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Irrigation canals in a semi-arid agricultural landscape surrounded by wetlands: Their role as a habitat for birds during the breeding season

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ABSTRACT

Traditional water supply systems in semi-arid agrarian ecosystems, mainly irrigation canals, contribute to the diversity of the landscape and influence the composition of species. To evaluate their effect on bird communities in the breeding season, we selected a rural area in southeastern Spain, where an intricate and extensive network of irrigation canals and cultivated areas is located between two wetlands declared as Natural Parks. Birds were counted at representative points distributed throughout the canal network at which we recorded several variables related to the physical features, the vertical and horizontal structure of associated vegetation, reed development (*Phragmites australis*) and land use in the neighboring areas. We detected 37 bird species, most of which were also breeding in the wetlands nearby. We used Hierarchical Partitioning analyses to identify the variables most strongly related to the probability of the presence of selected species and species richness. Vegetation cover and height close to the canals, together with reed development, were the most important types of variables explaining species presence and richness. We found that current management practices for reeds in canals are not well-suited for biodiversity conservation. We therefore propose alternatives that could be implemented in the area in cooperation with stakeholders.

1. Introduction

The semi-arid southeastern corner of the Iberian Peninsula is rich in wetlands representing an important focus of biodiversity (Paracuellos et al., 2007). However, Mediterranean wetlands have been intensely transformed due to the increase of population density, urbanization intensity and the expansion of intensive agriculture, which aggravate the impacts of recurrent water deficits in drought periods. In addition, a lack of understanding of ecological and social relationships are accelerating degradation and reduction processes. Thus, over the last few centuries, extensive marsh and swamplands were transformed into agrarian landscapes. The previous landscape in these regions comprised Mediterranean salt steppes (*Limonietalia*), halophilous scrubs (*Sarcocornetea fruticosi*) and salt meadows (*Juncetalia maritime*) that today are reduced to small fragments (Rigual-Magallón, 1972).

Given the reduced natural water availability in semi-arid areas, complex supply systems were developed to transport and store water from neighboring rivers and lakes. Today, many irrigation canals criss-cross the area and form a complex heterogeneous landscape, where a variety of irrigated and dry crops, including both herbaceous (artichoke, cereals) and tree crops (pomegranate, palm, olive), and recently deserted crops, coexist. Irrigation canals are artificial linear structures in the landscape that transport water of variable quality and whose flow fluctuates both temporally and spatially depending on their specific characteristics. They are constructed of various materials and dimensions and thus their associated vegetation varies from sparse annual grasses to dense riparian habitats. Most of these canals belong to the community of irrigators and particular farmers, and their management is aimed at increasing crop yields and satisfying irrigation requests. The most important management action is the removal of common reeds (*Phragmites australis*), because of their capacity to interfere with the structure and functionality of canals. Reed management alters riparian habitats producing vegetation changes that affect bird species (Graveland, 1998; Moreno-Mateos et al., 2009; Poulin and Lefebvre, 2002; Poulin et al., 2002), but at the same time vegetation in irrigation canals must be kept under control to avoid their obstruction. Thus, a conflict between vegetation management and habitat conservation arises, and a compromise could be attained by

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management proposals that incorporate research on the use of these habitats by birds and other animals.

Hydric infrastructure may benefit aquatic bird species, and thus several studies have analyzed relationships among birds and artificial water structures, such as ponds, wetlands and man-made dams, and their characteristics (Erwin et al., 1994; Herremans, 1999; Moreno-Mateos et al., 2009; Sánchez-Zapata et al., 2005). However, there are few studies on the influence of irrigation canals, in particular in arid or semi-arid regions. A study carried out in the Thar Desert in India, where an important irrigation system was built to support an agricultural project, showed an increase in bird diversity due to the attraction of waterbirds, shorebirds and riparian birds to new fluvial structures (Rahmani and Soni, 1997). Irrigation canals also provide several ecosystem services, among them their function as corridors since they generate aquatic and riparian habitats that connect wetlands isolated by anthropized environments (Aspe et al., 2014). Yet, the ecological consequences of irrigation canals within Mediterranean agricultural landscapes have received little attention thus far.

The use by birds of the new habitat generated by irrigation canals may be affected by several variables that are modified by human activity. These features include the way in which canals are designed and the materials used for building them, the characteristics of the vegetation growing on the canal shores, which are a direct consequence of their management, and the land uses in the landscapes around the canals. Knowledge of those variables with the greatest influence on bird species using the canals should provide important clues for the design of management strategies that are compatible with biodiversity conservation in semi-arid regions. If variables related to canal bed and shore management are important, measures at this scale could be negotiated with canal managers and considered by planners of future infrastructure. Thus, in this study we aim to identify the relative importance of these features for determining bird species richness in irrigation canals and their probability of use by selected species. Based on these results, we develop proposals for improving the quality of canals as a habitat for birds.

