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ORIGINAL PAPER

Effect of landscape configuration and habitat quality on the community structure of waterbirds using a man-made habitat

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Abstract Species occurrence and community structure are strongly influenced by multiple factors like habitat selection, species movement capabilities, competition, or conspecific and heterospecific attractions. More specifically, in waterbird communities, previous studies have identified the importance of environmental and structural characteristics of wetlands for their occupation and use. However, the effect of the surrounding landscape configuration remains unknown. In this article, we use a large network of artificial irrigation ponds to evaluate the importance of pond features in comparison to the effect of landscape and spatial configuration on the community at three different spatial scales. Our results show that landscape configuration has relatively little influence on structure of the waterbird community. Pond features were by far the most important variables to describe waterbird abundance and richness. At the species level, we detected differences in habitat preferences relating to species-specific ecological requirements. Our results highlight the importance of using a multiscale approach to understand and predict richness and abundance in waterbird communities. Our findings emphasize the need to maintain high-quality ponds to enhance their suitability for use as breeding and foraging sites.

Keywords Agriculture intensification · Artificial pond · Southeastern Spain · Deviance partitioning · Wetland

Introduction

An important principle of landscape ecology is that the spatial configuration of landscapes can have major effects on a wide variety of ecological processes (Wiens 2002), thus determining species and community structure (Knutson et al. 1999; Froneman et al. 2001; Mazerolle et al. 2005; Thornton et al. 2011). For example, some forest bird species show more sensitivity to the surrounding matrix than to the structure and composition of the habitat patch where they live (Hanowski et al. 1997; Sisk et al. 1997; Estades and Temple 1999; Vergara and Armesto 2009). At the community level, some studies have found local species richness to be dependent on both local and regional landscape factors (Ekroos and Kuussaari 2012). However, the effect of this landscape complexity on species communities is still poorly understood (Turner 2005). In fact, the unknowns of the interactions between communities and landscape complexity are some of the largest barriers for effective species conservation in agricultural regions (Lindenmayer et al. 2008; Prugh et al. 2008; Ranganathan et al. 2010).

Human growth has led to intensified agriculture in order to cover increasing food demands (Green et al. 2005). This fact has had several negative environmental effects, such as native habitat loss, habitat fragmentation, alterations to hydrologic systems, introduction of exotic species, and decline in the biodiversity associated with agro-ecosystems (Chamberlain et al. 2000; Donald et al. 2001; Swift et al. 2004; Tscharntke

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et al. 2005), which have vastly altered landscape configuration. Agriculture intensification has especially affected wetlands through the contamination of water and drainage of large areas (Hollis 1990). Nevertheless, some artificial infrastructures that result from human development have created new habitats for many species (Hazell et al. 2001; Knutson et al. 2004; Abellán et al. 2006; Julian et al. 2006), especially for birds (Sebastián-González et al. 2010a). Rice fields, salt marshes, agricultural ponds, or gravel pits are good examples of new wetlands used by waterbirds (Elphick and Oring 2003; Múrias et al. 2002; Ma et al. 2004; Santoul et al. 2004).

Habitat transformations have been severe in Mediterranean regions (Blondel and Aronson 1999), where 60–70 % of natural wetlands disappeared between 1940 and 1991 (Montes 1991). In southeastern Spain, more than 3,900 irrigation ponds have been constructed in the last three decades to store the water from an inter-river water transfer. These ponds are used by some waterbirds all year round to breed, forage, or rest (Sánchez-Zapata et al. 2005). Recent studies demonstrate the importance of irrigation ponds as an alternative habitat for the regional waterbird community (Sebastián-González et al. 2010a). Understanding how the ponds are occupied and the relationship between community pattern, landscape configuration, and pond characteristics could contribute to the waterbird conservation.

