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Seasonal changes in bird assemblages of a remnant wetland in a Mediterranean landscape: implications for management

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Abstract Seasonal bird assemblages (both breeding and wintering) in a Mediterranean remnant wetland were described by a sample-based approach. Species richness, diversity index and the number of equally common species had higher values in winter than during the breeding period. At the guild level, wetland-related species were more represented in winter, either in terms of species richness or of frequency of occurrences. In winter, the availability of food resources related to seasonally flooded areas and the increment of the habitat heterogeneity increased the species richness and diversity, especially for wintering wetland-related species. The nature of the study area, a small remnant wetland embedded in a man-disturbed and land reclaimed landscape, explains the high rate of synanthropic species either in terms of richness or frequency of occurrences. Among these species, the Italian Sparrow (*Passer italiae*) was observed to use intensively the rush beds (*Juncetalia maritimi* habitat type) during the breeding period for foraging and fledging, owing to the abundance of suitable prey. Although these latter results require further studies, the utilization of wetlands by a declining Italian endemic, the Italian Sparrow, evidenced as these type of habitat may contribute to conserve threatened species other than waterbirds, providing support during the breeding season.

Key words: wintering season, breeding season, synanthropic species, matrix effect, *Passer italiae*.

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1. Introduction

Wetlands are patchy and dynamic ecosystems where a high number of species occur in different periods of the year (van der Walk 2006). In Mediterranean areas, cyclic changes in wetland patchiness owing to water availability (size, depth and shape of water ponds) may affect the presence, abundance and diversity of birds in the local assemblages, inducing a high species turnover rate among seasons (Wiens 1989). Abrupt changes in water depth that occurs in wetland fragments alters the size and shape of the flooded areas, reed beds and rush beds, and induces changes in the local distribution of the species (Williams 1991).

The human-induced habitat fragmentation and transformation has been considered as a complex process induced by a plethora of disturbances in a landscape-scaled scenario (Fahrig 2003, Lindenmayer & Fisher 2007). A component of habitat fragmentation is the reduction of ecological suitability of the remnant fragments (e.g. for habitat degradation and/or reduction of the resource availability) due to a large number of different disturbances originating from the surrounding landscape matrix (Andrèn 1994, Fahrig 2003). The landscape matrix may act as a source habitat for a large set of species differently related to human transformed environments (e.g., synanthropic and generalist species; Bennett 2003). Moreover, the habitat edges developing in the interface between matrix and wetland are landscape structures that influence bird diversity and composition depending on season and habitat characteristics (Ries & Sisk 2004, Vâlcu 2006). In human-transformed and fragmented landscapes, wetlands are usually small, isolated and surrounded by a human altered matrix (urbanized or cultivated) that may act as source of disturbance increasing the edge effect on these remnant fragments (Leibowitz 2003, Benassi *et al.* 2007, Paracuellos 2008).

The aim of this work is to highlight the seasonal differences in bird species, guilds and assemblages in a remnant wetland of Central Italy, as well as to provide the wildlife management authorities with valid ecological information concerning Mediterranean coastal marshlands.

2. Material and Methods

2. 1. Study area

Data were collected in the "Torre Flavia wetland" Natural Monument (41° 58' N; 12° 03' E; Special Area of Conservation according to the EU "Bird" Directive 79/409), a Mediterranean coastal marshland, 40 ha large, located on the Tyrrhenian coast of Central Italy. The area belongs to the meso-Mediterranean xeric region (Blasi & Michetti 2005) and represents the remnant of a larger wetland, mostly drained and transformed during the last fifty years. Water is mainly of meteoric and sea storm origin, with scarce flow from the surrounding areas (Battisti 2006). Water level varies with the seasons: from October to March the water level is up to 70 cm depth, while it is at its minimum between April and September and the rush bed is reduced to muddy soil (Battisti *et al.* 2006). Water level is artificially managed by fish farmers according to their needs (Battisti 2006).

