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20-year changes in the distribution patterns of Italian breeding birds

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Abstract – Due to the lack, in Italy, of old and continuous breeding bird monitoring schemes, it is very difficult to identify, in a objective way, changes occurred in the population size and distribution of bird species. In this paper the authors present the results of the comparison between data gathered through the first four years of MITO2000 project (2000-2003) and the Italian Breeding Bird Atlas (1983-86). The main problem has been, starting from two different sampling methodologies, to obtain comparable data. These strong differences make possible comparisons about changes in distribution patterns only. Starting from the 103 MITO2000 target species, a significant distribution change was found for seven species: in particular, four species showed a clear southward range contraction: Hoopoe, Wryneck, Woodchat Shrike, and Corn Bunting; two species have expanded southwards: Woodpigeon and Collared Dove; whereas the significant change in Linnet distribution seems less clear. These results agree well with known general European processes, like the biodiversity loss within farmland and the increase in woodland surface.

INTRODUCTION

In the last 50 years Italian landscapes, like other Mediterranean countries, have undergone big modifications, essentially linked with the improvement of socio-economical conditions. These processes have determined a significant shift in the distribution of people and resources, with an almost overall modification of the traditional land-use activities, and therefore of landscape that these activities had contributed to generate (Rombai 2002).

A 40-year comparison, made at the Italian national level (Falcucci *et al*. 2007), among three different land-use maps (1960, 1990 and 2000), has registered a sharp increase both in forested areas, especially on mountains and hilly landscapes, and in urban settlements, above all along the coastline; contemporarily a significant reduction in pastures and extensive agricultural landscapes was recorded, with a concentration of intensive farmland in lowlands. The effects that these widespread changes have produced, and are still producing on biodiversity are enormous, even if not always negative. The recovery of forested areas, coupled with an increased number of protected areas, has determined the recovery, both in population size and distribution, of several species, especially among mammals (Boitani *et al.* 2003), but also in birds (Laiolo *et al*., 2004, Tellini Florenzano *et al*. 2004).

Nevertheless, most of the Mediterranean species, especially among plants, birds and invertebrates, due to the ancient co-evolution with human activities and man-made landscapes (Blondel and Aronson 1999), seem to have been negatively affected by these modifications. According to a trend that can be generalised to the whole Mediterranean basin (Preiss *et al.* 1997, Estrada *et al.* 2004, Burfield and Van Bommel 2004, Suárez and Santos 2005), the significant reduction in extensive farmland, pastures and high diversity agricultural landscapes have produced a decrease, or even the disappearance, of many bird species (Baccetti and Meschini 1986, Farina 1991, Lo Valvo *et al.* 1993, Tellini Florenzano 2001).

Within such a situation of continuously occurring changes, monitoring projects, carried on at broad scale and at continuous and regular time-intervals, seem to be essential to assess actual variations in both species geographical distribution and population size, and an indispensable support to correctly set priorities in biodiversity conservation (Gregory *et al.* 2005).

The need of carrying on monitoring projects seems to be, nowadays, even more important, due to the evidence of global climate changes. Birds are, probably, the animal group where possible effects of climate change have been better studied (Moller *et al*. 2004, Robinson *et al*. 2005); we know, for instance, that during the last decades, some species have suffered modifications in their geographical distribution, linked with the registered increase in average temperatures (Thomas and Lennon 1999, Crick 2004). Many other species have shown changes in their migratory behaviour, becoming resident also in the northern parts of their range (Terrill and Berthold 1990, Berthold 1993), or modifying their phenology (Parmesan and Yohe 2003, Root *et al*. 2003). Although we do not completely know what are the real effects that these changes might have on these populations (Sparks and Mason 2004, Robinson *et al*. 2005), it is clear that there is a need to investigate more in this field (Crick 2004).

In spite of the recent development of bird-monitoring projects by many European countries (Van Strien *et al*. 2001), there are still important differences among countries. In some of them, in particular in the Mediterranean region, data are available only for small areas and are nearly always related to short time-periods (Santos 2000; Tellini Florenzano 2004). Such data-sets are therefore unable to objectively evaluate the possible changes in species distribution patterns. In Italy, for example, the bird monitoring national scheme (MITO2000; cfr. Fornasari *et al*. 2004), has started only since year 2000, being therefore of no use to detect possible modifications started some decades ago. The only national data-set potentially available for comparison with present data, is that of Italian Atlas of Breeding Birds (PAI), carried on during the 1983-1986 period (Meschini and Frugis 1993). In this paper we present the results of a comparison between the above-listed two projects.