Species occurrence and community structure are strongly influenced by multiple factors like habitat selection (Cody 1985), species movement capabilities, competition, or conspecific and heterospecific attractions (Moilanen and Hanski 1998; Mazerolle and Villard 1999; Fleishman et al. 2002; Sebastián-González et al. 2010b). Previous studies detected a relationship between the value of ponds for birds and their structural and environmental features (Sebastián-González et al. 2010a, c), but the effect of landscape structure and connectivity on habitat selection by waterbirds has been poorly studied. In this study, we aimed to investigate the effect of landscape configuration on the structure of waterbird communities using a network of artificial irrigation ponds and evaluate the relative contribution of landscape, pond features, and spatial configuration to the abundance and richness of nesting and non-nesting waterbirds.

Methods

Study area

This study was carried out in the *Vega Baja* Valley, southeastern Spain (Fig. 1), where a large number of ponds (>3,900) have been built since the 1980s (Sánchez-Zapata et al. 2005). These irrigation ponds are distributed over an area covering 95,840 ha, although density is lower along the Segura River and in close proximity to the coastline, which is mostly occupied by tourist villages and bungalows. The climate is Mediterranean semiarid with little annual rainfall (300 mm) and warm mean annual temperatures (18 °C). The surrounding matrix is dominated by intensive agriculture (citrus fruits and vegetables), palm trees *Phoenix dactylifera*, towns, and sparse houses. Small amounts of extensive crops such as almond *Prunus dulcis*, olive *Olea europea* var. *oleaster*, and cob trees *Ceratonia siliqua* still remain, as well as remnants of natural vegetation such as Mediterranean shrubs (*Pistacea lentiscus*, *Rosmarinus officinalis*, *Rhamnus lycioides*, *Chamaerops humilis*, *Thymus* spp.) and pine trees *Pinus halepensis* and *Pinus pinea*. Relief is flat with small hills close to the sea (Sierra Escalona; 300 m.a.s.l.) and small rocky mountains in the vicinity of the Segura River (Sierra de Orihuela; 600 m.a.s.l.) and to the north of the study area (Sierra de Crevillente; 800 m.a.s.l.).

In the study area, there are several seminatural wetlands. Some of them (El Hondo Water Reservoir, Lakes of La Mata and Torrevieja, Salines of San Pedro, and Salines of Santa Pola) are under regional environmental protection (as natural parks or protected areas) and have an international status as Special Protected Area (SPA) because of their importance for waterbirds.

Waterbird surveys

We randomly selected 978 irrigation ponds (c.a. 25 % of the total) over the study area. We divided the study area in sections, and in each section, we surveyed all the irrigation ponds that could be reached (i.e., the ponds are privately owned and fenced, so they were often not accessible). Surveys were performed in one single year; however, we expect the results of our study to be robust to temporal variations because we know from previous studies that the waterbird community at the irrigation ponds does not present big annual changes (Sebastián-González et al. 2010a).

The survey was performed during June 2009 at the end of the breeding season. At this time, the chicks are not too small, minimizing disturbance. Surveys took place during two intensive weeks by two to four different groups of surveyors at the same time. Each group was formed by at least one experienced researcher and between two to three assistants. The surveys were performed from 8:00 to 13:00 h and from 17:00 to 20:30 h, avoiding the period of the day with the lowest avian activity. In each pond, we counted all the adult individuals for all the waterbird species detected. We did not consider any feral and domestic species present. We used scopes and binoculars, and we remained in the pond for the time required to assure a complete survey (approximately 10 min, depending on the size). The ponds' small size (ranging between 0.01 and 6.61 ha, average size=0.63 ha) and low vegetation cover (less than the 30 % of the ponds presented vegetation on their shore) reduced the survey error. We

