

BREEDING BIRDS IN AN APPENNINE MASSIF (MAJELLA, CENTRAL ITALY): DO “COMMON SPECIES” COULD ACT AS SURROGATE FOR CHARACTERIZE SPECIES RICHNESS AND COMPOSITION OF THE COMMUNITIES?

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Abstract

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Breeding bird communities were studied in eight habitat types in the Majella massif (central Italy) in two years (2007 and 2008) with two sampling methods (general survey and random point counts). At level of the general survey, our data confirm as bird communities are structured in response to vegetation structure and internal heterogeneity induced either by human activities (e.g., landscape patchiness) or natural limiting factors (e.g., linked to altitude). Richer habitat types correspond to mosaics of oak woods in both of years. In this habitat, the high level of habitat heterogeneity could increase the species richness at landscape level (i.e., γ -diversity). The low values in species richness observed in *Pinus mugo* formations and in primary pastures may be due to the altitudinal gradient of species richness (inverse correlation between altitudinal mid-point of each habitat type and number of species). Cluster analysis showed a first level of dissimilarity among faunal communities linked to the vegetation structure (forest *versus* open/shrubby habitat types), and a second one for open/shrubby habitats could be based either on spatial-heterogeneity and altitudinal effect. At level of species richness, a large proportion of the species (> 80%) has been sampled with random point count method when compared to general survey. Therefore, at species richness level, the method with lower research effort could furnish a reasonable description of the communities. At species composition level, data obtained by random sampling point count method showed different pattern between years for several habitat typology, turning out less exhaustive than general survey method. Therefore, in those habitat types a low research effort could expose the data to stochastic oscillations.

Key words: bird communities, habitat types, habitat heterogeneity, altitudinal gradient, point count method

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Introduction

In landscape mosaics, spatial heterogeneity may be observed, e.g., at level of habitat types (i.e., land use cover, plant associations) (Wiens, 1994; Forman, 1995; Tews et al., 2004). Spatial heterogeneity constitutes a driving force that explains patterns of species richness and abundance in bird communities occurring in mountainous areas of Mediterranean basin where either historical and recent anthropogenic disturbances or the articulated orography and Quaternary climatic events, contributed to structuralize complex landscape patterns (Blondel et al., 1992; Blondel, Aronson, 1999).

The level of research effort is an important constraint that influence the data obtained, especially in avian studies (Bibby et al., 1992). Among the different approach in this research, the point count method was widely used to characterize quali-quantitatively bird assemblages in terms of species richness, diversity and composition (Sutherland, 2006). A limitation of this method is that the limited research effort (from 3 to 20 min to each point count) agree to acquire biased data only related to “common species”, or species easily detectable and locally abundant (Bibby et al., 1992).

The aim of this work is to increase own knowledge on breeding avian diversity in a mountain massif of central Apennine (Majella massif), and on the differences among habitat vegetation type. Moreover, we would to compare data obtained by a qualitative general survey with data obtained by a standardized sampling effort by point count method. Our hypothesis is that species composition and richness was biased if the sampling effort is very limited and that the differences obtained could be due to an arrangement limited to “common species” when a point count method was carried out.

Material and methods

Study area

The study area includes the entire territory of the Majella National Park and the strictly neighbouring areas, occurring in three administrative provinces of the Abruzzi region (Chieti, Pescara, L'Aquila; central Italy), for a total area of 74.095 ha. The Majella massif (Abruzzi, central Italy) forms a wide, continuous and heterogeneous system of Apennine habitats primarily characterized by beech forests, primary and secondary pastures, including also extensive patches of shrubby *Pinus mugo*, a relict tree species forming an uncommon habitat at high elevations (Tammaro, Pirone, 1995). This massif represents one of the most important South Mediterranean mountain areas, due to the richness of its fauna and flora. Its geographic position (southern portion of central Apennines) and the great altitudinal gradient (ranging from about 400 to 2700 m a.s.l.) biogeographically characterize this area (e.g. Minelli et al., 2005; Stoch, 2006).

The study sites are located on the Majella and the Morrone massifs, connected by the San Leonardo pass, and on the Pizi Mts isolated from the main mountain system by a large karstic highplain area including the “Quarti” and the “Settemiglia” plains. The hydrographic system is well structured at lower elevation with two main basins: the Orta, Vella and Gizio rivers, tributaries of Pescara river on the western slope; the Aventino-Verde system, tributary of the Sangro river on the eastern slope.