The study area shows a semi-natural patchiness, composed by different patches of vegetation: (1) reed beds, dominated by Common Reed *(Phragmites australis)* and cut off by water basins as ponds and channels (used for fish farming of mullets, *Mugil cephalus, Liza ramada, Liza saliens*); (2) flooded meadows dominated by rush, *Juncus* sp. and *Carex* sp. (*Juncetalia maritimi*, a habitat type of conservation concern according to the 79/409 "Habitat" E. U. Directive, code 1410); (3) shifting dunes along the shoreline with *Ammophila arenaria* (white dunes: 79/409 "Habitat" E. U. Directive, code 2120). The surrounding matrix is a mosaic of cultivated and uncultivated lands, adjacent to human settlements (Ladispoli and Cerveteri towns; urbanization rate: 400-800 mq/ha; Romano 2006), and includes a seasonally flooded pasture moderately grazed by horses. Therefore, at landscape scale, the study area can be considered a fine-grained disturbance mosaic (Hobbs & Huenneke 1992) within a coarse-grained anthropized (i.e. agricultural and urbanized) matrix.

2. 2. Methods

We randomly juxtaposed on the study area a grid with 100×100 m cells, so that each portion of the wetland was included (some cells at the border of the wetland area partially included non-wetland habitats). Therefore, we obtained 67 cells that covered the whole study area. In the centre of each cell we sited a sampling point. We used the method of Echantillonage Frequential Progressif (EFP) to define the occurrence of each species in each cell (Blondel 1975, Bibby & Burgess 1992), following a sample-based approach and reporting the species occurrence values in each point count, not the number of individuals (individual-based approach) (Magurran 2004).

We carried out the sampling in two seasonal periods (breeding and wintering seasons) using the same set of point counts (*n*=67). We sampled each point count for 5 min. in the early morning (7:00-11:00 a.m.), repeated twice in each season always by the same observer (R.M.). A first phase took place during the 2005 breeding season (I session: 1-28th April; II: 1st May-10th June). A second phase took place during the 2005/2006 wintering season (I session: 15th November-30th January; II: 15th February-15th March). The whole sampling took 670 minutes (335 in the breeding season and 335 in wintering season). We recorded all birds seen or heard within 50 m from the point count's centre. Distance between surrounding point counts was always larger than 100 m. MGE Coordinate System Operation (MCSO – Intergraph) gave the terrestrial coordinates of each point count. We carried out the point count sampling in a random order and took them under favorable environmental conditions, in windless days without precipitation (Bibby & Burgess 1992). Because of the EFP method focused only on 'common species' (i.e., species locally more abundant, diffuse and easy detectable; Blondel 1975, Bibby & Burgess 1992), we did not obtain data on more rare and less detectable species.

2. 3. Data analysis

We analysed the data at three level: species, assemblage and guild. We refer to the term "assemblage", as a taxonomically related assortment of species seasonally occurring in the study area. We refer to the term "guild", as an ecologically related assortment of species seasonally occurring in the study area (Fauth *et al.* 1996, Magurran 2004). We identified two guilds: i) water-related species (i.e., species strictly related to wetlands for a broad period of the year) and, ii) synanthropic species (i.e., species strictly related to anthropized areas, as urban exploiters, largely dependent on human resources in fine-grained urban and suburban mosaics; McKinney 2002) (Table 1.).

For both seasons and for each species, from the total number of species occurrences (*n*), we obtained: (*1*) the relative frequency of occupied cells (fr_{cel}; ratio: n. species occurrences/total number of cells, i.e., 67); (2) the relative frequency of species occurrences (fr_{occ}; ratio: n. species occurrences/total number of occurrences). We considered dominant species, those with $fr_{occ} > 0.05$ (Turcek 1956).

At assemblage and guild level, we obtained: (1) the registered species richness (S); (2) the normalized species richness (Margalef index) as D_{Mg} = (S-1)/log N; this parameter normalizes the number of recorded species in respect to the sample size (i.e. in respect to the number of occurrences, N). (3) At the assemblage level, we calculated also the Shannon diversity index applied to species occurrences ($H = - \Sigma f_{occ} \ln f_{occ}$; Shannon & Weaver 1963) and the number of equally common species as $ECS = e^{H}$.

