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Importance of the 2014 Colorado River Delta pulse flow for migratory songbirds: Insights from foraging behavior

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ABSTRACT

The Lower Colorado River provides critical riparian areas in an otherwise arid region and is an important stopover site for migrating landbirds. In order to reverse ongoing habitat degradation due to drought and human-altered hydrology, a pulse flow was released from Morelos Dam in spring of 2014, which brought surface flow to dry stretches of the Colorado River in Mexico. To assess the potential effects of habitat modification resulting from the pulse flow, we used foraging behavior of spring migrants from past and current studies to assess the relative importance of different riparian habitats. We observed foraging birds in 2000 and 2014 at five riparian sites along the Lower Colorado River in Mexico to quantify prey attack rates, prey attack maneuvers, vegetation use patterns, and degree of preference for fully leafed-out or flowering plants. Prey attack rate was highest in mesquite (Prosopis spp.) in 2000 and in willow (Salix gooddingii) in 2014; correspondingly, migrants predominantly used mesquite in 2000 and willow in 2014 and showed a preference for willows in flower or fruit in 2014. Wilson's warbler (Cardellina pusilla) used relatively more low-energy foraging maneuvers in willow than in tamarisk (Tamarix spp.) or mesquite. Those patterns in foraging behavior suggest native riparian vegetation, and especially willow, are important resources for spring migrants along the lower Colorado River. Willow is a relatively short-lived tree dependent on spring floods for dispersal and establishment and thus spring migrants are likely to benefit from controlled pulse flows.

1. Introduction

Habitat loss and degradation is one of the major causes of decline of many long-distance migrant songbird populations in North America (Carlisle et al., 2009; Terborgh, 1989), and is the primary threat cited for the majority of bird species listed under the Endangered Species Act (Johnson, 2007). Riparian habitats of the southwestern United States and northern Mexico are increasingly threatened by ongoing habitat alteration (e.g., Glenn et al., 1996; Krueper, 1993) and have been the focus of many regional conservation and restoration actions (Carrillo-Guerrero et al., 2013; Glenn et al., 2001, 2008; Gerlak et al., 2013; Skagen et al., 2005). These riparian areas are of key importance to migrant songbirds traveling between their wintering grounds in Central or South America to their breeding grounds in the northern United States and Canada, because they provide critical food and shelter in an otherwise hostile arid landscape (Arizmendi et al., 2008; Kelly and Hutto, 2005; Knopf et al., 1988; Skagen et al., 1998). Anthropogenic changes to hydrologic regimes can strongly influence the structure, composition, and phenology of riparian vegetation (Nagler et al., 2005, 2008; Stromberg, 1998, 2001; Zamora-Arroyo et al., 2001), potentially influencing the quality of the habitat. Our current understanding of what constitutes quality stopover habitat, particularly in western North America, is poor relative to our understanding of breeding- and wintering-ground habitat requirements for many species (Moore et al., 1995; Skagen et al., 2005). An improved understanding of stopover ecology will be critical for guiding habitat restoration efforts with the goal of improving habitat quality for songbirds during a potentially limiting stage in their lifecycle (Carlisle et al., 2009).

The lower Colorado River in Mexico is an important region for migratory landbirds (Hinojosa-Huerta et al., 2008; Hinojosa-Huerta et al., 2013b; Zamora-Arroyo et al., 2005). The hydrology of this region has been greatly altered since the completion of Glen

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Canyon Dam in 1964, which prevented surface water from entering the lower reaches of the Colorado River. Today surface water reaches the Gulf of California only during flood releases in high precipitation years associated with El Nino cycles (Zamora-Arroyo et al., 2005). These flows have been shown to improve riparian vegetation in subsequent years by encouraging establishment of new cohorts of native cottonwood and willow (Nagler et al., 2005). In fact, while much of the riparian corridor in Mexico is dominated by invasive tamarisk (*Tamarix* spp.) (Hinojosa-Huerta et al., 2013a), there remains greater cover of native trees and shrubs than in the neighboring U.S. reaches (Zamora-Arroyo et al., 2005). This important area remains under threat due to the paucity of surface water in most years, particularly in the face of recent (2002–2007) droughts, during which tamarisk cover increased with a corresponding decline in riparian breeding bird abundance (Hinojosa-Huerta et al., 2013a). To address those concerns, between March and May 2014, a pulse of water (hereafter "pulse flow") was released from Morelos Dam and from two downstream points in Mexico (Km 18 and Km 27 spillways) into the extensive dry stretches of the Colorado River basin, to assess the response of the Lower Colorado River Delta ecosystem to renewed flow (Daesslé et al., 2016; Flessa et al., 2014; Stokstad 2014). This pulse flow, through its influence on the survival and recruitment of native riparian vegetation, has the potential to improve habitat quality for breeding and migratory landbirds in the region.