STUDY AREA AND METHODS

The main problem we are facing with when comparing two data-sets, is to make sure that data are comparable without bias. In our case, unfortunately, the two projects followed very different methodologies. In the PAI project, observers were left free to gather as much data as possible, moving freely within the sample areas, 20 km-side grid-units (Meschini and Frugis 1993). The only available data are, at present, the species lists for each grid-unit, with no information about neither the species abundance nor the sampling effort.

On the other hand, the MITO2000 project followed a 10-min point-count census methodology, with a 1-km accuracy in the localization of sampling sites (cfr. Fornasari *et al*. 2004). The native database of this project contains basic bird information (in terms of counted individuals) at this geographical level.

These strong differences between the two projects lead us to consider only the possibility to compare distribution patterns of species, being obviously impossible any quantitative approach. To obtain reliable data-sets for such a comparison, first of all we have chosen as reference grid the PAI 20 km units, referring therefore also MITO2000 points to these geographical units. We have thus obtained, for each sampled grid-unit, 1983-86 and 2000-2003 species lists. A direct comparison of these would be strongly biased, owing to the above-listed sampling differences. Nevertheless, we think that reliable distribution-pattern comparisons can be done if, within each project, we can obtain an estimate of the level of sampling coverage, allowing in turn to select only those grids having a 'ordinary' coverage-level for both projects. We call 'ordinary' coverage-level that one that allows to reach, within each project, comparable species richness values among different grid-units. These richness values are not directly comparable between projects, but the species' distribution patterns of occupied grid-units seem to be comparable, at least for those bird species not restricted to very scattered habitats and/or having clumpy distributions (cfr. Lack 1986).

To define 'ordinary' coverage within PAI project we were forced to use an indirect approach, due to the lack of information about the sampling effort. It is known (Battisti and Contoli 1995, 1999) that bird-species richness tend to decrease along the peninsular axis of Italy. This general pattern depends on biogeographical factors, although it is partly masked by local environmental conditions (Battisti and Testi 2001). It is therefore necessary to take into account both biogeographic and environmental factors to model species richness across Italian peninsula. Starting from these assumptions, we have built a GLM model (Poisson error distribution, log link-function, see Rushton *et al*. 2004) for species-richness per grid-unit, considering only those squares with at least 50% mainland (see Evans and Gaston 2005), and limiting the species list to the 103 ones considered sufficiently 'common' and 'widespread' to be reliably monitored by MITO2000 project (Fornasari *et al.* 2004). The model was built selecting among both biogeographical (peninsular gradient along Italy, cfr. Fig. 1; dummy variables for Sicily and Sardinia) and environmental (altitudinal range, no. of Corine land-cover III level categories and Shannon index computed on them) variables. Variable selection was made via the Akaike Information Criterion (McQuarrie and Tsai 1998), then checking selected variables for the significance of their marginal contribution ($P<0.05$). 'Ordinary' grid-units were then select-

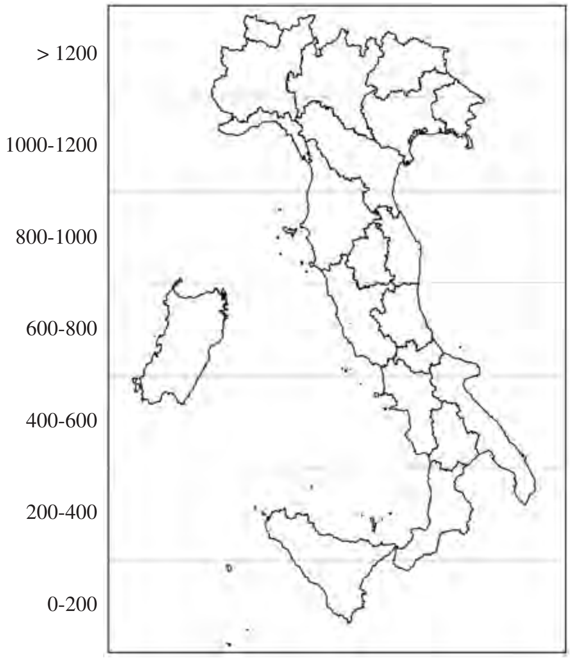

Figure 1. Distribution of the seven peninsular-axis 200 km-wide belts (obtained from a rotation of Italian map) considered in the analysis.

