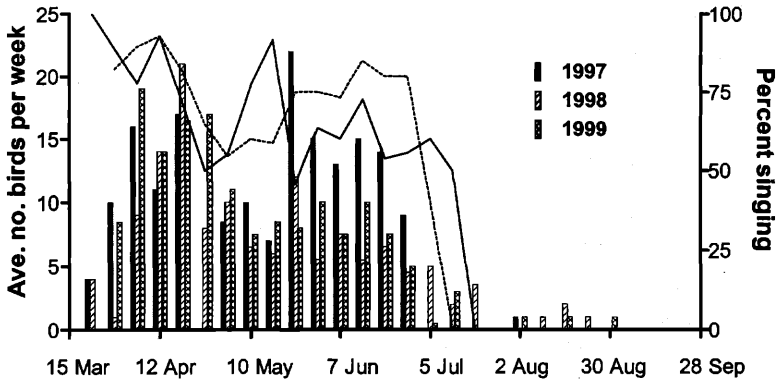

Figure 1. Average numbers of Lucy's Warblers detected on weekly censuses of the Gila National Forest study site, 1997–1999 (bars). Lines indicate the percentage of birds detected that were singing in 1998 (solid line) and 1999 (dashed line).

detected after the first week in July. The proportion of birds singing showed at least two peaks, one from late March to early April, another in late June (Figure 1). An additional peak was noted in early May 1998 but was not detected in 1999. The dates of last detection for 1997, 1998, and 1999 were 2, 18, and 27 August, respectively. Most warblers stopped vocalizing approximately the first week of July (Figure 1), but individuals were detected singing as late as 18 August. Owing to their small size and tendency to remain silent after breeding, they were more difficult to detect in late summer than earlier in the year.

Population Density

Lucy's Warbler was one of 50 species breeding in the study patches but constituted from 3.7% to 10.1% of all territories in each patch (mean 7.2%). The estimated number of territories per patch was not correlated with patch size (Spearman $r_s = -0.60$, $p = 0.24$). The estimated average density over three years ranged from 1.7 to 3.3 pairs/ha (mean 2.3 ± 0.7 pairs/ha). Total breeding-bird densities in these patches ranged from 21.8 to 36.0 pairs/ha (Stoleson and Finch unpubl. data). Patches with higher densities of Lucy's Warbler tended to have a more closed canopy and more mature trees than patches with lower densities.

Population Trends

We found no evidence to suggest that populations of Lucy's Warblers are declining in the lower Gila River Valley. There was no significant difference in the number of Lucy's Warblers detected for the years 1997–1999 on the GNF upper transect according to a nested ANOVA ($F = 0.26$; df = 2, 36; $p = 0.77$). Our estimates of population densities from 1997 to 1999 were higher (1.7 to 3.3 pairs/ha) than the 0.8 pairs/ha Baltosser (1986) reported from a spot-mapping study on an adjacent site in 1975.

Nest Sites

We located 24 nests within our spot-mapping plots in three years. Nests were placed in two types of locations: in cavities (n = 13) and behind bark (n = 11). Most cavities used for nesting were natural; the one exception was an old nest hole excavated by a Ladder-backed Woodpecker (*Picoides scalaris*). Of 24 nests, 19 were placed in live trees. Of these, 11 nests were placed in dead limbs, of which seven were broken. All five nests in dead trees were in broken limbs or trunks. We found nests in three tree species: Goodding's Willow (n = 10), cottonwood (n = 9), and Boxelder (n = 5). Use of willow and cottonwood was proportionally higher than their occurrence. In contrast, Boxelder and other species were under-utilized (χ^2 = 31.1, df = 3, $p < 0.0001$; Figure 2). At the GNF site, a pair nested in a natural cavity in an Arizona Sycamore.

Lucy's Warblers chose nest cavities that were relatively close to the ground (median height 5.0 m), although most nest trees were large in diameter (Table 1). Nest trees less than 5 m in height tended to be large, leaning willows. Placement of nests within patches did not appear to be related to water or edge. We found no significant differences between nest trees and random points in average distance to open water (30.7 ± 40.0 vs. 48.8 ± 57.1 m; U = 1621.0, p = 0.25) or average distance to habitat edge (12.2 ± 8.9 vs. 11.4 ± 9.9 m; U = 2030.0, p = 0.23).

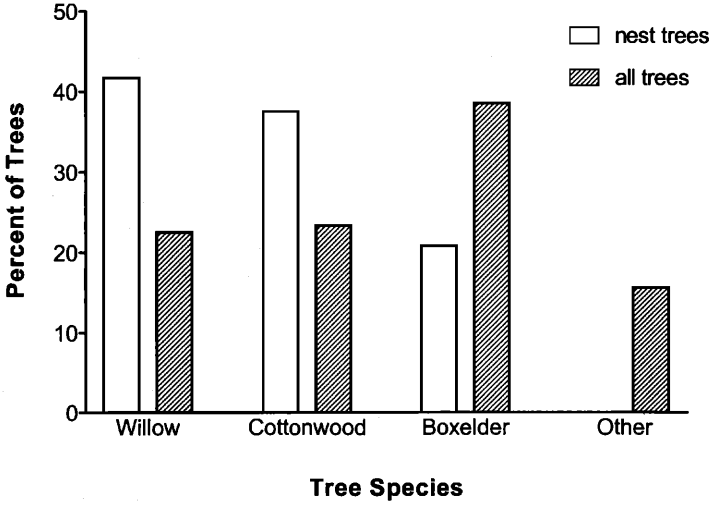

Figure 2. Tree species used as substrates for 24 Lucy's Warbler nests compared to availability of all trees >15 cm diameter within 140 randomly located 0.02-ha plots. Lucy's Warblers used cottonwood and willow more, and Boxelder and other species less, than expected from their availability within the study area (χ^2 = 31.1, df = 3, $p < 0.0001$).

