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Choosing a totally repeated or partially-repeated sampling strategy to assess both population changes and distribution: the case of Italian breeding birds

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Abstract – We tested how well different point-count sampling strategies can be used both as measures of species' population indices and as a source of distribution information. Four sampling strategies were compared using Italian monitoring data (MITO2000). The strategies differed in terms of the number of random and repeated point-counts. To test the efficiency of each strategy as a population index, the population indices per grid-unit were compared between-years (2000 vs 2001) with Spearman correlation and Syrjala test; to assess data usefulness for chorological purposes, the no. of species significantly detected was assessed for each strategy. Strategies involving both repeated and non repeated counts seem to give a useful compromise to gather both population and distributional data, though it would be better, at least in terms of cost, to plan different programmes for these two important attributes of the avifauna.

INTRODUCTION

Bird monitoring programmes are generally planned for the assessment of population dynamics of species through time and space (e.g. Sauer and Droege 1990, Koskimies and Vaisanen 1991). The results of these surveys allow to detect large-scale (e.g. national) population trends (e.g. Crick *et al.* 1998, Zbinden *et al.* 2005), a basic tool for biodiversity assessment (Gregory 2006, Pereira and Cooper 2006), and planning correctly informed conservation measures (Greenwood *et al.* 1995, Rich *et al.* 2004). Coordinated projects like these need the involvement of a lot of participants and are highly cost-demanding. For such reasons it is of paramount importance to carefully plan the survey methods, aiming at the optimization of sampling and data-processing efforts (Thompson *et al.* 1998, McDonald 2003, Kéry and Schmid 2004).

One of the features that would be taken into account regards the production of a series of by-products of the survey itself. Bird monitoring data can be used not only for detecting national population indices and trends, but can be processed in various ways to obtain other important information, regarding e.g. natural history traits of species (Freeman and Crick 2003, Jiguet *et al.* 2006), habitat selection (Gregory and Baillie 1998), community ecology (Howe *et al.* 1995, Devictor and Jiguet 2007), site- and/or habitat-specific population trends (Reif *et al.* 2007). The achievement of such by-products permits to greatly increase the value of the monitoring programme itself, and, in some instances, is the sole way to match the requirements of the subjects involved in the monitoring scheme (researchers, observers, land managers and planners, public administrators, see Pereira and Cooper 2006).

Among the above-defined by-products of a bird monitoring programme, one of the most obvious, linked with the availability of geographical details about data (highly improved in recent years thanks to instruments like the GPS, Farina 1997, Dale *et al.* 2005), concerns the availability of distributional data, that can be used to define ranges at several (Price *et al.* 1995, Schmid *et al.* 1998) scale levels (Villard and Maurer 1996). In spite of this, being monitoring programmes not planned for a complete coverage of the study area, such geographical data are frequently incomplete, in particular for nocturnal, rare and localized species, and for those species having breeding seasons (and related activities like song and displaying) not matching the standard sampling periods, species-which need specific monitoring methods (see e.g. Gilbert *et al.* 1998) In particular, a group of species seems to occupy a sort of "borderline", being too common and widespread to deserve specific monitoring efforts and, on the other hand, too rare to be sufficiently detected by standard bird-monitoring (e.g. Marchant *et al.* 1990).

In Italy, the most recent chorological work about breeding birds is the National Atlas, dating 1983-1986 (Meschini and Frugis 1993), and no updating is planned. On the other hand, MITO2000, the Italian Bird Monitoring Scheme, was started in 2000 (Fornasari *et al.* 2003), collecting point-count data from the whole country, and is still running as a standard monitoring project.

In this paper, starting from actual data collected during the two first years of MITO2000, we test the efficiency of different point-count sampling strategies to obtain species' population trend and distribution information.

METHODS

Field survey

The field survey consists in a simplified version of the point count method (Blondel *et al.* 1981, Bibby *et al.* 2000). Here we give only a brief description of the Mito2000 sampling scheme, more details are given elsewhere (Fornasari *et al.* 2002, 2003, 2004). The bulk of the program consisted in 10 minutes, single visit point-count stations (Massa *et al.* 1987, Ralph *et al.* 1995) scattered through the whole country (301,000 km^2) according to a hierarchical two-stage sampling design based firstly on the 50 x 50 km UTM grid. In each of the 181 50 x 50 km units, four 10 x 10 km secondary units (out of 25) were randomly selected, fewer when the larger unit was not totally occupied by Italian land. Within each secondary unit, 15 randomly selected 1 x 1 km squares are planned, where perform as close as possible to the centre a point count; a substitution procedure was used when the square originally selected proved unreachable, but not for those not occupied by Italian land (Fornasari *et al.* 2002). In the second year survey, the repetition of one out of the four selected secondary units was planned, together with three new secondary units.

