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The effects of habitat variables and land use on breeding birds in remnant wetland strips in an arid, rural landscape

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A B S T R A C T

The Jordan Valley exemplifies the pressure of multiple human actions including intensive livestock grazing and agriculture on bird diversity. The abundances and occurrence of breeding birds were studied along remnant perennial streams which flow into the River Jordan. A patch – landscape approach was used to study the influences of vegetation cover and disturbances at the local and landscape scales. For 21 species, Principal Component Analysis was used to reveal the importance of each spatial scale and relationships with habitat variables were modeled. The abundances and occurrences of 57% of the species were predicted by local habitat variables only, while most others were apparently influenced by a mixture of habitat and landscape factors. Birds with restricted distribution were associated with less degraded wetland habitat strips with heterogeneous vegetation including reed beds and inundated *Tamarix* thickets. Some species were negatively influenced by intensive grazing and the spread of invasive mesquite *Prosopis juliflora*. Most species appeared to be tolerant to low levels of grazing within the habitat and current land use in the surrounding landscape. Based on the results, we emphasize the importance of protecting and managing remnant strips or patches of natural and semi-natural wetland habitats in the Jordan Valley.

1. Introduction

Human actions, including habitat conversion and degradation, habitat fragmentation, climate change, harvesting and pollution are causing increasing pressure on terrestrial biodiversity (Newbold et al., 2015). The Jordan Valley exemplifies such impacts due to limited resources, a rapidly growing population and regional political conflicts (Venot et al., 2008; Hoff et al., 2011). The Jordan Valley consists of low-lying plains with a hot, arid climate. Located in the northern part of the Rift Valley, it includes the River Jordan which drains into the Dead Sea at 410 m below sea level. The banks of the River Jordan, its adjacent floodplains and tributaries historically contain important wetland habitats for birds, located amidst a rather barren landscape (Andrews, 1995; Royal Society for the Conservation of Nature, 2000; Khoury et al., 2006). This landscape has been partly converted to agricultural land and natural water flow has dramatically diminished in recent decades due to high demands for water and building dams in the upper reaches of the tributaries (Albert et al., 2004; Waitzbauer and Petutsching, 2004a; Venot et al., 2008). Overgrazing by livestock, wood cutting, and invasion of alien mesquite *Prosopis juliflora* (Andrews, 1995; Khoury et al., 2006; Dufour-Dror and Shmida, 2017), are causing additional pressures on the ecosystems and bird habitats.

Information on the ecology of wetlands in arid environments is generally scant. It is well established that wetlands in arid regions are characterized by considerable seasonal and interannual fluctuations in hydrology, nutrient inputs and consequently, the biotic communities. However, recent man-induced habitat degradation is causing the decline of many avian species dependent on wetland habitats in semi-arid and arid lands (Álvarez-Cobelas, 2010). The effects of the loss of a wetland habitat in an arid region on migrating and breeding bird species are well demonstrated in the Azraq Oasis marshland in the eastern desert of Jordan. This wetland dried out during the 1980s due to overpumping of ground water (Andrews, 1991; Khoury, 1996). Detailed research focusing on the effects of land use on the bird populations of the northern Rift Valley at both the habitat and landscape scales are however rare or unpublished. A decline has been noted in the diversity and abundance of avian species in the Huleh Valley, which is located at the northern tip of the Jordan Valley, after the marsh has been partly drained (Shirihai, 1996). Signs of population declines or local extinctions have been recently noted by the authors in at least three breeding

Abbreviations: PCA, Principal Components Analysis; WAIC, Watanbe-Akaike's information criterion

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passerine species (Common Nightingale, Clamorous Reed Warbler and Dead Sea Sparrow) north of the Dead Sea (Khoury, 2001; Khoury et al., 2006). These species have a restricted breeding range in Jordan and are considered habitat-specialists.

In this study, we examined the habitat variables and local disturbances (mainly vegetation cover and grazing intensity) which affect the abundances and occurrences of breeding birds in the remnant wetland habitats of the Jordan Valley. Moreover, we investigated the influence of land use (mainly agriculture) in the immediate surroundings. A multi-scale approach of studying both the local habitat requirements and the effects of the surrounding landscapes could be essential to understand breeding distribution and maintain populations of the species (Dunning et al., 1992; Graham and Blake, 2001; Rodewald and Yahner, 2001; Cunningham and Johnson, 2006). Lee and Rotenberry (2015) showed that riparian birds in a semi-arid region vary considerably in their associations with local habitat and landscape variables. In our study area, water flow, vegetation features and disturbances, varied among and within the valleys being sampled. We thus expected that the occurrence or abundance of bird species that show a restricted distribution would be (a) more influenced by local habitat factors, and (b) sensitive to disturbances in their breeding habitat and surroundings, when compared to widely distributed species.

