

POLISH JOURNAL OF ECOLOGY (Pol. J. Ecol.)	57	1	171–179	2009
--	----	---	---------	------

Regular research paper

Rachele MALAVASI¹, Corrado BATTISTI^{2*}, Giuseppe M. CARPANETO¹

¹Department of Biology, University “Roma Tre”, Viale Marconi, 446, 00146 Rome, Italy,
e-mails: r.malavasi@campus.uniurb.it, carpanet@uniroma3.it

²Nature Conservation Office, Environmental Service, Province of Rome,
via Tiburtina, 691, 00159 Rome, Italy, *e-mail: c.battisti@provincia.roma.it (*corresponding author*)

SEASONAL BIRD ASSEMBLAGES IN A MEDITERRANEAN PATCHY WETLAND: CORROBORATING THE INTERMEDIATE DISTURBANCE HYPOTHESIS

ABSTRACT: The structure of bird assemblages recorded in breeding and wintering period in a Mediterranean wetland of Central Italy was studied in order to evaluate their seasonal changes and the influence of land cover on their parameters. We identified three habitat macro-types, according to a man-disturbed gradient (from natural to man-made macro-types). Bird assemblages showed differences in relation to season and habitat type, either at quantitative (species richness, diversity index) or qualitative level (species composition and turnover, similarity). In winter, we obtained the higher values of mean species richness, Margalef richness, Shannon diversity, and β -diversity. The dendrogram of similarity showed a major clear-cut division between seasons, and a secondary division among habitat macro-types. In winter, assemblages were more rich and diverse, with a high turnover among point counts. The semi-natural habitat macro-types showed always the higher values of these indexes, with the exception of the β -diversity, which showed the highest value in winter but the lowest in the breeding period. The high mean values of richness (α -diversity) of the semi-natural habitat macro-types, especially in the breeding period could be mainly explained by the ‘intermediate disturbance hypothesis’; on the contrary, differences in turn-over (β -diversity) between the seasons are mainly due to seasonal changes in habitat heterogeneity of this habitat macro-type (from an arid homogeneous pasture

to a patchy flooded one). A pattern of intermediate disturbance was evident at mean species richness level (significant values) but not at diversity index level (not significant values). These results could imply specific strategies for the management of small wetlands, focused on maintaining a regime of natural (flooding) and man-made (grazing) disturbances.

KEY WORDS: bird assemblages, wetland patches, frequency, diversity, species turnover, intermediate disturbance hypothesis

1. INTRODUCTION

Man-made disturbances as land reclamation, urbanization, land cover change and habitat fragmentation shaped the current Mediterranean landscapes in historic times (Thomas 1956, Olson and Direnstein 1998, Blondel and Aronson 1999). In this mosaic of disturbances, natural ecosystems juxtapose with semi-natural or man-disturbed areas building “harlequin landscapes” (Blondel *et al.* 1992). Among natural ecosystems, Mediterranean wetlands, especially in plains and littoral areas, are generally embedded in human-transformed landscapes and several of them are small sized (i.e., the frequency of distribution of size area is

skewed toward small size; Paracuellos 2006, Benassi *et al.* 2007).

Disturbances associated to human-transformed landscapes may affect the structure of bird populations and assemblages (e.g., Dunning *et al.* 1992, Niemi *et al.* 1998, Brawn *et al.* 2001). Despite their small size, wet ecosystems in human-dominated landscapes host a large part of water-related and specialist birds (e.g., Anseriformes, Gruiformes, Charadriiformes), with many threatened species (BirdLife International 2004). Therefore, in Mediterranean remnant wetlands, vagrant synanthropic species belonging to the surrounding human-transformed ecosystems (e.g., pastures, croplands, urban areas) mix to water-related species, and generate heterogeneous bird assemblages (Benassi *et al.* 2007).

Wetlands are highly dynamic ecosystems, whose life forms strongly depend on local water cycle (van der Walk 2006). In Mediterranean areas, wetlands (especially the small ones) show a summer drought period alternate to winter flooding (seasonally flooded wetlands *sensu* Cowardin *et al.* 1979). Consequently, a strong seasonal species turnover characterizes wetland-related bird communities, induced by the intrinsic ecology and phenology of the species, but also by extrinsic factors linked to dynamics of annual water cycle in these ecosystems (Brönmark and Hansson 2005).