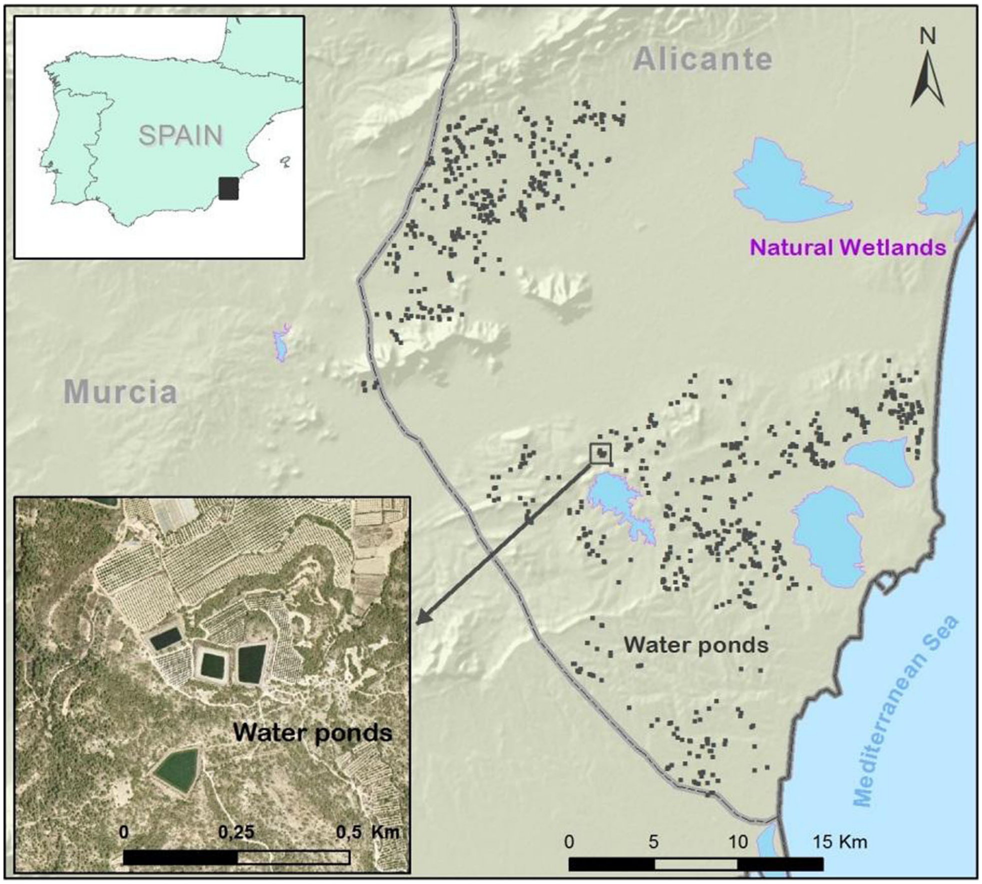

Fig. 1 Study area: the Vega Baja Valley (SE Spain). We located natural wetlands and irrigation ponds included in this work

grouped the species detected according to the use that birds do in ponds in nesting (i.e., species that were detected nesting at least inside one of the ponds) or non-nesting (Sebastián-González et al. 2010a).

Pond characterization and landscape variables

We evaluated three groups of variables:

1. Pond features, we included 11 features described in previous studies as important for waterbirds (Sebastián-González et al. 2010a; Paracuellos and Tellería 2004). For each pond we determined the following: (a) water level (ranging from 1, full to 5, empty), (b) shore width (m), (c) shore slope (in degrees), (d) presence of reed *Phragmites australis*, (e) submerged vegetation, (f) shore vegetation and (g) floating vegetation, (h) perimeter fence, (i) fishes, (j) amphibians, and (k) construction material. Ponds were divided in to three groups depending on their construction material: low-density polyethylene (LDP), high-density polyethylene (HDP), and concrete. LDP ponds are covered by a layer of gravel to protect the plastic from solar radiation that can damage them, and this cover provides the pond with a more natural appearance, while HDP ponds do not have any gravel cover. In general, LDP ponds are significantly larger; have smoother slopes; and hold more abundant and richer vegetation, waterbird, and macroinvertebrate communities than HDP and concrete ponds (Sánchez-Zapata et al. 2005; Abellán et al. 2006).
2. Landscape configuration, which included land uses (%), number of ponds, number of habitats, habitat diversity measured by means of the Shannon diversity index (Shannon 1948), and slope (°) in 0.15, 0.5, and 1.5 km buffers (Table S1).The minimum buffer (0.15 km) represents the nearest habitat to the pond, medium buffer (0.5 km) represents regional habitat, and maximum buffer (1.5 km) represents landscape configuration. Buffer distances were selected in relation to median minimum distance between ponds (median=0.16±0.19 km).
3. Spatial localization, which included spatial coordinates (x, y) from the center of the pond and distance to nearest: urban areas, roads, natural wetlands, and seacoast. In order to assess the spatial autocorrelation of the environmental data, we included a trend surface analysis by a combination of linear, quadratic, and cubic distributions of the spatial coordinates (x, y, x^2, y^2, x^3, y^3, xy, x^2y, xy^2). Previously, spatial coordinates were centered and standardized (Legendre 1993; Legendre and Legendre 1998).