Table 1. Number of occurrences (*n*), relative frequency of occupied cells (fr_{cel}) and of occurrence (fr_{occ}) in breeding and wintering season (Palude di Torre Flavia, Central Italy); (*w*): wetland-related species; (*s*): synanthropic species. In bold, the dominant species ($fr_{occ} > 0.05$). Significance levels (χ^2 test): * : $p < 0.05$; ** : $p < 0.01$; *ns* = not significant.

Species	**Breeding**			**Wintering**			
	n	fr_{cel}	fr_{occ}	***n***	fr_{cel}	fr_{occ}	**χ^2 test**
Tachybaptus ruficollis (w)				1	0.015	0.003	
Ixobrychus minutus (w)	2	0.030	0.007				
Ardea cinerea (w)				1	0.015	0.003	
Casmerodius albus (w)				2	0.030	0.005	
Anas platyrhynchos (w)	10	0.149	0.033	8	0.119	0.021	ns
Anas clypeata (w)				1	0.015	0.003	
Anas crecca (w)				4	0.060	0.011	
Anas penelope (w)				2	0.030	0.005	
Phalacrocorax carbo (w)				4	0.060	0.011	
Circus aeruginosus (w)				5	0.075	0.013	
Falco tinnunculus				2	0.030	0.005	
Rallus aquaticus (w)				6	0.090	0.016	
Gallinula chloropus (w)	7	0.104	0.023	9	0.134	0.024	ns
Fulica atra (w)	6	0.090	0.020	3	0.045	0.008	ns
Charadrius hiaticula (w)				5	0.075	0.013	
Pluvialis squatarola (w)				3	0.045	0.008	
Vanellus vanellus (w)				3	0.045	0.008	
Gallinago gallinago (w)				17	0.254	0.045	
Larus ridibundus (w)				16	0.239	0.042	
Columba livia domestic form *(s)*	9	0.134	0.030	12	0.179	0.032	ns
Streptopelia decaocto (s)	3	0.045	0.010	2	0.030	0.005	ns
Alcedo atthis (w)				1	0.015	0.003	
Alauda arvensis	5	0.075	0.017	5	0.075	0.013	ns
Galerida cristata	15	0.224	0.050	14	0.209	0.037	ns
Anthus pratensis				43	0.642	**0.113**	
Motacilla alba	1	0.015	0.003	19	0.284	0.050	7.225**
Erithacus rubecula				17	0.254	0.045	
Phoenicurus ochruros				13	0.194	0.034	
Saxicola torquata	9	0.134	0.030	16	0.239	0.042	ns

Table 1 (continued)

Species	Breeding			Wintering			
	n	fr_{cel}	fr_{occ}	*n*	fr_{cel}	fr_{occ}	χ^2 test
Turdus merula	27	0.403	**0.090**	14	0.209	0.037	ns
Sylvia melanocephala	5	0.075	0.017				
Phylloscopus collybita				12	0.179	0.032	
Remiz pendulinus (w)				7	0.104	0.018	
Acrocephalus scirpaceus (w)	6	0.090	0.020				
Acrocephalus arundinaceus (w)	1	0.015	0.003				
Cisticola jundicis	46	0.687	**0.153**	15	0.224	0.039	7.377**
Cettia cetti (w)	23	0.343	**0.076**	10	0.149	0.026	ns
Corvus corone cornix (s)	20	0.299	**0.066**	19	0.284	0.050	ns
Pica pica (s)	5	0.075	0.017	6	0.090	0.016	ns
Sturnus vulgaris (s)	20	0.299	**0.066**	9	0.134	0.024	ns
Passer italiae (s)	43	0.642	**0.143**	20	0.299	**0.053**	3.841*
Passer montanus (s)	3	0.045	0.010	5	0.075	0.013	ns
Carduelis carduelis (s)	9	0.134	0.030	9	0.134	0.024	ns
Carduelis chloris (s)	6	0.090	0.020	5	0.075	0.013	ns
Serinus serinus (s)	8	0.119	0.027	1	0.015	0.003	ns
Miliaria calandra	12	0.179	0.040				
Emberiza schoeniclus (w)				14	0.209	0.037	

In this case, ECS estimates how many bird species have a similar occurrence in a given season, based on the point count results (Magurran 2004). (4) We calculated a non parametric estimator of species richness (Chao 2; Palmer 1990, Colwell & Coddington 1994) in two seasons, as an evaluation of our research effort. This index is based on the ratio between singletons (i.e. the number of species that occur in one sampling point count only) and doubletons (i.e. the number of species that occur in two samples), therefore, consider the presence of rare (i.e. occurring in one or two point counts) species in a sample (Magurran 2004).