Food availability is an important component of habitat quality because it can limit populations of bird species across diverse taxa (Arcese and Smith 1988; Johnson 2007; Lyons 2005; Rodenhouse and Holmes 1992; Rota et al., 2015). Food availability is especially critical for small migratory songbirds, whose capacities for storing and carrying fuel reserves is far exceeded by the energy demands of long-distance migration (Blem 1990; Newton 2008). The presence of high quality stopover sites along the migration route, therefore, is crucial for survival, allowing birds to rest and replenish depleted fat reserves before resuming migration (Hutto 1998; Lindström 2003). Food availability, however, is difficult to measure directly or accurately, particularly for insectivores; most insect sampling methods do not capture all taxa equally, and furthermore, due to the diversity of insect forms, behaviors, and the preferences of different bird species, no sampling scheme will accurately reflect how food availability is perceived by a foraging bird (Hutto 1990; Wolda 1990). Instead, observing the behavior of a foraging bird can provide an index of food availability that can be used to compare the quality of different habitats (Lovette and Holmes 1995; Lyons 2005; Maslo et al., 2012; Rota et al., 2015). In particular, observational and experimental studies have demonstrated that the number of attack maneuvers (attempts to capture prey) per unit time is positively correlated with prey availability (Delestrade 1999; Hutto 1990; Loegering and Fraser 1995).

A cooperative international study was initiated to assess the hydrologic and environmental effects of the 2014 engineered pulse flow and to evaluate the potential for such practices to aid riparian restoration (e.g., Hinojosa-Huerta et al., 2013a; Ramírez-Hernández et al., 2013, 2015). While concurrent studies measured the direct effects of the flow on groundwater recharging and native plant recruitment patterns (Flessa et al., 2014), our objectives were to elucidate the relationships between vegetation and migrant birds, as evidenced by their foraging behavior. We assessed which riparian habitats and tree species were most important to migrant songbirds by: 1) comparing foraging attack rates among birds using different sites and tree species; 2) quantifying tree species use among multiple species of migrant songbirds; and 3) comparing the use of different foraging maneuvers (indicative of potential prey quality and energetic expenditure) of a focal bird species observed foraging in several tree species.

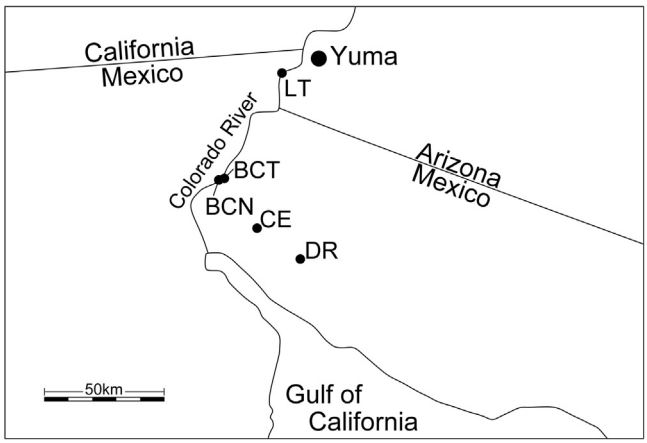

Fig. 1. Location of five study areas along the Colorado River and adjacent wetlands in Mexico (LT = Limitrophe, BCT = tamarisk site along the river, BCN = native site along river, CE = Ciénega de Santa Clara, DR = El Doctór wetlands) where spring passerine migrants were observed foraging in 2000, 2001, and 2014.

2. Methods

2.1. Study area

We visited four study areas along the lower Colorado River in eastern Baja California Norte state, Mexico, in 2000, 2001, and 2014, with a fifth study area visited in 2014 (Fig. 1). Baja California Native (BCN; 32.2217° N, −115.0828° W) and Baja California Tamarisk (BCT; 32.2271° N, −115.0584° W) were adjacent sites, both located in the riparian corridor on the west side of the Colorado River. BCN was a ~1-ha area within the larger Laguna Grande restoration site, comprising primarily native trees and shrubs: cottonwood (*Populus fremontii*), willow (*Salix gooddingii*), honey mesquite (*Prosopis glandulosa*) and screwbean mesquite (*P. pubescens*), whereas BCT was an area ~1.5 ha in size covered in >90% non-native tamarisk shrubs. Surface water from the pulse flow first reached these areas on 4–5 Apr 2014 (Flessa et al., 2014). The Ciénega de Santa Clara (CE; 32.0394° N, −114.9113° W) was a brackish 6000-ha wetland within the Colorado River Delta, fed by agricultural runoff and irrigation drainage from the Wellton-Mohawk Irrigation and Drainage District in southern Arizona (Glenn et al., 1992). Vegetation within the wetland was predominantly cattail (*Typha domingensis*) with some common reed (*Phragmites australis)* and bulrush (*Schoenoplectus americanus*). The wetland was surrounded by dry salt mudflats, with sparse cover of tamarisk and pickleweed (*Salicornia* spp.) immediately bordering the emergent vegetation. El Doctór (DR; 31.9260° N, −114.7185° W) was a slightly brackish spring-fed wetland area (864 ha) southeast of Ciénega de Santa Clara, with emergent vegetation in the wetland including bulrush, surrounded by a corridor of tamarisk, willow, and mesquite (van Riper et al., 2008; Zamora-Arroyo et al., 2005). In 2014 observers also visited a fifth site, the riparian areas on the west side of the Colorado River at the border ("limitrophe") between the U.S. and Mexico (Limitrophe – LT; ~32.6258° N, −114.7983° W). Vegetation in this area was ~70% tamarisk, with the remaining vegetation cover comprising mesquite, willow, and cottonwood trees. Surface water from the pulse flow passed through this area beginning on 23 Mar 2014 (Flessa et al., 2014).

2.2. Field data collection

Observers conducted foraging observations at each site between 29 Mar – 11 May 2000, 29 Mar – 26 Apr 2001, and 14–24 Apr 2014, corresponding with peak spring migration of Neotropical passerines (Hinojosa-Huerta et al., 2013a) and in 2014 occurring