Landscape and spatial variables were calculated using GIS software (gvSIG 10.1; http://www.gvsig.org) and Sextante plugin. Land use and topography data were obtained from CORINE land cover 2006 (EEA 2011) and from a 5-m resolution digital elevation model (DEM) downloaded from the governmental spatial data web repository (www.idee.es). A brief statistical description of all variables used was included in Supplementary Material Table S1 and Table S2.

Richness and abundance analysis

We used generalized linear models (GLMs; McCulloch and Searle 2000) to relate habitat features with the waterbird community. We used species richness and bird abundance of each pond as dependent variables for the model at the community level and presence/absence for the model at the species level. We performed the models only at the species level for those species nesting in ponds because these species are the most representative of the community. We constructed multivariate models that established response relationships between the dependent variables and the three groups of independent variables (pond features, spatial location, and landscape configuration). We used the link function log and Poisson error distribution for the richness and abundance data and the link function logit and binomial error distribution for the occupation data. The linear and quadratic forms of all the explanatory variables were tested. High collinearity among variables can lead to high standard errors and difficulties in interpreting parameter estimates in the GLMs (Graham 2003). Therefore, as a rule, we did not include pairs of variables with Spearman pairwise correlation coefficients higher than |0.6| in the same model. From the occupancy data, multivariate models were constructed that establish response relationships between occupation and the three groups of variables. We evaluated the overdispersion or lack of fit by c-hat value, and when the value was higher than 1, we used a negative binomial error distribution (Burnham and Anderson 2002). Each multivariate model was obtained by excluding variables step by step, and the corrected Akaike information criterion was used (AICc; Burnham and Anderson 2002) as a criterion for selecting models. We computed delta AICc to determine the strength of evidence and AICc weights to represent the relative likelihood of each model (Burnham and Anderson 2002). We included the percentage of deviance that was explained by each variable (D^2). Then, we calculated the proportion of the deviance explained by the combination of all three models, and we obtained the percentage of pure deviances for all three groups (pond features, spatial localization, and landscape configuration) following the steps for the analysis of variation partitioning described in Anderson and Cribble (1998) and in Cushman and McGarigal (2002). For all analyses, we used R statistical software (R Development Core Team 2008) with the MASS package for the GLM analysis.

Results

We counted a total of 2,735 birds of 27 different species. Seven species were detected to be nesting in the wetlands: little grebe *Tachybaptus ruficollis*, black-winged stilt *Himantopus himantopus*, common shelduck *Tadorna tadorna*, mallard *Anas platyrhynchos*, little ringed plover *Charadrius dubius*, common coot *Fulica atra*, and moorhen *Gallinula chloropus*. Non-nesting species included gulls and terns (fam. Laridae, seven spp.), herons (fam. Ardeidae, six spp.), ducks (fam. Anatidae, three spp.), waders (fam. Charadridae, two spp.), and grebes (fam. Podicepidae, 1 spp.).

Habitat vs. landscape community effects

Waterbird richness and abundance were related to the landscape variables at three spatial scales (0.15, 0.5, and 1.5 km). The richness of both breeders and non-breeders was better described at the 1.5 km buffer, while abundance was better described on local scales as 0.5 km for nesting and 0.15 km for non-nesting (Table 1).