Moreover, wetlands are ecosystems characterized by a high number of natural and man-made disturbances with different regime and therefore suitable to test the 'Intermediate Disturbance Hypothesis' (IDH) (Connell 1978). This hypothesis states that an increase of species richness (or other comparable parameters at community level) is often observed in moderately disturbed ecosystems (i.e. with intermediate levels of severity or frequency of a disturbance; see also Sousa 1984, Petraitis *et al.* 1989). The IDH has been implicitly recognized in studies on wet ecosystems *sensu lato* (e.g., floodplain forests and large rivers ecosystems; Conner and Day 1976, Hobbs and Huenneke 1992, Brawn *et al.* 2001), but data are lacking for Mediterranean wetlands.

The aim of this work is to analyze the seasonal structure of bird assemblages in

a Mediterranean remnant wetland along a gradient of habitat types characterized by a different level of man-made disturbances. We would like to verify if a different land use cover, originated by various disturbances, induces change in the structure of bird assemblages at level of richness, diversity and species turnover. In particular, we would test the hypothesis that intermediate levels of disturbance can induce a pick of richness and diversity in relation to seasons.

2. STUDY AREA

The study area is the "Palude di Torre Flavia" (41°58'N; 12°03'E; Special Area of Conservation according to the EU Directive 79/409), a nature reserve consisting of a coastal wetland 40 ha large, located on the Tyrrhenian seashore (Central Italy). From a bioclimatic point of view, the area belongs to the meso-Mediterranean xeric region (Tomasselli *et al.* 1973, Blasi and Michetti 2005) and represents a relict of a larger wetland, partially drained and transformed in the last fifty years, where water is mainly of meteoric and sea storm origin. Flow from surrounding areas is scarce. Water depth varies with the seasons: from October to March the flood level reaches the maximum value (70 cm), while from June to October is reduced to form some areas of muddy soil or shallow ponds (Battisti *et al.* 2006; seasonally flooded wetland *sensu* Cowardin *et al.* 1979).

The study area shows a specific, semi-natural patchiness, composed by different patches of reed beds, dominated by *Phragmites australis* (Cav.) Trin. ex Steud. and cut off by water basins as ponds and channels used for fish farming of mullets, as *Mugil cephalus* L., *Liza ramada* (Risso), *Liza saliens* (Risso), rush flooded meadows dominated by *Juncus* sp. and *Carex* sp. (Juncetalia maritimi: habitat type of conservation concern; 79/409 "Habitat" EU directive), and coastal dunes (Battisti 2006). The surrounding matrix is a mosaic of cultivated and uncultivated lands, adjacent to human settlements, 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 and Huenneke

1992) within a man-disturbed matrix (i.e. agricultural and urban). Land cover use shows various level of naturalness, from high (reed beds and rush meadows), to medium (pasture and uncultivated lands) and low or absent (croplands and urban areas).

3. METHODS

3.1. Protocol

Data were collected from 45 sampling points randomly distributed in three Habitat Macro-Types (hereafter, HMT; 15 sampling points each one), including approximately half of the wetland area (36 ha):

- natural HMT: including wet areas with a water-related vegetation with fine-grained structure (reed-beds and rush meadows; sampled size area: about 12 ha)
- semi-natural HMT: including seasonally flooded pasture lands, affected by a moderate human disturbance (horse grazing and trampling) which hampers the natural recovery toward the original vegetation (*Juncetalia maritimi* EU habitat type; sampled size area: about 12 ha);
- man-disturbed HMT: including both orchards and low-density urban areas at the borders of the protected area (mean urban density: 400–600 m² ha⁻¹; Romano 2006) (sampled size area: about 12 ha).