2. Methods

2.1. Study area

Fieldwork was conducted along tributaries (in this text often called wadis) flowing into the River Jordan, in the central and southern parts of the Jordan Valley. More than half the transects were carried out in two major wadi systems, in addition to further transects along three smaller wadis (Fig. 1; see plate in Appendix 2). Study sites were in a low-lying (100–380 m below sea level), flat area, where mean annual precipitation is around 110 mm, and mean annual temperature 23 °C. Most rain falls in winter (occasionally causing flash floods in the wadis) when temperatures are mild, whereas the summer is very hot and dry (45 °C absolute maximum temperature; Waitzbauer and Petutsching, 2004b). The narrow and shallow wadis were surrounded by an arid landscape often used as rangeland, abandoned or fallow fields, or intensive, irrigated agriculture. Farmland dominates much of the landscape, and agricultural expansion caused widespread destruction and fragmentation of natural habitats (Andrews, 1995; Albert et al., 2004). In addition to open, irrigated fields, there were a few sites with greenhouses, fish ponds, banana, palm and citrus groves. There are few villages at the eastern edge of the study area. However, Bedouin camps were frequent (some of which are vacated in summer) and this apparently caused overgrazing by livestock (sheep, goats and camels) and woodcutting in some sections of the wadis.

The wadis usually contained continuous or intermittent perennial streams. The banks of the streams and edges of wadis often contained scattered shrubs and trees, e.g. *Zizihpus spina-christii, Balanites aegyptiaca*, *Tamarix* sp., and/or *Nerium oleander.* The current sources of water were springs and/or treated water from waste water plants, drainage from farms and small desalination plants. The width of the stream with its banks usually ranged from 10 to 100 m. Relatively undisturbed sections downstream often had marsh-like conditions with *Tamarix* thickets, and reed *Phragmites australis* along the streams, occasionally with grasses, sedge, cattail, and in drier sections various shrubs. Highly disturbed sections had either extremely impoverished vegetation or were dominated by alien *Prosopis juliflora* shrubs. The sections closest to the River Jordan appeared to be less disturbed by grazing and woodcutting and were fairly inaccessible as they were part of a military zone. A riparian-like vegetation occurred where wadis meet the River Jordan, with a mix of *Tamarix* sp, reeds, poplar *Populus euphratica* and willow *Salix* sp.

2.2. Line transects

2.2.1. Bird recordings

Sixty four line transects with a length of 200 m each, were carried out during the breeding season of 2016 to count birds along the wadis (Fig. 1). The short line transect method was adopted here instead of point counts due to the linear and narrow shaped and relatively open habitat (Bibby et al., 2000). Line transects also allowed us to record less common species along the wetland habitats. Locations were selected randomly, but several had to be relocated due to accessibility restrictions. This caused some spatial clustering, but transects were generally well spaced, with a minimum distance of 200 m between neighboring transects. Each transect was assessed twice between late March and early June, and the bigger count for each breeding species was considered for analysis. The observer recorded all species seen or heard to a distance of 50 m while walking slowly along the wadi. The surveys were carried out by the same observer (F. Khoury) and were all performed in the morning from sunrise to around 11 a.m. or when temperatures reached more than 30 °C. We considered for analysis only birds that are known or expected to breed in the study sites. Individuals just flying over or visiting the study sites, e.g. birds on migration, or breeding in other habitat, were excluded.

2.2.2. Habitat variables

Habitat variables were quantified at three points (near the two ends and at the middle) along each line transect to a range of 50 m before being averaged. The variables included mainly structural attributes related to the vegetation, in addition to signs of grazing intensity (Table 1). Landscape variables were estimated using a recent Google Earth map (https://www.google.com/earth). The free accessible map was dated one year before the study and general features were verified in the field. The map accuracy was sufficient for identifying urbanized (built-up) and agricultural areas that were in the form of rectangular units. Presumed abandoned fields were not distinguished from natural dry scrub. The landscape variables of the immediate surroundings included land cover of agriculture and urbanization in a circular area surrounding the centre of each transect to a distance (radius) of 350 m. We moreover measured the distance of each transect to the edge of the nearest agricultural area or urban development.

2.3. Data analysis

2.3.1. General

All 64 samples were used for analysis. We excluded species that were recorded in less than 10 transects from detailed analyses. A description of the independent habitat variables used for analysis is found in Table 1. Five of the 66 correlations between two of the predictors had a Pearson correlation coefficient of more than 0.5 or less than −0.5: “Tamarix” and "*Prosopis juliflora*" (−0.58), “Vegetation diversity” and “Reed” (0.67), “Vegetation diversity” and “Grazing intensity” (−0.71), “Grazing intensity” and “Distance-agriculture" (−0.57), and “Arid scrub area” and “Distance-agriculture" (0.66). The variable “Agriculture area” was not used due to its strong correlation (−0.94) with “Arid scrub area” in the surrounding landscape. Numeric predictors were z-transformed (scaled to mean 0 and standard deviation 1) for better comparability among the coefficients. If indicated by bivariate scatter plots (i.e. between a predictor and the occurrence or abundance of a species), we also included a quadratic effect of the predictor, but deleted it again if its 95% credible interval (see below) included zero. Where quadratic effects were included, we used orthogonal polynomials (this helps model convergence; however, the effect size is not comparable with the coefficients of other predictors). Per species the same polynomials were used for all analyses. First, with a focus on separating landscape from habitat variables, we built a model based on principal components. Second, we built a linear model using the habitat variables themselves (next sections).