Variables retained in each multivariate model are presented in Table 2. Briefly, the richness and abundance of waterbird community were higher in more isolated ponds and with more naturalized landscape around it. Specifically, nesting community was more abundant and rich in ponds located in areas with a higher roughness and land use heterogeneity. In contrast, the non-breeding community was related with urban areas and with low percentage of citrus crops (see Table 2). The multivariate models explaining community richness (landscape configuration + spatial location + pond features) showed a greater explicative power for the nesting (Nst; 48.2 % of explained deviance) than for the non-nesting guild (N-nst; 21.5 %) (Fig. 2). The most important factor in determining species richness at the ponds was pond features (Nst=22.3 % and N-nst=14.4 %), while pure effects of landscape configuration (Nst=2.2 % and N-nst=3.1 %) and spatial location (Nst=1.9 % and N-nst=2.1 %) had a smaller influence.

The model assessing the abundance of nesting waterbirds was more explicative (58.4 % deviance explained) than the model for non-nesting waterbirds (33.4 %). Pond features had a greater influence than landscape configuration, while landscape pure effects were very small (Nst=2.4 % and N-nst=4.8 %). The effect of spatial location, compared with the richness results, increased for both groups (Nst=6.4 % and N-nst=4.0 %). Interactions between groups of variables were always greater for the breeding than for the non-nesting guild in both waterbird richness and abundance.

Table 1 Generalized linear models investigating the factors influencing richness and abundance of nesting and non-nesting waterbirds in ponds on three spatial scales

	Scale	Nesting					Non-nesting				
		% D^2	*k*	AICc	ΔAICc	*W*	% D^2	*k*	AICc	ΔAICc	*W*
Richness	**0.15**	15.5	10	1,892.6	95	0	2.3	4	1,062.4	323.1	0
	0.5	20.5	13	1,830.9	33.3	0	4.0	10	1,114.6	375.3	0
	1.5	**22.5**	**9**	**1,797.6**	**0**	**1**	**4.9**	**4**	**739.3**	**0**	**1**
Abundance	**0.15**	18.0	11	5,230.1	3,922.4	0	**11.8**	**8**	**1,316.6**	**0**	**1**
	0.5	**21.2**	**13**	**1,307.7**	**0**	**1**	49.9	14	2,339.1	1,022.5	0
	1.5	31.3	12	4,544.8	3,237.1	0	39.5	14	2,742.1	1,425.5	0

The model with the lowest AIC value (in bold) is the most parsimonious

% D^2 percentage of deviance explained, *k* total number of parameters (explanatory terms+random term+residual deviance), *AIC* Akaike information criterion, *ΔAIC* difference between the AIC value for that model and the best model, *W* Akaike weights

At the species level, we found high variability in the percentage of explained deviance of the occupation models, ranging from a 25.4 % for the little ringed plover to 60.0 % for the common coot (Fig. 3). Pond features were the most important factor for all the species, except for the mallard, which was more affected by spatial variables. Pond features and spatial configuration had similar effects on the shelduck occupation patterns. Pond features explained less deviance for the black-winged stilt and the little ringed plover (11–18 %), but power increased for the moorhen and the common coot (31 and 34 %). The spatial variables had a slight effect on the little grebe, the little ringed plover, and black-winged stilt, but they had a major effect on the other species, especially *Anatidae*. Landscape had a minor effect on the common coot and the black-winged stilt but did not affect the little grebe. The effect of landscape on ducks and moorhens increased explained deviance to 6–10 %.