Sampling was aimed at defining the structure and the seasonal variation of bird assemblages in the three HMTs. We used the E.F.P. method (Echantillonage Fréquentiel Progressif; Blondel 1975, Bibby and Burgess 1992) following a sample-based approach, which reported the species record (i.e. the number of individual sampled of each species) in each sampling point count (hereafter, point count) and their number (i.e., a measure of species richness), not considering their absolute abundance (i.e., number of individuals, absolute or relative) (Magurran 1988, Magurran 2004). We carried out the sampling in two seasonal periods (breeding and wintering season), using the same set of point counts. We sampled each point count in the early morning (7:00–11:00 a.m.) with sessions of 5 minutes, twice repeated in each season, always by the same observer (R.M.). A first period took place during the 2005

breeding season (I session: 1–28th April; II session: 1st May–10th June). A second period took place during the 2005/2006 wintering season (I session: 15th November–30th January; II session: 15th February–15th March). The whole sampling effort was around 900 minutes (15 hours). We recorded all the birds seen or heard within 50 m from each point count centre. Distance between surrounding point counts was always larger than 100 m. MGE Coordinate System Operation (MCSO Intergraph – 1995) gave the terrestrial coordinates of each point count.

We carried out the point count sampling in a random order under favorable environmental conditions, avoiding extreme rain and strong wind (Bibby and Burgess 1992).

3.2. Data analysis

At species level, for each HMT and season, we calculated the frequency of records of each species as n_i/n ; where n_i is the number of record of the species i and n is the total number of records.

At assemblage level, for each HMT and season was calculated the following structural parameters:

- total species richness, i.e. the total number of species sampled (S);
- mean species richness (S_{mean}), i.e. the ratio between the total species richness and the number of point counts; this parameter normalizes the number of recorded species in respect to the number of point counts (Whittaker 1960, Magurran 2004);
- Margalef richness index (D_{Mg} ; Clifford and Stephenson 1975) as:

$$D = (S-1)/\log n \quad (1)$$

where S is the number of species recorded, and n the number of records in the samples; this parameter normalizes the number of recorded species in respect to the sample size (i.e. in respect to the number of records, n);

- Shannon diversity index (Shannon and Weaver 1963) as:

$$H' = - \sum fr \ln(fr) \quad (2)$$

where fr is the frequency of records of each species (n_i/n ; where n_i is the number of records of the species i); species diversity indices have commonly been used to summarize species record data (Flather 1996);

- evenness index (Lloyd and Ghelardi 1964), as:

$$J = H'/H'_{\max} \quad (3)$$

where: $H'_{\max} = \ln S$ (Pielou 1966) and H' is the Shannon diversity index;

- Whittaker's β -diversity index (Whittaker 1960, Whittaker 1970) as:

$$\beta_w = S/S_{\text{mean}} \quad (4)$$

where S : is the total number of species recorded in each season (i.e. a measure of γ -diversity) and S_{mean} is the mean species richness (i.e., a measure of average α -diversity; Magurran 2004).

We performed a multivariate statistic using a hierarchical cluster analysis using the unweighted pair group mean average as amalgamation rule and the Euclidean distance as distance measure. The tree was rescaled to $d_{\text{link}}/d_{\text{max}}*100$. We performed a Mann-Whitney U test between the values of mean species richness and a Kolmogorov-Smirnov test between the Shannon diversity values setting an *alfa* level = 0.05. We used the statistical package SPSS 15.0 (version for Windows) (SPSS 2006).

4. RESULTS

We sampled 45 species (23 in breeding and 41 in wintering period), obtaining 518 records/species (Table 1).

In winter, we achieved higher values of species richness, mean species richness, Shannon and β -diversity indexes for each HMT (Table 2). Differences between mean species richness values were significant only in breeding period between assemblages of semi-natural HMT and the other two HMTs (man-disturbed: $Z_{\text{sub T}} = 2.017$, $P = 0.044$; natural: $Z_{\text{sub T}} = 2.115$, $P = 0.034$). No differences were observed between natural and man-disturbed assemblages ($Z_{\text{sub T}} = 0.169$, $P = 0.866$, Mann-Whitney U-test) in the breeding period.