2. Material and methods

2.1. Study area

The study was carried out in Carrizales, an area located between two important wetlands in Alicante (South-east of Spain), El Hondo Natural Park and Salinas de Santa Pola Natural Park (0°39′- 0°45′W; 38°07′- 38°10′N) (Appendix A, electronic version only). This area is characterized by a semi-arid Mediterranean climate, with an average annual temperature of 18 °C and an annual rainfall less than 350 mm, with a characteristic dry season in summer, and intense and irregular rainfall usually concentrated in autumn.

In ancient times, this area was an extensive wetland, called Sinus Illicitanus, into which two rivers (the Segura and Vinalopó Rivers) flowed. Three hundred years ago, for natural reasons, this gulf was separated from the sea resulting in a coastal lagoon (Albufera de Elche), becoming a very important fishing area because of its salinity gradient (Box-Amorós, 2004). Due to the change in the course of the Segura River, the first irrigation canals were built to maintain fresh water flow. Subsequently, some important sectors of this wetland system were drained to create agricultural land and to eradicate malaria, and a network of irrigation canals was developed to maintain a flow of water for agriculture and to remove the excess water from the fields (Martín-Cantarino et al., 2009). Today, traditional crops in the area, which cover approximately 1649 ha, include a mix of herbaceous (artichoke, oats, melon) and tree crops (palm and pomegranate trees). Uncultivated patches are occupied by reed stands and halophilous scrub formations (*Sarcocornia fruticosae*, *Artrocnemum macrostachyum*, *Suaeda vera*, *Atriplex halimus*, *Limonium* spp.) called “saladar”. These irrigation canals together with their associated vegetation, the agricultural matrix and patches of natural vegetation, form a heterogeneous mosaic of land uses.

Carrizales is not only a wetland, but also an irrigated agricultural area and is included in the Humid Areas Catalogue of the Valencian Autonomous Region (Catálogo de zonas húmedas de la Comunidad Valenciana) because of the importance of the irrigation canal network as a natural corridor between the aforementioned wetlands. Recently, it has been proposed that this area be included in the N.R.O.P. (Natural Resources Ordenation Plan) of the Humid Zone Systems in Southern Alicante (Sistemas de Zonas Húmedas del Sur de Alicante).

2.2. Bird counts

To study bird assemblages associated with irrigation canals, 45 counting points were selected representing the different combinations of canal features (earth or cement, with or without vegetation inside or at the edge of the canals and, particularly, with or without reed stems) and surrounding environments (Appendix A, electronic version only). At each sampling point, birds were counted within a 100 m long plot, along the canal, with a width of 6.5 m on each side of the canal. Counting was carried out at the center of this plot for 5 min, after waiting an additional 5 min to allow birds to settle down after initial disturbance, and always within 3 h after sunrise. The distance between counting points was at least 200 m (Bibby et al., 1999). Birds at each point were counted twice in the breeding season, in May and in June of 2007.

2.3. Habitat features

Several groups of variables were estimated for each counting point. Physical variables were recorded as the canal width (m), its building material (coded as concrete (0) or earth (1)) and the distance of the counting point to the nearest wetland. To study vegetation associated with irrigation canals we measured the percentage of cover of each plant species, its height and a group of variables related to reeds, due to its importance for the bird community, particularly for riparian birds (Table 1).

To estimate vegetation and land use cover near to the canals, at each sampling point we performed 5 transects on each side of the canal, each of 6.5 m. Transects were perpendicular to the canal edge and were spaced 25 m apart. The transect length intercepted by plant species or bare soil was measured and used to estimate percentage of cover. Its maximum height was also measured. Plant species were grouped according to morphological characteristics or functional groups in several categories (Table 1). Variables depicting the vertical profile of the vegetation near canals were calculated by assigning the length intercepted by each plant or land use in the above-mentioned transects to the following height classes, representing the main vegetation strata: without vegetation; from 0 to 0.3 m, usually herbaceous species in early development; from 0.3 to 1 m, corresponding to developed herbaceous and woody scrub plants in a low level of development; from 1 to 2 m, normally developed woody scrub plants and medium height reeds; and taller than 2m, mainly represented by developed reed formations. These variables were expressed as percentage of cover.

The Common reed is an invasive plant that was present in spring in all the studied canals and at most of the bird counting points