All tests were two-tailed, and alpha was set at 5%. For calculation, the statistical software SPSS (version 13.0 for Windows) was used (SPSS 2003).

3. Results

We obtained 681 records of species occurrences belonging to 47 species. Twenty species were sedentary (i.e., occurring in both seasons), 22 wintering, and 5 summer residents which occurred only in breeding period (Table 1.). Chao 2 estimator of species richness showed values of 45.1 in winter

Table 2. Registered (S) and normalized (D_{Mg}) values of species richness, number of occurrences (N), and total relative frequency of occurrences (fr_{occ}) at assemblage and guild levels (water-related and synanthropic species).

	Breeding season				Wintering season			
	S	D_{Mg}	N	fr_{occ}	S	D_{Mg}	N	fr_{occ}
Total assemblages	25	9.68	301		42	15.89	380	
Water-related	7	3.45	55	0.18	21	9.59	122	0.32
Synanthropic	10	4.28	126	0.42	10	4.63	88	0.23

(5 singletons, 4 doubletons) and 25 (only 3 singletons) in the breeding period.

At the assemblage level, values of species richness (absolute and Margalef normalized) resulted in higher values in winter compared to that of the breeding period (Table 2), analogously to the Shannon diversity index (H_{winter} = 3.4, H_{summer} = 2.83) and the number of equally common species (29.96 and 16.95, respectively).

At the guild level, wetland-related species showed higher values in winter compared to the breeding period, either in terms of species richness (absolute and normalized) or in terms of total frequency of occurrences (Table 2.). Despite the equality of the number of synanthropic species in both seasons, their total frequency of occurrences was higher in the breeding period (Table 2.).

At the species level, Blackbird *(Turdus merula),* Zitting Cisticola *(Cisticola juncidis),* Cetti's Warbler *(Cettia cetti),* Hooded Crow *(Corvus corone cornix),* Starling *(Sturnus vulgaris)*, and Italian Sparrow *(Passer italiae)* were found to be dominant during the breeding period, while Meadow Pipit *(Anthus pratensis)* and Italian Sparrow were dominant in winter. Zitting Cisticola and Italian Sparrow showed a higher frequency (> 50 %) of occupied cells in the breeding period, while Meadow Pipit did so in winter (Table 1.).

Among the resident species, Zitting Cisticola and Italian Sparrow had a number of occurrences significant higher in breeding period (χ^2= 7.377, P < 0.01 and 3.841, P< 0.05; Yates correction, df = 1, respectively) than in wintering period. On the contrary, White Wagtail *(Motacilla alba)* showed a higher frequency of occurrences in winter (χ^2= 7.225, P< 0.01; Yates correction, df = 1).

4. Discussion

Bird assemblages in the study area were shown to be more rich and diverse in winter (absolute and normalized Margalef richness, Shannon index and number of equally common species). In this period, the availability of food resources and the higher habitat heterogeneity and patchiness, linked to seasonally watered areas, increased the richness and diversity, especially of wintering wetland-related species (Wiens 1976, Williams 1991).

Chao 2 estimated a small increase of species richness in winter (45.1 *vs*. 42 sampled), but not in the breeding period, therefore emphasizing the presence of rare species which were not sampled in winter. The subtle differences between estimated and sampled values (7% in winter, 0% in the breeding period) showed that the research effort was adequate (Magurran 2004).

Some results at species level were expected. The number of occurrences of Zitting Cisticola was significantly higher in the breeding period. This is a typical species of reed beds, sedges, grassy wastelands and wetlands with salt-marsh vegetation (Arlott 2007), largely spread in Central Italy (Boano *et al.*, 1995), and shows a higher detectability in the breeding period (territorial song flight of males; Cramp & Simmons 1983). Therefore the easy sampling of this species can induce an overestimation of the effective frequency of occurrence. The relationships among detectability, sampling accuracy and ecological traits of bird species were widely investigated (Scott *et al.* 2002), also in birds of Mediterranean landscapes (Carrascal *et al.* 1989, Seoane *et al.* 2005).