Along the habitat gradient, diversity index values did not differ significantly between HMT assemblages (wintering period: man-disturbed – semi-natural: $Z = 1.339$; semi-natural – natural: $Z = 1.162$; breeding period: man-disturbed – semi-natural: $Z = 0.768$; semi-natural – natural: $Z = 0.586$; all $P > 0.05$) and seasons (man-disturbed:

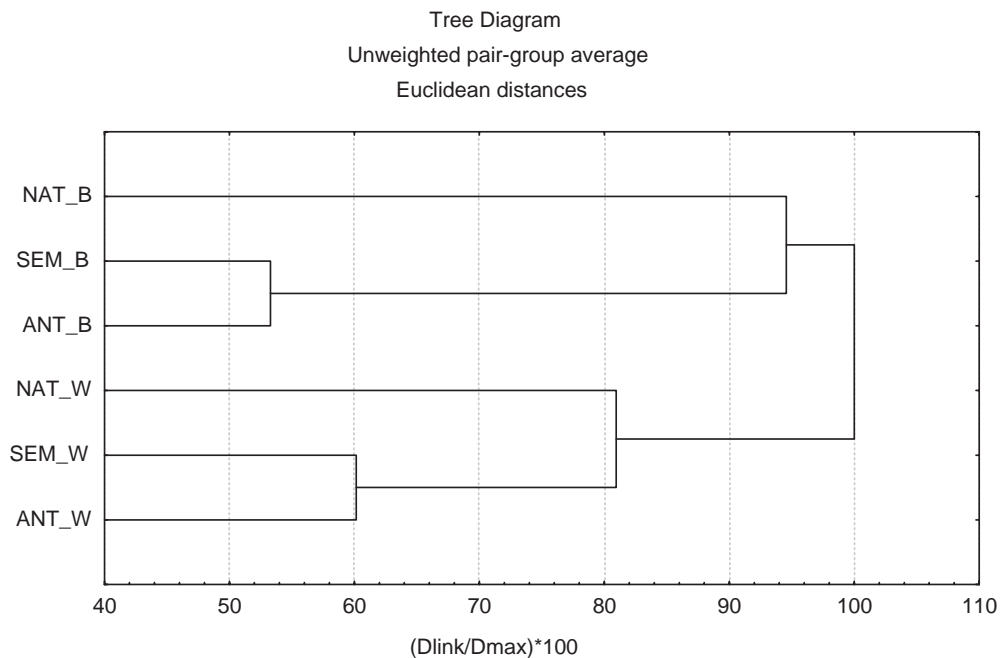


Fig. 1. Qualitative dendrogram of similarity (matrix species/records) among communities in breeding (B) and in wintering (W) period in the three habitat macrotypes. NAT: natural macrotype, SEM: semi-natural, ANT: man-disturbed.

Table 1. Frequency of records (in percentage) of birds in the three habitat macrotypes (natural, semi-natural, man-disturbed) in breeding and wintering periods: n = total number of records.