Discussion

Our results reveal that landscape configuration had relatively little influence on the structure of the waterfowl community. Deviance partitioning allowed us to discriminate the proportion of deviance explained by each group of variables, and we found that pond features were, by far, the most important variables to describe waterbird abundance and richness. Landscape pure effects did not reach more than 5 % of the total deviance explained in any model, and their importance was even lower for breeding waterbirds. Both the nesting and non-nesting guilds showed similar responses to landscape configuration and habitat quality. Previous studies have found important relationships between the habitat characteristics surrounding wetlands and bird communities (Chan et al. 2007; Guadagnin and Maltchik 2007; King et al. 2010). However, their analyses focused on wetland landscapes rather than the

Table 2 Variables retained in multivariate generalized linear models that better explain richness and abundance of nesting and non-nesting waterbirds in ponds

	Group	Variables retained	
		Nesting	Non-nesting
		Nesting	Non-nesting
Richness	Pond features	Constr. (**HPD**, **LDP**), **Sh. width**, per. fence, W. level, Sh. slope, **subm. veg.**, **shore veg.**, **float. veg.**, **reed**	Constr. (HPD, **LDP**), **Sh. width**, **W. level**, **subm. veg.**, **float. veg.**, amphib.
	Landscape	**Slope av.**, N. ponds, **N. habitat**, **pine for.**, **dry crops**, wasteland, urban area	N. ponds, **pine for.**, citric crops, dry crops, **urban area**
	Spatial	**X**, Y, **dist. urban area**, dist. nat. wetland	**X**, Y, dist. urban area, dist. nat. wetland
Abundance	Pond features	Constr. (**HDP**, **LDP**), **Sh. width**, **W. level**, Sh. slope, **subm. veg.**, **shore veg.**, **float. veg.**, **reed**, amphib.	Constr. (**HPD**, **LDP**), **Sh. width**, **W. level**, Sh. slope, **subm. veg.**, **shore veg.**, **float. veg.**, **reed**, amphib.
	Landscape	**Slope av.**, N. ponds, **N. habitats**, **shrublands**, **pine for.**, citric crops, orchards, **dry crops**	N. ponds, shrublands, **pine for.**, citric crops, orchards, **dry crops**, wasteland, **urban area**
	Spatial	**X**, Y, **dist. urban area**, dist. nat. wetland	**Y**, dist. nat. wetland

Landscape buffer was selected from the most parsimonious multivariate models (see Table 1). Variables in bold had a positive effect while others had a negative effect on waterbird abundance and richness