At the lower elevation, thermophilic woodlands, especially dominated by *Quercus pubescens* and *Q. cerris*, are mixed to derived pastures and cultivations. The middle elevation is characterised by almost monophytic forest of *Fagus sylvatica*. The higher areas are characterised by *Pinus mugo* formations alternate to primary pastures, and by the cacuminal “highland limestone desert” (Pirone, 1995; Tammaro, Pirone, 1995).

Sampling design and data collection

In the Majella National Park, we carried out two surveys sessions in two different years: in 2007 (from 3 to 6 June) and in 2008 (from 29 May to 1 June) in the following seven habitat types with an altitudinal range from 760 to 2140 m a.s.l. with a comparable research effort (20 hours of sampling for each year for 40 hours in total) (for a further description of vegetation, see Pirone, 1995):

- *Quercus cerris* oak woods (CER): altitudinal range: 1125–1365 m a.s.l. (altitudinal mid-point: 1245 m);
- mosaics of oak woods (*Quercus cerris* and *Q. pubescens*) (MOS) with open heterogeneous habitats (cultivations, pasture lands): range: 760–1050 m a.s.l. (altitudinal mid-point: 905);
- beech forests (monophytic forest of *Fagus sylvatica*) (FAG): range: 1045–1600 m a.s.l. (altitudinal mid-point: 1322.5 m);
- derived pastures (PAS): range: 980–1365 m a.s.l. (altitudinal mid-point: 1172.5 m);
- karstic highplains (KAR): range: 1300–1305 m a.s.l. (altitudinal mid-point: 1302.5 m);
- primary pastures (PRI): range 1980–2095 m a.s.l. (altitudinal mid-point: 2037.5 m);
- *Pinus mugo* formations (MUG): 2100–2140 m a.s.l. (altitudinal mid-point: 2120 m).

During these surveys we collected any records (herding or singing bird) belonging to potentially breeding bird species in a not-standardized way, obtaining a simple cumulate measure of species richness (S) in each habitat type. This parameter corresponds, at landscape level, to a γ -diversity measure (Whittaker, 1972; Magurran, 2004).

We consider the whole of the sampled species (“typical” and “vagrants”; see Benassi et al., 2007) without an a priori selection.

To assess quantitatively the structure of breeding bird communities in the seven habitat types in a standardized way, we performed a standardized point count method (Koskimies, Väisänen, 1991; Bibby et al., 1992). This approach provides a more useful method of developing bird-habitat relationships (Morrison, 2002). In each of seven selected habitat types we randomly selected five sites where we carried out one point count each one (total: 35 point counts/year). In each point count we sampled any territorial sighting or singing individual of any bird species inside 150 m (fixed radius of detection). This method did not permit a differentiation among sex, age or fitness of individuals (see Bibby et al., 1992). Time of sampling in each point count was 5' and the total point count effort was 175 minutes/year (i.e., about 1/10 of the general survey effort). Samplings were carried out mainly in morning (from 7.00 to 12.00 a.m. in spring season). We maintained a minimum distance between points of 300 m to reduce biases due to double-counting the same individuals. To determine the location and elevation of each point we used a GPS. Because of point count method acquire bird records in a very short time (i.e., 5 minutes), obtained data are limited to “common species” (i.e., species locally more abundant, diffuse and easy detectable; Sutherland, 2006). Therefore, we did not obtain data on more rare and on less detectable species.

For each point count we obtained, the number of species (Sp); this parameter corresponds, at spatial level, to an α -diversity measure (i.e., the number of species referred to a single sampling point, Whittaker, 1972; Magurran, 2004).

- For each habitat type, at level of the whole set of point counts, we obtained the following community parameters:
- mean number of species (S_{mean}), as the ratio between the number of species recognized in five randomly selected point counts and the number of point counts (5);
 - mean abundance index (ab_{mean}), as the ratio between the sampled in five randomly selected point counts in each habitat type and the number of point counts (5).

We did not account for the different detectability of the species. Therefore we obtained only a simple index of abundance (Sutherland, 2004).