	Natural	Semi-natural	Man-disturbed	Natural	Semi-natural	Man-disturbed
<i>Tachybaptus ruficollis</i> (Pallas)				1.1		
<i>Phalacrocorax carbo</i> (L.)						1.1
<i>Ixobrychus minutus</i> (L.)	2.7					
<i>Casmerodius albus</i> (L.)					1.0	
<i>Anas platyrhynchos</i> L.	11.0			7.7		
<i>Anas clypeata</i> L.				1.1		
<i>Anas crecca</i> L.					2.0	
<i>Anas penelope</i> L.					2.0	
<i>Circus aeruginosus</i> (L.)				2.2	1.0	1.1
<i>Falco tinnunculus</i> L.					1.0	
<i>Rallus aquaticus</i> L.				6.6		
<i>Gallinula chloropus</i> (L.)	8.2		1.4	8.8		1.1
<i>Fulica atra</i> L.	6.8	1.1		3.3		
<i>Charadrius hiaticula</i> L.						1.1
<i>Pluvialis squatarola</i> (L.)				1.1	1.0	
<i>Vanellus vanellus</i> (L.)					1.0	1.1
<i>Gallinago gallinago</i> (L.)				3.3	10.2	3.2
<i>Larus ridibundus</i> L.					6.1	4.3
<i>Columba livia</i> forma <i>domestica</i> Gmelin	1.4	4.3	2.9		6.1	3.2
<i>Streptopelia decaocto</i> (Frivaldszky)		1.1	1.4		1.0	
<i>Alcedo atthis</i> (L.)					1.0	
<i>Alauda arvensis</i> (L.)		2.2	2.9		5.1	
<i>Galerida cristata</i> (L.)	1.4	8.6	5.7	1.1	5.1	5.4
<i>Anthus pratensis</i> (L.)				11.0	13.3	11.8
<i>Motacilla alba</i> L.					3.1	9.7
<i>Erithacus rubecula</i> (L.)				2.2	4.1	2.2
<i>Phoenicurus ochruros</i> Gmelin				1.1	2.0	7.5
<i>Saxicola torquata</i> L.	1.4	5.4	4.3	3.3	3.1	6.5
<i>Turdus merula</i> L.	5.5	10.8	7.1	2.2	2.0	5.4
<i>Sylvia melanocephala</i> (Gmelin)	2.7	2.2				
<i>Acrocephalus scirpaceus</i> (Hermann)	8.2					
<i>Cisticola jundicis</i> (Refinesque)	19.2	15.1	12.9	5.5	5.1	1.1
<i>Cettia cetti</i> (Temminck)	16.4	4.3	4.3	6.6	2.0	1.1
<i>Phylloscopus collybita</i> (Vieillot)				6.6	2.0	3.2
<i>Remiz pendulinus</i> (L.)				7.7		
<i>Pica pica</i> (L.)	2.7	2.2		2.2	2.0	1.1
<i>Corvus corone cornix</i> L.	5.5	9.7		4.4	3.1	4.3
<i>Sturnus vulgaris</i> L.	2.7	6.5	10.0		2.0	6.5
<i>Passer italiae</i> (Vieillot)	4.1	12.9	21.4		2.0	10.8
<i>Passer montanus</i> (L.)			2.9			4.3
<i>Carduelis carduelis</i> (L.)		2.2	8.6	1.1	3.1	1.1
<i>Carduelis chloris</i> (L.)		1.1	4.3		2.0	2.2
<i>Serinus serinus</i> (L.)		3.2	4.3		1.0	
<i>Emberiza schoeniclus</i> (L.)				9.9	4.1	
<i>Miliaria calandra</i> (L.)		7.5	5.7			
<i>n</i>	73	93	70	91	98	93

Table 2. Structural parameters of bird assemblages in breeding and wintering period and in habitat macrotypes (natural, seminatural, man-disturbed). S : total species richness; S_{mean} : mean species richness; D_{Mg} : Margalef richness index (1); H' : Shannon diversity index (2); J : evenness index (3); β : Whittaker's β -diversity index (4).

Parameter	Breeding period			Wintering period		
	Natural	Semi-natural	Man-disturbed	Natural	Semi-natural	Man-disturbed
S	16	18	16	23	31	25
S_{mean}	4.87	6.20	4.67	6.07	6.53	6.20
D_{Mg}	8.05	8.64	8.13	11.23	15.07	12.19
H'	2.47	2.61	2.52	2.89	3.15	2.92
J	0.89	0.90	0.91	0.92	0.92	0.91
β	3.29	2.90	3.43	3.79	4.74	4.03

$Z = 1.125$; semi-natural: $Z = 0.959$; natural: $Z = 0.801$; all $P > 0.05$; Kolmogorov-Smirnov test).

Both in breeding and in wintering period, the bird assemblage in semi-natural HMT showed the highest values either of the species richness or the normalized species richness (S_{mean} and D_{Mg}) if compared to the other HMTs, as soon as the higher values of Shannon diversity index. This assemblage showed the highest β -diversity (i.e. species turnover) value during the wintering period, the lowest during the breeding one (Table 2).

The range of evenness values was very narrow (0.89–0.92), with higher values in winter.

When we compared bird assemblages altogether, the dendrogram of similarity showed two groups cut off by seasons, and secondarily by HMTs. Inside each group, the assemblage of natural HMT was dissimilar in respect to others (Fig. 1).

5. DISCUSSION

In our study area, bird assemblages showed seasonal and ecological differences. The structure of assemblages varied either with the seasons and among HMTs, in both quantitative (total and normalized species richness, diversity index) and qualitative sense (species turnover, dendrogram of similarity).