The Meadow Pipit, the most dominant species of the assemblage occurring only in winter, showed a number of occurrences more than twice as large as that of the second ranked species (Italian Sparrow). This species prefers a wide variety of pastures, coastal meadows, open grasslands in the whole Mediterranean region (Delgado & Moreira 2000). Marshland coastal areas of Central Italy represent an ecosystem type hosting highly suitable habitats for this pipit (Biondi *et al.* 1999), explaining the high frequency observed in our study area.

The study area is a small remnant wetland embedded in a human-transformed and land reclaimed landscape (Battisti 2006). This explains the high frequency of synanthropic species which are widespread in the study area (Beissinger & Osborne 1982) as a consequence of a matrix effect (Moilanen & Hanski 1998, Ricketts 2001; for birds in agricultural landscapes, see Allen & O'Connor 2000, Tworek 2002, Hostetler *et al.* 2005). In our study area, this phenomenon appeared to be more evident in the breeding period when we recorded an increase in the number of species (40 % in the breeding period, 24 % in winter) and in total frequency of the synanthropic guild. Despite any authors highlight it in human-disturbed landscapes, the matrix effect can induce a biotic homogenization among the habitat types (Clergeau *et al.* 1998, Blair 2001, McKinney 2002, Blair 2004). Data on the seasonal changes of this effect are less studied (e.g., Vâlcu 2006), at least in the Mediterranean area.

Among the synanthropic species, only the Italian Sparrow increased significantly its occurrences in the breeding period. In this season, this dominant species utilized largely rush beds for foraging owing to the high availability of invertebrates in these environments (Carpaneto *et al*. 2006). The congeneric Tree Sparrow *(Passer montanus)* behaves similarly: wetland edge habitats are frequently used by foraging adults when feeding the nestlings since invertebrate prey of aquatic origin was frequently recorded in the diet of chicks (Field & Anderson 2004; see also Báldi & Kisbenedek 1999). We suggest that the rush beds function as wetland edge habitats and play a key role in providing adequate availability of preys also for the synanthropic Italian Sparrow, analogously to other bird species (although not related to wetlands) that use seasonal ponds and the surrounding vegetation for foraging (Paton 2005). Further data on a more large set of wetland remnants are need to assess if this pattern is widespread in the Mediterranean wetlands or only a local opportunistic behaviour. Nevertheless, the observed use of rush bed as foraging area by Italian Sparrow could have important implications for bird conservation and wetland management. Several sparrow species are facing a severe decline in Europe (Sanderson 2001, Prowse

2002, Robinson *et al*. 2005, Brichetti *et al*. 2008), *e.g.* the House Sparrow *(Passer domesticus)* in Great Britain and the Italian Sparrow *(P. italiae)* during the last decades. Therefore, wetlands bordered by farmlands or human settlements may also have a role not only in conservation of water-related birds but also for synanthropic decreasing species. In particular, the management of these areas, with a special attention to the ecology of rush beds, could provide practical tools for conserving a threatened Italian endemic species.

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References

Allen, A.P. & R.J. O'Connor. 2000. Interactive effects of land use and other factors on regional bird distributions. – J. Biogeogr. 27: 889-900.

Andrén, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. – Oikos 71: 355-366.

Arlott, N. 2007. Birds of the Palearctic: Passerines. – Harpers Collins Publishers Ltd., London.

Báldi, A. & T. Kisbenedeck. 1999. Species-specific distribution of reed-nesting passerine birds across reed-bed edges: effects of spatial scale and edge type. – Acta Zool. Hung. 45: 97-114.

Battisti, C. (ed) 2006. Biodiversità, gestione, conservazione di un'area umida del litorale tirrenico – Provincia di Roma, Assessorato alle politiche agricole e dell'ambiente, Gangemi, Roma.