To assess the habitat heterogeneity of each habitat type, we calculated the Whittaker β -index (Whittaker, 1960), as:

$$\beta_w = S_p / S_{mean}$$

where S_p has been considered a measure of γ -diversity and S_{mean} , a measure of average α -diversity values among point counts. This index indirectly estimates an internal habitat heterogeneity assessing the species turnover among points (assuming that the more high is the species turnover, the more high is the habitat heterogeneity; Magurran, 2004).

Statistical analyses

Median values of number of species among the point counts belonging to the same habitat type were compared using non-parametric Kruskal-Wallis ANOVA. All tests were two-tailed, and alpha was set at 5%.

To classify the similarity among habitat vegetation types, either for the entire set of species sampled during the survey or the set of species sampled with random point count method, we performed a hierarchical cluster analysis on species/habitat types matrix (between-groups linkage; squared Euclidean distance) using the software SPSS version 13.0 (SPSS Inc., 2003) and Primer-Statistica software (Glantz, 1996).

Results

General survey

During the whole study period we sampled 61 breeding bird species (42 in 2007; 58 in 2008; Table 1). In both of the years, the bird community of MOS showed the higher values of species richness; in 2007 PRI and MUG showed the lower values (< 10 species; Table 1). As concerns the habitat types, the number of species resulted inversely correlated with altitudinal mid point in 2007 ($r_s = -0.991$; $p < 0.01$; Spearman rank correlation test).

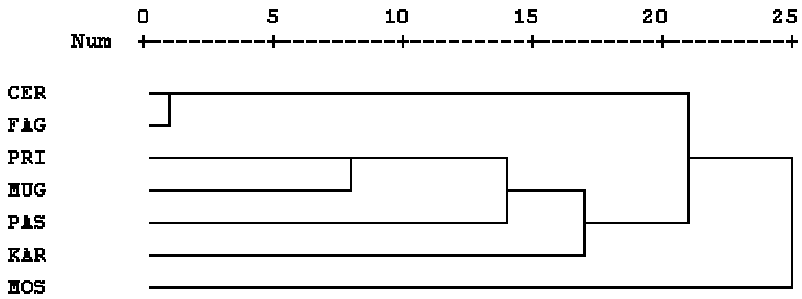
Table 1. Checklist of the breeding bird species in the Majella massif sampled during the two sampling periods (X = 2007; O = 2008; between brackets: species not sampled in five random point counts). CER: *Quercus cerris* oak woods; MOS: mosaics of oak woods (*Quercus pubescens* and *Q. cerris*); FAG: beech forests (monophytic forest of *Fagus sylvatica*); PAS: derived pastures; KAR: karstic highplains; PRI: primary pastures and cacuminal "highland limestone desert"; MUG: *Pinus mugo* formations.

Species	Habitat types						
	CER	MOS	FAG	PAS	KAR	PRI	MUG
<i>Buteo buteo</i> (Linnaeus, 1758)		X					
<i>Falco tinnunculus</i> Linnaeus, 1758						O	O
<i>Columba palumbus</i> Linnaeus, 1758	O						
<i>Coturnix coturnix</i> (Linnaeus, 1758)				X	XO		
<i>Alectoris graeca</i> Meisner 1804							O
<i>Cuculus canorus</i> Linnaeus, 1758	X	O	O				
<i>Apus apus</i> (Linnaeus, 1758)				O		X	
<i>Apus melba</i> (Linnaeus, 1758)						X	
<i>Upupa epops</i> Linnaeus, 1758				O			
<i>Picus viridis</i> Linnaeus, 1758			(O)				
<i>Picoides major</i> (Linnaeus, 1758)		O					
<i>Dendrocopos minor</i> (Linnaeus, 1758)		O					
<i>Alauda arvensis</i> Linnaeus, 1758				O	O	XO	
<i>Lullula arborea</i> (Linnaeus, 1758)		X		O			(O)
<i>Delichon urbica</i> (Linnaeus, 1758)					X		
<i>Hirundo rustica</i> Linnaeus, 1758		(X)O		(X)O	XO		
<i>Anthus trivialis</i> Linnaeus, 1758				X			O
<i>Anthus spinoletta</i> (Linnaeus, 1758)				XO		(X)	
<i>Motacilla flava</i> , Linnaeus 1758					XO		
<i>Motacilla alba</i> Linnaeus, 1758		O			XO	O	
<i>Troglodytes troglodytes</i> (Linnaeus, 1758)	XO	O	XO				(O)