In winter, all the bird assemblages were more rich and diverse, with a higher species turnover among the point counts (i.e., β -diversity > 3.50) if compared to breeding sea-

son. In the assemblage of semi-natural HMT, high values of richness (either absolute or normalized) and diversity were observed in all the seasons due to the marked variation of the ecological factors, mainly the presence of water ponds which transformed this HMT from a dry grassland (late spring-summer) to a patchiness of shallow water basins (winter). In this HMT, seasonal changes in water availability were responsible of the change in the parameters of bird assemblages. The semi-natural HMT includes pastures in phase of natural recolonization toward the *Juncetalia maritimi* formation, and shows a medium degree of man-disturbance. In breeding period, this HMT sustains a structured bird fauna linked to open and edge habitats (e.g., *Alaudidae*, *Emberizidae*, *Passeridae*) mixed to wetland-related species (e.g., *Fulica atra* Linnaeus, 1758), that could explain the significant higher values of mean species richness if compared to the assemblages of both natural and man-disturbed HMTs (characterized by less species, more stenoecious or more synanthropic, respectively).

During the breeding period, the vegetation associated to the semi-natural HMT shows a high structural homogeneity (dry pasture), which explains the low β -diversity (i.e., species turnover among point counts). In winter, the increase of water level induces structural changes in semi-natural HMT increasing the local habitat patchiness and heterogeneity (flooded patchy pasture), so increasing the β -diversity values in winter, *viz.* an indirect measure of habitat heterogeneity (Magurran 2004).

Bird community responses to land use cover along habitat gradients were widely investigated around the world (e.g., Fairbanks 2004, Chapman and Reich 2007, Lee *et al.* 2004). In both of seasons (significantly in breeding period), the higher mean species richness of the assemblage in semi-natural HMT could be explained by the intermediate level of disturbances in this environment, corroborating the IDH (see Connell 1978, Hobbs and Huenneke 1992) and the effect of stress in ecology (Barrett *et al.* 1976, Rapport *et al.* 1985). The first hypothesis predicts that diversity will be highest in communities with intermediate levels of disturbances. In this case, species richness is maximized because of the coexistence between disturbance-tolerant synanthropic species and specialized species (Collins and Glenn 1997). Despite studies on this issue were carried out especially on plants along a temporal gradient (e.g. Armesto and Pickett 1985, Connell *et al.* 1995), more recently this pattern was recognized also for animals along a spatial gradient (Petraitis *et al.* 1989). In the present study, the intermediate disturbance pattern did not emerge clearly for each season and structural parameter. Indeed, it was significantly evident only in breeding period and at mean species richness level, not at diversity level (differences not significant between HMT assemblages).

Cluster analysis (Fig. 1) highlighted the structural changes occurring in bird assemblages, *in primis*, between the two seasonal periods and, secondarily, among HMTs, suggesting the presence of basic processes responsible of intermediate disturbance pattern. The bird assemblage of natural HMT sharply differs from the other two assemblages in both seasons; on the contrary the assemblages of semi-natural and man-disturbed HTMs show a higher similarity in the breeding period, when the bird composition is more homogeneous. Vice versa, in winter, semi-natural and man-disturbed HMT assemblages are more different among them, because of the presence of water ponds which follow the seasonal flooding in semi-natural-HMT.

Understanding the role of disturbances in habitat of conservation concern has implications for ecosystem management (Steuter *et*

al. 1990). In small patchy wetlands, especially in dynamic areas subject to abrupt seasonal changes (e.g. in Mediterranean wetlands), the conservation strategy could be to maintain sectors with moderate levels of disturbance and a high habitat heterogeneity, in order to increase richness and turnover among sites. According to Brawn *et al.* (2001), conservation strategies in man-disturbed landscapes could involve the management of disturbances, either natural (in our case, flooding) or man-made (in our case, grazing), focused on maintaining a high richness of birds at the local scale.

ACKNOWLEDGEMENTS: This study has been performed within the activities of the Nature Conservation Office, Environmental Service, Province of Rome, that manages 'Torre Flavia wetland' protected area. We would like to acknowledge Francesca Causarano, Simone Ciccobelli, Adriano Mazziotta and Emanuele Rizzo for their support.