Table 1 Characteristics of 24 Lucy's Warbler Nests in the Lower Gila River Valley of New Mexico, 1997–1999

Nest characteristic	Mean	SD[a]	Range
Height of nest (m)	6.2	4.6	0.9–17.5
Height of nest tree (m)	17.2	9.8	3.0–34.0
Diameter of nest tree (cm)	75.8	51.9	14.0–196.0
Distance from nest to nearest open water (m)	30.7	40.0	0–150
Distance from nest to nearest edge of habitat (m)	12.2	8.9	1–40

[a]SD, standard deviation.

Nesting Success

Lucy's Warblers enjoyed high rates of nest success. Of 23 nests of known outcome, 19 (83%) successfully produced one or more fledglings. We found two nests parasitized by Brown-headed Cowbirds (*Molothrus ater*), but neither fledged young of either species. Both parasitized nests were located behind loose bark. We observed one or two pairs of warblers feeding cowbird fledglings each year but never located their nests.

DISCUSSION

Lucy's Warblers consistently arrived in the Gila River Valley in the third week of March, making them among the first migrant birds to arrive (Shook unpubl. data). Following the fledging of their last broods, Lucy's tended to become silent. Consequently, we do not know when they migrate from the study area, but few were detected after late July.

Lucy's Warbler is suspected of regularly raising two broods (Johnson et al. 1997). Without color banding we were unable to verify whether individual birds reared multiple broods. However, we observed at least two peaks in singing in each of the two breeding seasons, which perhaps correspond to the raising of two broods.

Lucy's Warbler was one of the most abundant breeding species in our Cliff–Gila study areas, comprising up to 10% of the bird territories within a forest patch. The species is known for its high breeding densities. Estimates range from 25 to 500 pairs/40 ha in mesquite-dominated habitats (Johnson et al. 1997), 26 to 48 pairs/40 ha in cottonwood–willow habitats, and 31.6 to 49.5 pairs/40 ha in mixed broadleaf habitats (Carothers et al. 1974, Stamp 1978, Baltosser 1986). In our mixed broadleaf forest plots, Lucy's Warbler densities ranged from 66 to 131 pairs/40 ha, the highest recorded from native nonmesquite habitats.

Lack of correlation between number of territories per forest patch and patch size implies nonrandom distribution within patches. More likely, birds were clumped in particular microhabitats. For example, in 1999 two pairs simultaneously occupied opposite sides of a single clump of large willows, while nearby areas of Boxelder had no warblers. Lucy's Warbler appears to

be dependent on such large trees for suitable nesting cavities. Nonrandom use of different tree species for nesting indicates that not all species are equally suitable. The under-utilization of Boxelder, sycamore, and ash may reflect the fewer nest sites offered by these relatively smooth, thin-barked trees. In contrast, cottonwood and willow have thick, coarse bark and tend to attain much larger girths than the other tree species. Thus, preferred microhabitats within the Gila River valley probably have more large cottonwoods and Goodding's Willows, fewer Boxelders, ashes, or sycamores, and fewer small trees than sites not used by this bird. This clear habitat preference contradicts the statement by Dunn and Garrett (1997) that Lucy's Warbler shuns mature cottonwood–willow associations.

We suggest that healthy populations of this warbler can be encouraged through management practices that not only protect riparian habitats but also promote a variety of age classes of willow and cottonwood. In particular, large trees, including snags, should be retained to provide a supply of suitable nest sites.

ACKNOWLEDGMENTS

We thank Beth Biagini, Gus Bodner, Kathleen Brodhead, Paul Chan, Joy Garcia, Brian Gibbons, David Hawksworth, Robyn Koch, Michael Means, Matthew Ricciardelli, and Hira Walker for field assistance; Paul Boucher, Jerry Monzingo, and Ralph Pope of the Gila National Forest and Ty Bays, Dawn Meidinger, Charles Rose, and Thomas Shelley of Phelps Dodge Corp. for logistical support; Randy Jennings for statistical help; and Tamara and David Ogilvie for their hospitality and for allowing us to use their livelihood as a laboratory. The Gila National Forest, Phelps Dodge Corporation, The Nature Conservancy, and Western New Mexico University provided funding. Comments by Jean-Luc Cartron, Helen Yard, Mark Sogge, Dale Zimmerman, and an anonymous reviewer greatly improved the manuscript.

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Accepted 5 September 2000