Battisti, C., Aglitti, C., Sorace, A. & M. Trotta. 2006. Water level and its effect on the breeding bird community in a remnant wetland in Central Italy. – Ekològia (Bratislava) 25: 252-263.

Beissinger, S.R. & D.R. Osborne. 1982. Effects of urbanization on avian community. – Condor 84: 75-83.

Benassi, G., Battisti, C. & L. Luiselli. 2007. Area effect on bird species richness of an archipelago of wetland fragments of Central Italy. – Community Ecology 8: 229-237.

Bennett, A.F. 2003. Linkages in the landscapes. The role of corridors and connectivity in wildlife conservation. – Gland, Switzerland/Cambridge, UK, IUCN.

Bibby, C.J. & N.D. Burgess. 1992. Bird Census Techniques. – Academic Press, London.

Biondi, M., Guerrieri, G. & L. Pietrelli. 1999. Atlante degli uccelli presenti in inverno lungo la fascia costiera del Lazio (1992-95). – Alula 6: 3-124.

Blair, R.B. 2001. Birds and butterflies along urban gradients in two ecoregions of the United States: is urbanization creating a homogeneous fauna? Pp. 33-56. In: Lockwood, J.L., McKinney, M.L. (eds), Biotic homogenization. – Kluwer Academic/Plenum Publishers, New York, USA.

Blair, R.B. 2004. The effects of urban sprawl on birds at multiple levels of biological organizations. – Ecology and Society 9: 2 (online).

Blasi, C., Michetti, L. 2005. Biodiversità e Clima. Pp. 57-66. In: Blasi, C., Boitani, L., La Posta, S., Manes, F., Marchetti, M. (eds). Stato della biodiversità in Italia, Contributo alla strategia nazionale per la biodiversità. – Ministero dell'Ambiente e della Tutela del territorio, Fratelli Palombi editori, Roma.

Blondel, J. 1975. L'analyse des peuplements d'oiseaux, élément d'un diagnostic écologique. La méthode des Echantillonages Frequentiels Progressifs (E.F.P.). – La Terre et la Vie 29: 533-589.

Boano, A., Brunelli, M., Bulgarini, F., Montemaggiori, A., Sarrocco, S. & M. Visentin (eds.) 1995. Atlante degli uccelli nidificanti nel Lazio. – Alula 2: 1-224.

Brichetti, P., Rubolini, D., Galeotti, P. & M. Fasola. 2008 Recent declines in urban Italian Sparrow *Passer (domesticus) italiae* populations in northern Italy. – Ibis 150 : 177–181.

Carpaneto, G. M., Mazziotta, A. & A. Vigna Taglianti. 2006. Ricerche preliminari sui Coleotteri. Pp. 205-214. In: Battisti, C. (ed), Biodiversità, gestione, conservazione di un'area umida del litorale tirrenico – Provincia di Roma, Assessorato alle politiche agricole e dell'ambiente, Gangemi, Roma.

Carrascal, L.M., Diaz, J.A. & M. Ruiz. 1989. Detectabilidad visual de aves en censos desde coche. – Ardeola 36: 210-214.

Clergeau, P., Savard, J.P.L., Mennechez, G. & G. Falardeau. 1998. Bird abundance and diversity along an urban-rural gradient : a comparative study between two cities on different continents. – Condor 100: 413-425.

Colwell, R.K. & J.A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. – Phil. Trans. R. Soc. Lond. B. 345: 101-118.

Cramp, S. & K.E.L. Simmons. 1983. The Birds of the Western Palearctic Vol. III. – Oxford University Press, Oxford.

Delgado, A. & F. Moreira. 2000. Bird assemblages of an Iberian cereal steppe. – Agr. Ecosyst. Environ. 78: 65-76.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. – Annu. Rev. Ecol. Syst. 34: 487-515.

Fauth, J.E., Bernardo, J., Camara, M., Resetarits, W.J., Van Buskirk, J. & S.A. McCollin. 1996. Simplifying the jargon of community ecology: a conceptual approach. – Am. Nat. 147: 282-286.

Field, R.H. & G.Q.A. Anderson. 2004. Habitat use by breeding Tree Sparrows *Passer montanus*. – Ibis 146: 60-68.