6. REFERENCES

- Armesto J.J., Pickett S.T.A. 1985 – Experiments on disturbance in old-field plant communities: impacts on species richness and abundance – *Ecology*, 66: 230–240.
- Barrett G.W., Van Dyne G.M., Odum E.P. 1976 – Stress ecology – *BioScience*, 26: 192–194.
- Battisti C. 2006 – Biodiversità, gestione, conservazione di un'area umida del litorale tirrenico [Biodiversity, management and conservation of a wetland of Tyrrhenian littoral] – Gangemi editore – Provincia di Roma, Assessorato alle politiche agricole e dell'ambiente, 496 pp.
- Battisti C., Aglitti C., Sorace A., Trotta M. 2006 – Water level and its effect on the breeding bird community in a remnant wetland in Central Italy – *Ekologia (Bratislava)*, 25: 252–263.
- Benassi G., Battisti C., Luiselli L. 2007 – Area effect on bird species richness of an archipelago of wetland fragments of Central Italy – *Comm. Ecol.* 8: 229–237.
- Bibby C.J., Burgess N.D. 1992 – *Bird Census Techniques* – Academic Press, London.
- BirdLife International 2004 – *Birds in Europe: population estimates, trends and conservation status* – BirdLife Conservation Series No.12, BirdLife International, Cambridge, U.K.

- Blasi C., Michetti L. 2005 – Biodiversità e Clima [Biodiversity and Climate] (In: Stato della biodiversità in Italia, Contributo alla strategia nazionale per la biodiversità [The biodiversity in Italy, a contribution to the national strategy of biodiversity] Eds. C. Blasi, L. Boitani, S. La Posta, F. Manes, M. Marchetti) – Ministero dell'Ambiente e della Tutela del territorio, Fratelli Palombi editori, Roma, pp. 57–66.
- Blondel J. 1975 – L'analyse des peuplements d'oiseaux, élément d'un diagnostic écologique. La méthode des Echantillonnages Fréquentiels Progressifs (E.F.P.) – *La Terre et la Vie*, 29: 533–589.
- Blondel J., Aronson J. 1999 – *Biology and wildlife of the Mediterranean Region* – Oxford University Press, Oxford.
- Blondel J., Perret P., Maistre M., Dias P.C. 1992 – Do harlequin Mediterranean environments function as source-sink for Blue-Tits (*Parus caeruleus* L.)? – *Landsc. Ecol.* 6: 213–219.
- Brawn J.D., Robinson S.K., Thompson F.R. 2001 – The role of disturbance in the ecology and conservation of birds – *Ann. Rev. Ecol. Syst.* 32: 251–276.
- Brönmark C., Hansson L.-A. 2005 – *The Biology of Lakes and Ponds*, 2nd edition – Oxford University Press, Oxford, New York, 285 pp.
- Chapman K.A., Reich P.B. 2007 – Land use and habitat gradients determine bird community diversity and abundance in suburban, rural and reserve landscapes of Minnesota, USA – *Biol. Conserv.* 135: 527–541.
- Clifford H.T., Stephenson W. 1975 – *An introduction to numerical classification* – London, Academic Press.
- Collins S.L., Glenn S.M. 1997 – Intermediate disturbance and its relationship to within- and between-patch dynamics – *New Zeal. J. Ecol.* 21: 103–110.
- Connell J.H. 1978 – Diversity in tropical rain forests and coral reefs – *Science*, 199: 1302–1310.
- Connell S.L., Glenn S.M., Gibson D.J. 1995 – Experimental analysis of intermediate disturbance and initial floristic composition: decoupling cause and effect – *Ecology*, 76: 486–492.
- Conner W.H., Day J.W. 1976 – Productivity and composition of a bald cypress-water tupelo and bottomland hardwood site in a Louisiana swamp – *Am. J. Bot.* 63: 1354–1364.
- Cowardin L.M., Carter V., Golet F.G., Laroe E.T. 1979 – Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31 – Fish and Wildlife Service, USDI, 103 pp.
- Dunning J.B., Danielson B.J., Pulliam H.R. 1992 – Ecological processes that affect populations in complex landscapes – *Oikos*, 65: 169–175.
- Fairbanks D.H.K. 2004 – Regional land-use impacts affecting avian richness patterns in Southern Africa – insights from historical avian atlas data – *Agric. Ecos. Environ.* 101: 269–288.
- Flather C.H. 1996 – Fitting species-accumulation functions and assessing regional land use impacts on avian diversity – *J. Biogeogr.* 23: 155–168.
- Hobbs R.J., Huenneke L.F. 1992 – Disturbance, diversity and invasions: implications for conservations – *Conserv. Biol.* 6: 324–337.
- Lee P.-F., Ding T.-S., Hsu F.-H., Geng S. 2004 – Breeding bird species richness in Taiwan: distribution on gradients of elevation, primary productivity and urbanization – *J. Biogeogr.* 31: 307–314.
- Lloyd M., Ghelardi R.J. 1964 – A table for calculating the equitability component of species diversity – *J. Anim. Ecol.* 33: 217–225.
- Magurran A. 1988 – *Ecological diversity and its measurements* – Princeton, N.J., Princeton University Press.
- Magurran A. 2004 – *Measuring biological diversity* – Blackwell Publishing, Malden, MA.
- Niemi G., Hanowski J., Helle P., Howe R., Mönkkönen M., Venier L., Welsh D. 1998 – Ecological sustainability of birds in boreal forests – *Conserv. Ecol.* 2: 17. Available on: <http://www.consecol.org/vol2/iss2/art17>.
- Olson D.M., Dinerstein E. 1998 – The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions – *Conserv. Biol.* 12: 502–515.
- Paracuellos M. 2006 – How can habitat selection affect the use of a wetland complex by waterbirds – *Biodiv. Conserv.* 15: 4569–4582.
- Petraltis P.S., Latham R.E., Niesenbaum R.A. 1989 – The maintenance of species diversity by disturbance – *Quart. Rev. Biol.* 64: 393–418.
- Pielou E.C. 1966 – The measurement of diversity in different types of biological collections – *J. Theor. Biol.* 13: 131–144.
- Rapport D.J., Regier H.A., Hutchinson T.C. 1985 – Ecosystem behaviour under stress – *Am. Nat.* 125: 617–640.
- Romano B. 2006 – La palude di Torre Flavia e lo scenario regionale di frammentazione e trasformazione insediativa [The wetland of Torre Flavia and the regional scenario of frag-