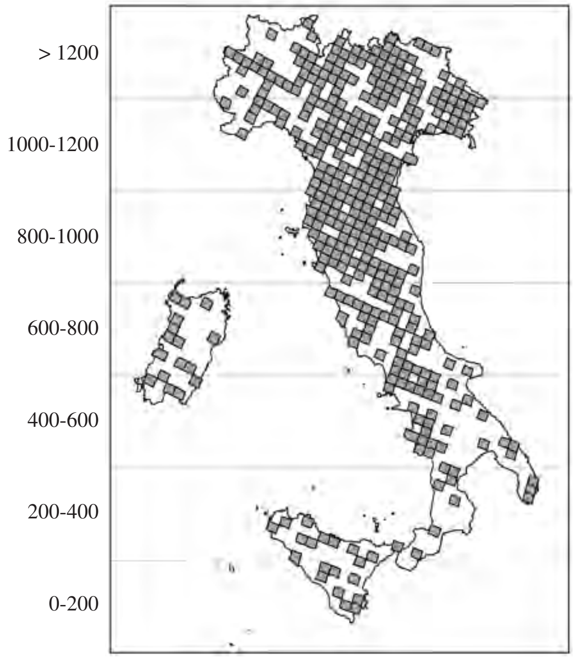

Figure 2. Distribution of the 388 comparable PAI grid-units resulting from the cross-selection of 'ordinarily' covered units.

ed excluding outliers, following the empirical threshold of ± 3 studentized deviance value (see e.g. Montgomery *et al.* 2001).

A similar procedure has been developed for the MITO2000 data, but in this case we were able to select the PAI grids according to sampling-effort. After checking for the accumulation curve built with increasing numbers of points, we selected the value of 25 points/grid-unit. At this value, at least the 50% of the species is found, and an enough number of grid-units is available for comparison. In those grid-units where more than 25 points were available, only 25 out of them were randomly chosen for analysis. At this point, we have followed the same procedure described for PAI data (GLM and then outlier exclusion) to obtain the list of 'ordinarily' covered MITO2000 grid-units.

After these analyses, we have considered for reliable comparison only those PAI grid-units that resulted 'ordinary' for both projects. To test the differences in the species distribution patterns between the two projects, owing to the particular shape of Italy, we have compared species along a single dimension, the peninsular axis, obtained from a rotation of the Italian map (see Fig. 1). The differences between distribution patterns were tested by means of a non-parametric test, the two-sample Kolmogorov-Smirnov one (see e.g. Siegel and Castellan 1988).

RESULTS

The two species richness models, built to evaluate the 'ordinary' coverage within each project, resulted very similar, with four variables entered each. Three out of them were the same: peninsular gradient, altitudinal range, and Sicily. Both models were completed with an environmental diversity measure: for the PAI, the number of land-cover categories, while for the MITO2000 the Shannon index. Starting from the complete grid-units set, it was possible to retain 388 grid-units (out of 991), that can be considered 'ordinarily' covered by both projects (Fig. 2). As we can see from the picture there is an evident discrepancy in the overall coverage between different parts of the country. Considering the original 103 comparable species, the Kolmorov-Smirnov test stressed significant differences only for seven of them (Tab. 1). Four species (Hoopoe *Upupa epops*, Wryneck *Jynx torquilla*, Woodchat Shrike *Lanius senator*, Corn Bunting *Emberiza calandra*) show a clear southwards range contraction and/or shift (these two options are impossible to distinguish with our data). In particular, the two northern belts of the peninsular gradient (roughly coincident with the Po basin) seem to have suffered the most important declines for these species. On the contrary, two species (Woodpigeon *Columba palumbus* and Collared Dove *Streptopelia decaocto*), seem to have

Table 1. Differences registered between the two data-sets for the seven species whose distributional pattern has significantly changed; for each species is indicated the total number of presence grids and, for each peninsular axis-belt (Fig. 1), the percentage of presence grid-units. In the last row is given the p value (K-S test). Woop, Woodpigeon; CollDov, Collared Dove; Hoop, Hoopoe; Wryn, Wryneck; WooShr, Woodchat Shrike; Lin, Linnet; CorBun, Corn Bunting.