Hobbs, R.J. & L.F. Huenneke. 1992. Disturbance, diversity, and invasion: implications for conservation. – Cons. Biol. 6: 324-337.

Hostetler, M., Duncan, S. & J. Paul. 2005. Post-construction effects of an urban development on migrating, resident, ad wintering birds. – Southeast. Nat. 4: 421-434.

Leibowitz, S.G. 2003. Isolated wetlands and their functions: an ecological perspective. – Wetlands 23: 517-531.

Lindenmayer, D.B., & J. Fisher. 2007. Tackling the habitat fragmentation panchreston. – Trends Ecol. Evol. 22: 127-132.

Magurran, A. 2004. Measuring biological diversity. – Blackwell Publishing, Malden, MA.

McKinney, M.L. 2002. Urbanization, biodiversity, and conservation. – BioScience 52: 883-890.

Moilanen, A. & I. Hanski. 1998. Metapopulation dynamics: effects of habitat quality and landscape structure. – Ecology 79: 2505-2515.

Palmer, M.W. 1990. The estimation of species richness by extrapolation. – Ecology 71: 1195-1198.

Paracuellos, M. 2008. Effects of long-term habitat fragmentation on a wetland bird community. - Revue d'Ecologie (Terre Vie) 63: 1-12.

Paton, P.W.C. 2005. A review of vertebrate community composition in seasonal forest pools of the northeastern United States. – Wetlands Ecology and Management 13: 235-246.

Prowse, A. 2002. The urban decline of the House Sparrow. – Brit. Birds 95: 143-146.

Ricketts, T.H. 2001. The matrix matters: effective isolation in fragmented landscapes. – Am. Nat158: 87-99.

Robinson, R. A., Siriwardena, G. M., & H. Q. P. Crick. 2005. Size and trends of the House Sparrow *Passer domesticus* population in Great Britain. – Ibis 147: 552–562.

Romano, B. 2006. La Palude di Torre Flavia e lo scenario regionale di frammentazione e pressione insediativa. Pp. 142-144. In: Battisti, C. (ed). Biodiversità, gestione, conservazione di un'area umida del litorale tirrenico. – Provincia di Roma, Assessorato alle politiche agricole e dell'ambiente. Gangemi, Roma.

Sanderson, R. F., 2001. Further declines in an urban population of House Sparrows. – Brit. Birds 94: 507.

Scott, J.M., Heglund, P.J., Morrison, M.L., Haufler, J.B., Raphael, M.G., Wall, W.A. & F.B. Samson (eds) 2002. Predicting species occurrences. Issues of scale and accuracy. – Island Press, Washington.

Seoane, J., Carrascal, L.M., Alonso, C.L., & D. Palomino. 2005. Species-specific traits associated to prediction errors in bird habitat modelling. – Ecol. Model. 185: 299-308.

Shannon, C.E. & W. Weaver. 1963. Mathematical theory of communication. – University of Illinois Press, Urbana, Illinois.

SPSS Inc. 2003. SPSS for Windows – Release 13.0 (1 Sep 2004), Leadtools (c), Lead Technologies Inc

Turcek, F.J. 1956. Zur Frage der Dominanze in Vogelpopulationen. – Waldhygiene 8: 249-257.

Tworek, S. 2002. Different bird strategy and their response to habitat changes in an agricultural landscape. – Ecol. Res. 17: 339-359.

Vâlcu, M. 2006. Seasonal changes in bird species diversity at the interface between forest and reedbed. – Biodivers. Conserv. 15: 3459-3467.

van der Walk, A.G. 2006. The biology of freshwater wetlands. – Oxford University Press, Oxford.

Wiens, J.A. 1976. Population responses to patchy environments. – Annu. Rev. Ecol. Syst. 7: 81-120.

Wiens, J.A. 1989. The ecology of bird communities. Vol. 2. Processes and variations. – Cambridge studies in ecology, Cambridge University Press, Cambridge, UK.

Williams, M. (ed.) 1991. Wetlands: a threatened landscape. – Basil Blackwell, Cambridge, Massachusetts.