Table 1. (Continued)

<i>Prunella collaris</i> Scopoli 1769							O
<i>Prunella modularis</i> (Linnaeus, 1758)							XO
<i>Erithacus rubecula</i> (Linnaeus, 1758)	XO	(X)O	XO				O
<i>Luscinia megarhynchos</i> Brehm, 1831		X(O)					O
<i>Phoenicurus phoenicurus</i> (Linnaeus, 1758)		O					
<i>Phoenicurus ochruros</i> Gmelin, 1789		(O)					
<i>Saxicola rubetra</i> Linnaeus, 1758		O					O (X)
<i>Saxicola torquata</i> Linnaeus, 1758		(O)					(X)O O
<i>Oenanthe oenanthe</i> Linnaeus, 1758		X					(O) XO
<i>Turdus merula</i> Linnaeus, 1758	XO	(X)O	XO	X			X O
<i>Turdus viscivorus</i> Linnaeus, 1758			(O)				
<i>Sylvia cantillans</i> Pallas, 1784		X					O
<i>Sylvia atricapilla</i> Linnaeus, 1758	XO	XO	XO	XO	X		
<i>Sylvia communis</i> Latham, 1787		X(O)					
<i>Hippolais polyglotta</i> (Vieillot, 1817)		XO					
<i>Phylloscopus sibilatrix</i> Bechstein, 1793			(O)				
<i>Phylloscopus collybita</i> Vieillot, 1817	XO	XO	O				(X)O
<i>Regulus ignicapillus</i> Temminck, 1820	(X)O						
<i>Aegithalos caudatus</i> Linnaeus, 1758		O					
<i>Parus palustris</i> Linnaeus, 1758	X	(X)	XO				
<i>Parus ater</i> Linnaeus, 1758	X	(X)O	(X)O				
<i>Parus caeruleus</i> Linnaeus, 1758	X	X(O)	(X)O				
<i>Parus major</i> Linnaeus, 1758	X	XO		XO			
<i>Sitta europaea</i> Linnaeus, 1758	XO		X				
<i>Certhia brachydactyla</i> Brehm, 1820	O						
<i>Lanius collurio</i> Linnaeus, 1758		O		XO			
<i>Garrulus glandarius</i> Linnaeus, 1758		(O)					
<i>Pyrrhonorax pyrrhonorax</i> (Linnaeus, 1758)					X	XO	(O)
<i>Corvus corone</i> Linnaeus, 1758		(X)(O)	O	O	XO	(X)	
<i>Pica pica</i> (Linnaeus, 1758)		(O)					
<i>Passer italiae</i> (Vieillot, 1817)		(O)			O		
<i>Fringilla coelebs</i> Linnaeus, 1758	XO	XO	XO	(X)	O		O
<i>Serinus serinus</i> (Linnaeus, 1766)		O					
<i>Carduelis chloris</i> (Linnaeus, 1758)		O		XO			
<i>Carduelis carduelis</i> (Linnaeus, 1758)		X(O)					
<i>Carduelis cannabina</i> (Linnaeus, 1758)		X		O	X	XO	XO
<i>Pyrrhula pyrrhula</i> (Linnaeus, 1758)			X(O)				O
<i>Emberiza cirlus</i> Linnaeus, 1758		XO		XO			
<i>Calandrella brachydactyla</i> Leisler, 1814					O		
<i>Miliaria calandra</i> (Linnaeus, 1758)		XO		XO	XO		
Number of species 2007	13	22	10	13	11	9	3
Number of species 2008	10	32	15	20	11	6	13

(a) 2007



(b) 2008

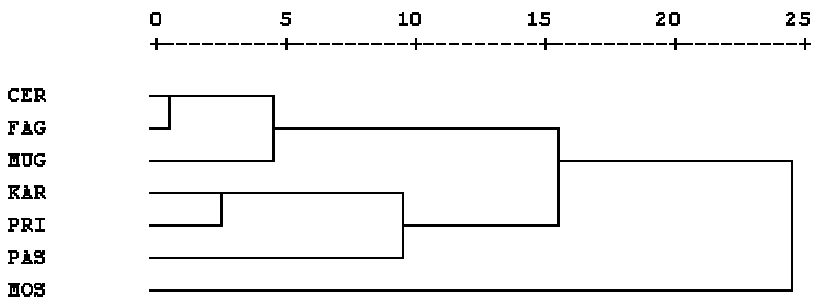


Fig. 1. Hierarchical cluster analysis on species/habitat types matrix (general survey) in 2007 (a) and 2008 (b). See Methods for abbreviations.