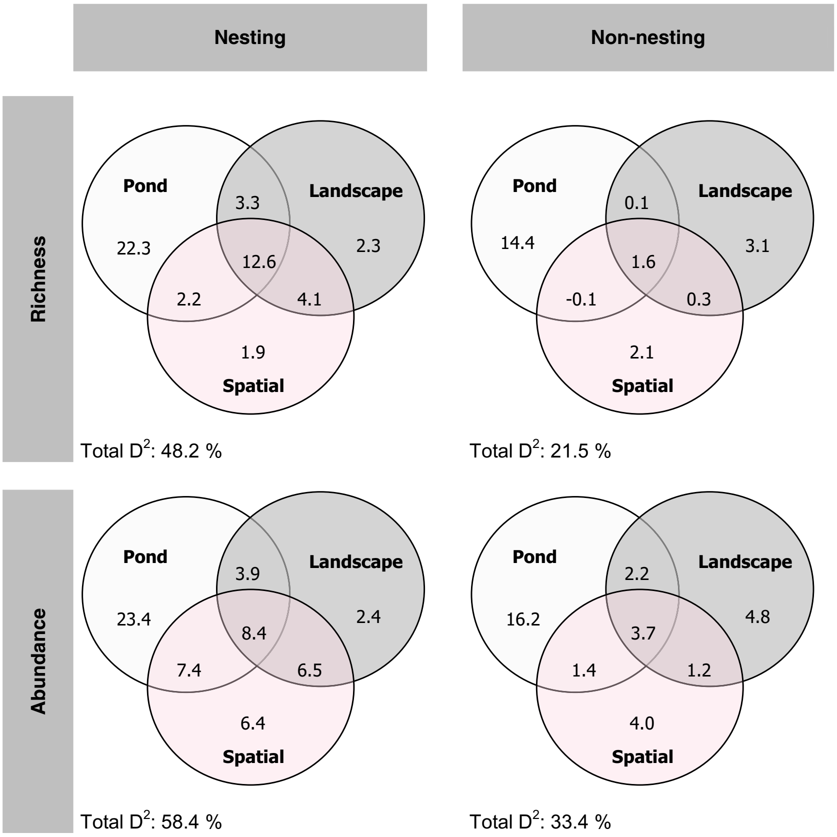

Fig. 2 Results of deviance partitioning using a partial regression analysis. The values shown in the diagram are the percentages of variation in the proportion of waterbird richness and abundance in ponds explained by spatial configuration (*Spatial*), landscape (*Landscape*), and pond features (*Pond*) and by the interactions among these components. Also, we include the total explained deviance of each model (total D^2). Landscape buffer was selected from the most parsimonious multivariate models (see Table 1). We present the results for the species that breed at the ponds (nesting) and for the remaining species (non-nesting)

complementarity of water and terrestrial habitats. In contrast, other studies have found a limited role of landscape configuration on waterbird use of wetlands, particularly for non-nesting terns (Steen and Powell 2012). The relatively scarce importance found of landscape composition and configuration for avian community richness and abundance (Cunningham and Johnson 2006) could be related to the high dependence of this guild on patch habitat (pond features). Waterbirds exploit aquatic habitats, which usually show major differences with the outer matrix and, in some cases, may constitute an almost neutral habitat for them (Fahrig et al. 2011). Avian species exhibit high dispersive and mobile capabilities (Haig et al. 1998), and this confers them some independence from the matrix between the habitats that they occupy (Frey et al. 2012). Moreover, the relatively higher importance of the landscape variables for non-nesting in comparison with the breeding species reflects the existence of some breeding colonies at the natural wetlands (Sebastián-González et al. 2010a). Some larids and ardeids use the natural wetlands as breeding areas and the ponds only to forage. As they need to move between both areas, the importance of the landscape configuration for these species may be higher, even if it continues to have a low general effect on community abundance and richness.

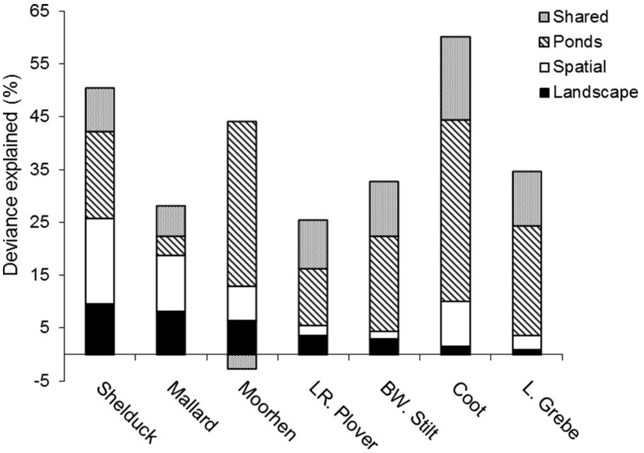

Fig. 3 Results of deviance partitioning using a partial regression analysis. The values shown in the figure are the percentages of deviance explained by the different groups of variables: spatial configuration (spatial), landscape (landscape), and pond features (pond) and interactions among these components (shared). The dependent variable was occupation. Landscape buffer was 0.5 km. Species were ranked from the greatest proportion of deviance explained by landscape configuration

At the species level, we detected differences in the habitat preferences related to species-specific ecological requirements (King et al. 2010). Previous studies with various taxa have already detected species-specific differences in the influence of landscape configuration, for example, in relation to different hunting and foraging strategies (Öberg et al. 2007; Hamer and Parris 2011). An important bird characteristic that may determine species requirements is body size (Schoener 1968; Sebastián-González and Green 2014). Larger species normally need larger areas for breeding and foraging. Consequently, they may show a trend to use, not only the resources of the pond, but also the ones at the surroundings, increasing the range of habitat that needs to be suitable for them to establish. In our study, several species (little grebe, common coot, little ringed plover, and black-winged stilt) behaved independently of the outer matrix. These species have small body sizes, and their requirements can be fulfilled using the resources at the pond. However, landscape configuration affected other species. Common shelduck was the most dependent on landscape features probably because it breeds outside the ponds in abandoned rabbit (*Oryctolagus cuniculus*) burrows (del Hoyo et al. 1992). In such cases, pond features and landscape configuration would offer complementary resources for feeding and breeding, respectively.