As a whole, this strategy tries either to achieve good population indices for monitoring purposes, and to reach, at least for widespread species, a reliable geographic knowledge, trying to update the Italian national Atlas, whose field work is more than 20-years old (1982-1986; Meschini and Frugis 1993).

The species which are mostly non-breeding during the survey in the study area (*Egretta garzetta*, *Ardea cinerea*, *Circus aeruginosus*, *Larus ridibundus*, *Larus michahellis*), were excluded from all calculations.

Selection of the data sub-sets and species-sets for comparisons

Starting from the actual data gathered during the first two survey years (2000-2001 breeding seasons), and considering the 50 km UTM grid as a basis, we have compared (between years), four subsets of the available database, that correspond to four actually feasible sampling strategies:

I grid-units with at least 10 points for each sampling year, either with repeated or not repeated points (N = 4772 points; grid-units = 121). This subset corresponds completely with the entire available database;

II grid-units with at least 10 points, without repeated points (N = 1702; grid-units = 53). This subset identifies a strategy aiming at mostly obtain a good geographical coverage;

III grid-units with at least 10 repeated points in the two years (N = 3071; grid-units = 68). This set corresponds to a "better" compromise between obtaining either monitoring (i.e. repeated counts) and distributional (i.e. new sites added each year) data;

IV grid-units with at least 10 repeated points, considering only these in the analysis (N = 953; grid-units = 68). This last set identifies a strategy strictly devoted to monitoring purposes.

For each of the above listed strategy we have chosen only those species reaching, in at least one year, a minimum frequency of 10 grid-units ($P<0.01$ significance threshold, chi-square test). This intermediate grid-level was chosen being a compromise between the too coarse 50 x 50 km level, and the single-point level, that in turn is too small, being likely affected by autocorrelation problems (e.g. Fortin and Dale 2005).

Comparing the efficiency of the strategies

To compare the efficiencies of each strategy either as population index measures or as distributional sources of information, we have conducted the following tests and analyses:

a) between-year overall similarity of the population indices of the selected species, obtained by correlation (Pearson) between the vectors of abundance (no. pairs, log+1 transformed, see Thompson *et al.* 1998). Correlation coefficients obtained in this way were then compared, between strategies, with ANOVA;
b) at the single-species level, we have tested the demographic change between years, with the Wilcoxon

matched-pair test on the pair numbers (log+1 transformed), at the 50 x 50 km grid-level. This non-parametric test was chosen owing to the non-normality of the data distributions. Because the outcomes of this test depend strictly on the sample-sizes, we have computed also, for each species, the similarity between 2000 and 2001 data-vectors through Spearman correlation. The rho coefficients obtained for all species were then compared among strategies with the t-test (after a check for normality, K-S test);

c) likely changes in geographical distributional patterns, still at the single-species level, were tested with the Cramér test, in the modified version proposed by Syrjala (1996). Also in this case we have adopted the 50 x 50 km grid level, using pair numbers (log+1 transformed);
d) as a measure of chorological efficiency, we have simply counted how many species have reached the above-defined threshold of 10 grid-units (50 x 50 km).

The rationale of the tests and strategies from I) to III) is that, comparing population indices between subsequent years, we are expected to obtain a high-level of similarity; in fact bird populations, as a general rule, are highly stable in such a short-time, at least in the Temperate zone (e.g. Newton 1998 and references therein).

RESULTS

The between-year overall similarity of the population abundance index is, for all strategies, very high, spanning from 0.935 to 0.991 (Tab. 1). To correctly examine the data given in Tab. 1 (and in the following data), we must take into account that there are strong differences in sampling effort among strategies. For example, strategy (IV) gives similar results with a sampling effort being much less than ¼ of that of strategy (I).

In Tab. 2 we give a general picture of the between-year comparisons made at the single-species level. All the four sampling procedures seem to give different pictures of the compared differences, with the exception of strategies III and IV, that are very similar, in spite of quite different sampling efforts (strategy III is based on 3071 points whereas strategy IV has only 953 points). The species whose abundance indices and/or distribution patterns were significantly different between years are listed in Tab. 3.