The cluster analysis performed on the bird species/habitat type matrix, showed in both of the years a first cluster, which includes the “forest habitats” (CER and FAG), a second one composed by the “pastures-shrubby” group. A third habitat type (MOS) showed a high (> 20%) dissimilarity from the others (Fig. 1 a, b).

Point counts

We obtained 197 records belonging to 38 species in 2007 (corresponding to the 90.5% of the number of species sampled during the general survey) and 271 records belonging to 51 species in 2008 (87.9%).

Table 2. Community parameters in the selected habitat types in the Majella Massif from the set of five random point counts.

	CER	MOS	FAG	PAS	KAR	PRI	MUG	
2007	S_p (S)	13 (13)	15 (22)	9 (10)	10 (13)	10 (11)	6 (9)	3 (3)
	S_{mean} (s.d.)	6.6 (1.82)	3.8 (2.49)	4 (2.00)	3 (2.55)	3.8 (1.30)	3 (0.71)	1.4 (0.55)
	ab_{mean} (s.d.)	9.4 (3.05)	6.6 (4.34)	4.2 (1.64)	4.2 (4.09)	5.4 (1.14)	7.4 (3.21)	2.2 (0.84)
	β_w	1.97	3.95	2.25	3.33	2.63	2.00	2.14
	n	47	33	21	21	27	37	11
2008	S_p (S)	10 (10)	21 (32)	11 (15)	18 (20)	11 (11)	6 (9)	10 (13)
	S_{mean} (s.d.)	7 (1.22)	8 (2.74)	5.2 (2.28)	4.4 (1.34)	5 (2.00)	3 (0)	3.8 (2.59)
	ab_{mean} (s.d.)	9.4 (2.07)	11.8 (4.82)	7.6 (3.21)	7.2 (1.92)	7 (2.12)	6.2 (1.10)	5 (3.54)
	β_w	1.43	2.63	2.12	4.09	2.20	2.00	2.63
	n	47	59	38	36	35	31	25

Notes: S_p – number of species (between brackets, the cumulate number of species by general survey, S); S_{mean} – number of species (and standard deviation); ab_{mean} – abundance index (and standard deviation); β_w – Whittaker's β index; n – number of sampling records.

For habitat type abbreviations, see caption in Table 1.

We obtained the higher values (> 6) of mean number of species in CER (2007) and in CER and MOS (2008); the lower values (≤ 3) in PAS, PRI, MUG (2007) and in PRI (2008) (Table 2). We obtained the higher values (> 9) of mean abundance index in CER (2007) and in CER and MOS (2008); the lower values (≤ 5) in FAG, PAS, MUG (2007) and in MUG (2008) (Table 2).

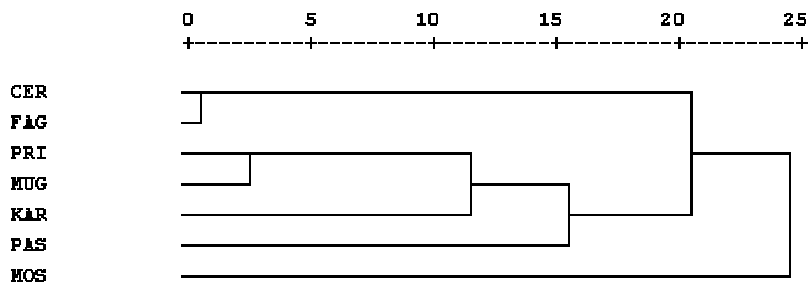
In both of the years, mean number of species and mean abundance index resulted significantly different among habitat types (2007: respectively, $H = 15.583$; $P < 0.01$ and $H = 15.321$; $P < 0.01$; 2008: respectively, $H = 16.705$; $P < 0.01$ and $H = 13.104$; $P < 0.05$; d.f. = 7; Kruskal Wallis ANOVA).