- mentation and urbanization](In: Biodiversità, gestione, conservazione di un'area umida del litorale tirrenico [Biodiversity, management and conservation of a wetland of Tyrrhenian littoral] Ed. C. Battisti) – Gangemi editore – Provincia di Roma, Assessorato alle politiche agricole e dell'ambiente, pp. 142–143.
- Shannon C.E., Weaver W. 1963 – Mathematical theory of communication. University of Illinois Press, Urbana, Illinois.
- Sousa W. 1984 – The role of disturbance in natural communities – *Annu. Rev. Ecol. Syst.* 15: 353–391.
- SPSS Inc, 2006 – SPSS for Windows (Version 15.0) – SPSS Inc, Chicago.
- Steuter A.A., Grygiel C.E., Biondini M.E. 1990 – A synthetic approach to research and management planning: the conceptual development and implementation – *J. Natur. Areas*, 10: 61–68.
- Thomas W.L.Jr. 1956 – Man's role in changing the face of the Earth – University of Chicago Press, Illinois.
- Tomaselli R., Balduzzi A., Filippello S. 1973 – Carta Bioclimatica d'Italia [Bioclimatic map of Italy] – Collana verde, 33. Ministero Agricoltura e Foreste, Roma.
- van der Walk A.G. 2006 – The biology of freshwater wetlands – Oxford University Press, Oxford, 173 pp.
- Whittaker R.H. 1960 – Vegetation of the Siskiyou Mountains, Oregon and California – *Ecol. Monogr.* 22: 1–44.
- Whittaker R.H. 1970 – Community and ecosystems – Macmillian, New York.

Received after revising April 2008