DISCUSSION

The purpose of achieving both demographic and geographic information from a single sampling program seems difficult to obtain. If we want to reach a good population

Table 1. Between years (2000-2001) overall similarity values, for the different strategies, as obtained by Pearson correlation coefficients. Values are given ± 95% c.i. The letters in the column 'comparison' refer to homogeneous groups according to one-way ANOVA test. Only the strategy II) is statistically different from the others (P<0.001).

strategy	Pearson correlation (r)	comparison
I	0.986 (0.978-0.991)	A
II	0.960 (0.935-0.975)	B
III	0.983 (0.972-0.989)	A
IV	0.984 (0.973-0.990)	A

Table 2. Comparison of differences at the single-species level, among the four strategies. The second column lists the number of the 'significant' species detected with each strategy; in the following two columns are listed the number of species whose abundance vectors (Wilcoxon) or distribution pattern (Syrjala) resulted significantly different between years. The last two columns refer to the mean similarity (as given by rho coefficient), computed for each species, and to the result of the comparisons between mean rho values (t-test), given in terms of homogeneous groups according to capitals. Only strategies III) and IV) give similarly higher similarities.

strategy	no. of compared species	no. of different species (Wilcoxon, P<0.01)	no. of different species (Syrjala, P<0.01)	mean Spearman rho coefficient	rho comparison
I	121	5	2	0.612 ± 0.125	A
II	93	2	1	0.559 ± 0.155	B
III	96	2	1	0.644 ± 0.139	C
IV	68	2	1	0.662 ± 0.154	C

Table 3. List of the species whose abundance index and/or distribution patterns resulted significantly different (P<0.01) between years, according to the four sampling strategies. W, significant difference in abundance index; S, significant difference in distribution pattern.

	strategy			
species	**I**	**II**	**III**	**IV**
Coturnix coturnix	W		W	
Streptopelia turtur				W-S
Cuculus canorus	W			
Jynx torquilla		W		
Alauda arvensis	W			
Motacilla flava			W	
Cisticola juncidis	W			W
Muscicapa striata	S	S		
Pyrrhula pyrrhula	W	W		
Passer domesticus italiae	S			
Emberiza calandra			S	

index assessment, a relatively small sample of repeated points seems the best choice, at least in terms of costs (Thompson 1998, Caughlan and Oakley 2001, Carlson and Shmiegelow 2002). If we need to update the chorological knowledge, we obviously need to cover the entire land surface establishing a sampling procedure that can span from almost entirely 'random' sampling (i.e. based on volunteer work without limitations about the choice of the sampling areas and periods, e.g. Meschini and Frugis 1993), to well-defined protocols about sampling effort and the choice of survey sites (e.g. Hustings and Vergeer 2002).

Our data seem to confirm the above statements, in fact the best demographic strategy seems to be that based on a 1/3-1/4 sampling-point number (strategy iv), whereas larger numbers of species are detected only if, during the sampling campaign, different sites are visited each year (strategy ii, in spite of a small number of points, allows to reach a relatively high number of 'significant' detected species). Also our data seem therefore to confirm that the acquirement of population index data seems contrasting with the needs of a good geographical coverage.

Intermediate solutions, represented in our data by strategies I) and III) seem to work quite well, giving a useful compromise between the two basic purposes, chorological and demographical. In this respect, although, it seems very important to consider the relative efficiency of these intermediate solutions in comparison with possible alternatives. As stated above, a reliable distributional updating (Atlas-like work), can be done with different methods. At the same time, a random choice of diurnal sampling sites has shown to be ineffective to detect important sets of species (nocturnal, raptors, woodpeckers, species with strict habitat requirements, see e.g. Marchant *et al.* 1990), many of these are considered either of conservation concern (e.g. Calvario *et al.* 1999; Burfield and Van Bommel 2004) and/or as important indicator species for habitat and landscape monitoring (Angelstam *et al.* 2004, de Heer *et al.* 2005, Gregory *et al.* 2005).

Though strategies involving both repeated and non repeated counts seem to give a useful compromise, it would be better - at least in terms of cost - to plan different sampling schemes to achieve good data in these two important attributes of bird populations.

A remake of the National Atlas would be a better choice to update regularly distributional knowledge, although it should need a big organizing effort. On the other hand, to obtain good, reliable and feasible population indices about common species, MITO2000 seems to work well, also at reduced sampling effort. A careful choice of sampling areas, through a sampling design taking into account biogeographical and ecological variables, would be able to enhance the efficiency of the scheme, maximizing the number of species reliably detected.

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