Among habitat types, the number of species in point counts resulted inversely correlated with altitudinal mid point in both of the years (2007: $r_s = -0.937$; $P < 0.01$; 2008: $r_s = -0.782$; $P < 0.05$; Spearman rank correlation test).

As concerns the application of β -Whittaker index, the higher values (> 3) were observed in MOS and PAS (2007) and in PAS (2008); the lower values (< 2) in CER (both of years).

Analogously to the data obtained for the general survey, the cluster analysis performed on the bird species/habitat type matrix obtained by the random selected point counts, showed the same cluster, composed of the "forest habitats" (CER and FAG) consistent for both the study years. Data were not similar between years as concerns the other habitat types. We observed MOS in 2007 and PAS in 2008 very dissimilar from other habitat type (Fig. 2a, b).

(a) 2007



(b) 2008

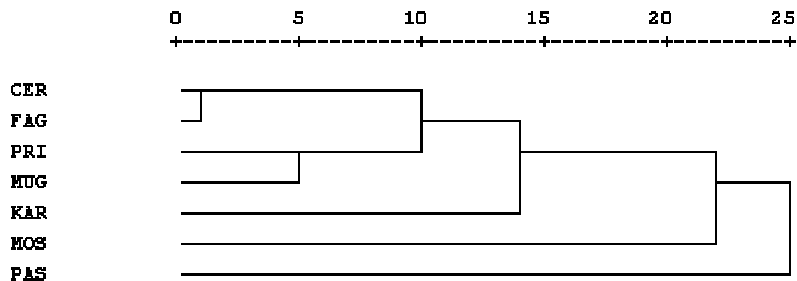


Fig. 2. Hierarchical cluster analysis on species/habitat types matrix (point count method) in 2007 (a) and 2008 (b). See Methods for abbreviations.

Discussion

The knowledge on this Apennine massif is scattered in the literature or focused on the biology of single species (e.g. Di Carlo, Heinze, 1975, 1978a, b, c; 1979a, b; Heinze, 1983; Brichetti, 1987; Penteriani, Pinchera, 1990; Penteriani, 1991; Manzi, Pellegrini, 1992; Febbo, Pellegrini, 1994; Buscemi et al., 1996; Santoleri, Pellegrini, 1997; Ricci et al., 2003). Moreover, data on similarity of bird communities among habitat types or studies on the influence of habitat types on species richness are lacking.

At the level of the general survey, our data support the widely known hypothesis that the bird communities are structured in response to vegetation and environmental constraints such as altitude, vegetation structure and internal heterogeneity (MacArthur, MacArthur, 1961; Wiens, 1976, 1989).

The richest habitat types corresponded to MOS in both of the years. For this habitat type, the high level of habitat heterogeneity in the oak wood mosaics could increase the species richness at landscape level (i.e., the γ -diversity; Whittaker, 1972; Wiens, 1976, 1989). As concerns the natural limiting constraints, the low values in species richness observed in *Pinus mugo* formations and PRI may be due to the altitudinal gradient of species richness (Kikkawa, Williams, 1977; Whittaker, 1977; Schwartz, 1988; Vargas et al., 1998): indeed, these habitat types are widespread prevalently at altitude > 1900 m a.s.l. Where vegetation is simplified with almost absent stratification. Moreover, an evident inverse relationship appears in both years when we compared the number of species (point counts) and altitudinal mid-point of each habitat type. A similar gradient has been reported also for bird communities in another sector of central Apennines (Vuerich et al., 2006), where climatic stress and changes in availability of ecological resources along an altitudinal gradient could explain this pattern (see also Lee, 1980; Vargas et al., 1998).