The identification of the scale on which a pattern can be observed is of vital importance in ecology (Levin 1992). In our case, despite the weak relationship between landscape and richness and abundance patterns in the waterbird community, both parameters were scale-dependent. The relationship between species richness and landscape configuration was more important at the larger scales. In contrast, abundance was more affected at the smaller scales. This difference was not unexpected as abundance generally relates more to availability of resources, while richness is probably more influenced by landscape heterogeneity. Indeed, studies performed with other guilds support our results. Ribeiro et al. (2012) found that the most diverse landscapes held a larger number of butterfly species, while smaller scales proved more effective to explain species abundance. Moreover, Simon et al. (2009) found that amphibian species richness is strongly related with medium scales (0.5–1 km) in surrounding storm water management ponds. Our results highlight the need for a multiscale approach to understand and predict richness and abundance in waterbird communities.

The factors that might limit waterbird populations and communities include food resources. Moreover, the breeding habitat and variables that describe such resources have been found to be important elsewhere (Weller 1999). Availability of such resources seems to be pond-dependent, and previous studies have shown that the richness and abundance of aquatic macroinvertebrates and macrophytes are related to pond features (Abellán et al. 2006; Sebastián-González et al. 2010a; Alexander et al. 2011). Our results are in agreement with these studies. We detected that pond construction material is an important variable retained by all the models, with ponds constructed under LDP design having richer and more abundant communities (Sánchez-Zapata et al. 2005; Sebastián-González et al. 2010a, b). Moreover, vegetation presence also increased the value of the ponds because it provides food and shelter. All these characteristics should be included in management recommendation programs to increase pond value for waterbirds.

Another important variable affecting aquatic communities is water availability. However, water resources in our system do not depend on terrestrial catchments, but on trans-basin water transfers. Thus, the ecological processes that are key factors in connecting terrestrial and aquatic ecosystems are absent (Davies et al. 1992). Other factors that might influence waterbird populations and communities include predation and human interference, which are landscape-dependent (Pasinelli and Schiegg 2006; Burton 2007). Feral predators such as cats, dogs, and rats are abundant in human-intensified landscapes, and human interference is also higher in such landscapes (Brady et al. 2011; Pita et al. 2009). Our results indicate a limited role of these factors in our study system, which might be explained by the fact that agricultural ponds are fenced, thus access of terrestrial predators and humans is precluded.

Our results also suggest that the artificial pond–waterbird system could be used as an experimental model system (EMS) to study pattern and process in ecology (Wiens et al. 1993; Sebastián-González et al. 2010c). Pond networks constitute an interesting system to study ecological theories about patchy habitats, as they are structurally simple, but not homogeneous, their limits are well defined, and they perform biologically as habitat islands surrounded by a matrix of non-available habitats for many species (De Meester et al. 2005; Céréghino et al. 2008). Moreover, the poor vegetation covering ponds and their small size greatly reduced the survey error. These types of systems are particularly interesting as simplified versions of reality to control variables beyond the objective of analyses.

For biodiversity conservation in human-dominated regions, it is especially important to understand the relationship between spatial heterogeneity and biodiversity in agricultural landscapes (Benton et al. 2003; Tscharntke et al. 2005; Fahrig et al. 2011). Artificial wetlands may be an important refugee for waterbirds, and the populations of some species can be even higher in artificial wetlands than in natural ones (Sebastián-González et al. 2010a; Alexander et al. 2011). Understanding how waterbirds respond to pond features and landscape configuration might help to conserve and manage their populations. In this sense, agro-environment policies promoted under the CAP regulations should encourage management strategies that attempt to combine the agricultural use of ponds with biodiversity conservation.

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