Peninsular	**Woop**		**CollDov**		**Hoop**		**Wryn**		**WooShr**		**Lin**		**CorBun**	
	PAI	MITO	PAI	MITO	PAI	MITO	PAI	MITO	PAI	MITO	PAI	MITO	PAI	MITO
belt (km)	253	237	198	230	339	201	327	157	189	59	256	156	312	227
> 1200	39.1	30.0	43.4	29.6	30.7	8.5	33.3	22.9	12.7	0.0	29.7	19.2	19.9	9.3
1000-1200	17.4	15.2	35.9	33.0	23.9	20.9	26.3	28.7	20.1	5.1	15.2	10.9	25.3	21.6
800-1000	17.0	23.6	13.1	19.6	20.1	33.3	20.8	22.3	23.3	22.0	18.0	21.8	20.8	30.0
600-800	13.8	14.8	5.6	11.7	14.5	21.4	13.5	17.2	20.1	33.9	18.0	26.3	17.9	21.1
400-600	5.1	7.2	2.0	4.3	5.6	8.0	3.4	3.2	12.2	20.3	9.4	9.0	8.3	8.8
200-400	5.5	6.8	0.0	1.7	3.5	5.5	2.8	3.8	8.5	13.6	7.4	10.3	5.8	7.0
0-200	2.0	2.5	0.0	0.0	1.8	2.5	0.0	1.9	3.2	5.1	2.3	2.6	1.9	2.2
p	**.025**		**.005**		**.001**		**.01**		**.001**		**.025**		**.005**	

expanded southwards. The last one, the Linnet *Carduelis cannabina*, shows a less clear pattern, although a tendency to be more frequent in the central part of Italy seems clear.

DISCUSSION

The use of the richness models, and the subsequent rejection of outliers, can be considered a good approach to identify grid-units with a comparable ('ordinary') coverage level within each data-set. Considering which variables were selected in the models, it seems that all of them have a simple ecological or biogeographical explanation. Direct (e.g. Shannon index) or indirect (altitudinal range) measures of habitat biodiversity, as well as geographical axes are in fact of general use in the study of regional patterns of species richness (e.g. Balmford *et al.* 2001, Araujo 2003). The effect of the Sicily dummy variable is readily explained owing to the particular geographic position and history of this island (Lo Valvo *et al.* 1993).

Examining one by one the seven species showing distributional change, we can say that two of them, the Woodpigeon and the Collared Dove, show a clear southwards expansion of their geographical distribution. These phenomena are well known, at least at the local scale (e.g. Tellini Florenzano 2004). The Woodpigeon is now expanding to areas (e.g. Central Italy) where its past ecologically inexplicable absence seemed linked mainly to direct human persecution (Illner *et al.* 1992), though this species is also positively influenced by the widespread increase of woodland (Falcucci *et al.* 2007). The Collared Dove is still conquering the south of Italy; continuing a colonization that has begun several decades ago (Brichetti *et al.* 1986), also favoured, among other factors, by the spread of human settlements.

The Hoopoe, Wryneck, Woodchat Shrike and Corn Bunting, by contrast, have experienced, and are still experiencing, a clear negative trend in the continental part of Italy, above all in the Po basin lowlands, as shown by several local studies (Quadrelli 1984, Groppali 1999, Allegri 2000, Ferlini 2005). With the exception of the Corn Bunting, the other three species are linked with the presence of orchards and hedgerows, habitats that have almost disappeared, owing to the homogenisation of the lowland agricultural landscape, or are intensively managed, becoming more and more unsuitable for many bird species (Genghini 2004). Taking into account the last species, the Linnet, we can suppose that its distributional change could be linked with a decrease in the suitable habitat in the northern Italy, coupled with an increase in the central and southern parts, where the recent abandonment of agriculture has determined an increase in fallow land and in shrubs, habitats particularly suitable for this species.

For what is related to climate change, we were not able to detected any effect; no species in fact, shows northwards shifts in its geographical range. It has to be again considered, however, that our comparisons are severely constrained by huge differences in data-sampling, allowing to detect only a little part of the actually occurred changes in bird distributions. Probably, owing to the dramatic environmental changes occurred in Italy in the past 50 years (Falcucci *et al*. 2007), our evidence is only the top of the iceberg. Nevertheless, the detected changes seem to agree well with some of the most important known habitat changes, and make us possible to identify, by means of bird distribution trends, at least three main large-scale habitat changes occurred in the past 20 years: the widespread intensification and banalization of agricultural landscapes in the Po-basin lowlands, the spread of human settlements, and the increase of woodland and shrubs in peninsular Italy.

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