The cluster analysis showed a first clear level of dissimilarity among bird communities (nearly 100%) linked to the vegetation structure (forest versus open/shrubby habitat types). A second level of dissimilarity for open/shrubby habitats could be based either on spatial-heterogeneity or altitudinal effect. In Majella mountains, oak wood mosaics and karstic highplains showed a high heterogeneity at landscape level due respectively to the patchy distribution of single vegetation components and to the transitional position surrounded by beech forest. Oak wood mosaics host a complex bird assemblages composed by species belonging to open and shrubby habitats (e.g. *Alauda arvensis*, *Lullula arborea*), edge fine-grained habitats (e.g. *Upupa epops*, *Saxicola torquata*), and forest habitats (e.g. Paridae, *Garrulus glandarius*). Karstic highplains were sited to an intermediate elevation in respect to forest habitat types and pastures and host mixed communities with specialists, as *Coturnix coturnix*, *Motacilla flava*, *Lanius collurio*, and forest-edge species occurring in surrounding beech forests, as *Cuculus canorus*. Inside the open/shrubby habitat groups, differences are mainly due to the altitudinal effect. Indeed, “pastures” includes derived pastures and xeric derived pastures, spread within the 1000–1400 m a.s.l. altitudinal range, whereas “high mountain habitats” includes primary pastures and *Pinus mugo* formations that spread at altitude higher than 1900 m a.s.l.

The differences among habitat types have been emphasized by random sampling with point count method. This method highlights the structural differences among habitats at level of α -diversity. CER and MOS appear the habitat types with higher mean species richness (a measure of α -diversity) and abundance. The oak woods, showing the higher values of the community parameters, were characterized by a high level of vegetation stratification while derived pastures are structurally simplified (lower values). As pointed out before, the increase of structural complexity of the vegetation may induce a higher availability of resources and niches, increasing the number of individuals (i.e. total abundance) and the species richness at γ -diversity level (MacArthur, MacArthur, 1961; Whittaker, 1972, 1977; Wiens, 1976, 1989; Tews et al., 2004). The complex structure of CER and MOS habitats, either spatial or vertical (foliage height diversity), may explain these data, confirming at quantitative level the data those obtained by general survey at level of species richness.

Beta-diversity values evidence the species turnover among point counts and, therefore, the internal habitat heterogeneity of each habitat type (Magurran, 2004). In 2007, MOS and PAS showed the higher β -diversity values, while CER showed the lower (but a high α -diversity values). In 2007, PAS, MOS and MUG showed the higher β -diversity, while CER showed the lower. Therefore, data are consistent in both of the year as concerns the oak wood habitat type, characterized by a low spatial heterogeneity, and to the mosaic and pasture habitat types, characterized by a high spatial diversity. Data appear not exhaustive for the *Pinus mugo* formations, where the level of spatial heterogeneity changes between years, perhaps because of the low research effort and stochasticity in sampling.

At level of species richness, a large proportion of the species (> 80%) has been sampled with random point count method when compared to general survey. Therefore, if at the species richness level point count method with a low research effort could furnish a preliminary arrangement, at the level of species composition, data obtained by random sampling with point count show an unstable pattern of similarity between years that appear different when compared to the pattern obtained by general survey. Only the dissimilarity between forest habitat types and “pastures-shrubby” group has been confirmed. Presumably, inside the “pastures-shrubby” habitat types, the higher β -diversity induces a higher turnover among sites (i.e., point counts), either spatial either temporal, also because of vagrants and rare species. Therefore, in these habitat types a low research effort could expose the data to stochastic oscillations.

Point count sampling has been indicated as a powerful method in stable environments with many “common species”, early detectable in a limited time (Bibby et al., 1992; Sutherland, 2006). Our data confirm as the point count method could be useful to obtain a value of species richness corresponding to a high percentage of cumulative γ -diversity values for each habitat type (i.e., the number of species obtained by general survey) with a very low research effort (about 1/10 of the general survey effort). Nevertheless, in respect to the level of species composition, the point count method with a low research effort is weak, especially when utilized in poor habitat types where vagrants and rare species could induce stochastic changes in species richness and composition. These changes could explain the pattern of similarities differing between years.

The high altitudinal range and patchiness in the Majella massif (from about 400 to 2700 m a.s.l.) constitute an interesting study area for further deepening investigations: i) the effects of altitudinal gradient and heterogeneity at spatial level on the bird community structure, and ii) the ecology of single species of biogeographic concern focussed on populations occurring in cacuminal habitats and *Pinus mugo* formations. Therefore, further research should be focussed on differences among habitat types considering also the role of rare and less detectable species.

Translated by the authors

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