Chapter 21
Species Richness and Species of Conservation Concern in Parks of Italian Towns

Alberto Sorace and Marco Gustin

Abstract The richness of all bird species and conservation concern species were investigated in 40 parks and their surrounding built-up areas of 27 Italian towns. Data were obtained from published urban atlases of breeding birds (25 parks) and additional personal communication of Italian ornithologists (15 parks). We define species of conservation concern as those included in the Annex I of EC Directive 09/147/CE and/or in the categories 1–3 of the Species of European Conservation Concern (SPEC). Total species richness and species of conservation concern were compared between the parks and the surrounding built-up areas (500 m around the parks). The role of park features such as size and distance from the centre was investigated for these two parameters. The analysis was repeated for single bird species of conservation concern and for a selection of functional groups of these species. According to homogenising theories of urban areas, no significant differences were observed between parks and surrounding built-up areas for the investigated parameters of breeding bird community and for the frequency of single species. Woodland bird species and woodpeckers of conservation concern were the only groups more diffuse in parks. Conversely, the frequency of building-nesting and aerial feeders was higher in built areas. Variables related to town size and distance from the centre appeared to produce higher effects than park size on species frequencies in parks.

Keywords Urbanisation • Homogenisation • Breeding birds • Functional groups • Park size • Town size • Urban matrix

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A. Sorace (✉)
SROPU, Via Roberto Crippa 60, 00125 Rome, Italy
e-mail: soracealberto8@gmail.com; sorace@fastwebnet.it

M. Gustin
Conservation Department, LIPU, Lega Italiana Protezione Uccelli, Via Udine 3, 43100 Parma, Italy

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21.1 Introduction

Due to the dramatic growth of urbanisation over the world (Antrop 2004; United Nations 2010; Haase et al. 2014), knowledge of processes affecting urban ecosystems has become a priority (Flores et al. 1998; Niemela 1999; Marzluff et al. 2001). Urbanisation is considered one of the strong forces causing biotic homogenisation and the loss of biodiversity (Blair 2001; Miller and Hobbs 2002; McKinney 2006). In particular, several studies have shown that urban habitats are characterised by a decrease in species richness and diversity to the advantage of a few broadly adapted species that may be particularly abundant (Jokimäki et al. 1996; Marzluff 2001; Sorace 2002; Garaffa et al. 2009; Møller 2012). However, information on the response of biological communities to the ecosystem changes caused by urbanisation requires further investigation (Jokimäki and Kaisanlahti-Jokimäki 2003; Clergeau et al. 2006). This information is critical for wildlife conservation and to enable correct management of large sectors of land surface. In particular, it may be interesting to investigate the response to urbanisation by species whose populations are decreasing.

The low predation pressure on adult birds (including the absence of hunting activity), combined with increased availability of food and milder microclimatic conditions, may attract certain species to urban areas (Jerzak 2001; Chace and Walsh 2006; Sorace and Gustin 2009). In some countries, urban areas may have an important value for the conservation of some thrushes such as *Turdus merula*, *T. philomelos* and *T. viscivorus* (Batten 1973; Gregory and Baillie 1998; Cannon 1999; Mason 2000). Some species of conservation concern might be even more abundant in urban areas than elsewhere. For example, in Italy the majority of Apulia and Lucania populations of *Falco naumanni*, a globally threatened species (BirdLife International 2004), breed in towns (Palumbo 1997). In Finland, *Accipiter gentilis* brood size is greater in urban areas than in rural areas (Solonen 2008). Non-built areas and urban parks, when managed to benefit biodiversity, can host rare species [Lerman et al. 2014; see Goddard et al. (2016) and Meffert (2016)], and, despite being located in an urbanised matrix, small protected parks may contribute to regional biodiversity conservation (Goodwin and Shriver 2014).

Among birds, the granivorous species (*Passer* and *Carduelis* sp.) and the aerial feeders (swifts) seem to better adapt to urban environments (Emlen 1974; Allen and O'Conner 2000; Jokimäki and Kaisanlahti-Jokimäki 2003; Lim and Sodhi 2004). As far as nesting sites are concerned, the ground and bush-shrub nesters appear to be disadvantaged in town as compared to the species nesting at greater heights (Luniak 1981; Jokimäki 1999, Clergeau et al. 2006; Luck and Smallbone 2010). Therefore, it is expected that the species of conservation concern that are more likely to settle in towns may include granivorous and aerial feeder species, hole-nesters and species nesting at greater heights above the ground. However, some recent data collected in Italian towns (Sorace and Gustin 2010) indicate that urbanisation negatively affects most bird species of conservation concern (see also Rayner et al. 2015), including those belonging to groups that are apparently better suited to urban conditions. Nevertheless, some decreasing species (*Falco tinnunculus*, *Upupa epops*, *Jynx torquilla*, *Delichon urbicum*, *Phoenicurus phoenicurus*, *Monticola solitarius*, *Muscicapa striata*) do accept high degrees of urbanisation (Sorace and Gustin 2010).

In this study, based on a sample of 40 parks in 27 Italian towns, we compared the richness of breeding bird species and some functional groups of these species between parks and the adjacent surrounding area. Urban parks represent the best preserved fragments of natural area in Italian towns; thus the richness of bird species including those of conservation concern is expected to be higher in parks than in surrounding built areas although built areas include greenery as well. However, if urbanisation homogenises breeding bird communities, scarce differences should be highlighted between these two urban environments. In addition, we evaluated if some variables (town size, park size, distance from centre) can affect the bird community parameters. All analyses were repeated for bird species of conservation concern with the aim of understanding which decreasing species can settle in town and penetrate in built areas thanks to the presence of natural fragments. Although some information is available on the distribution of single species of conservation concern and on the variation of the composition of bird communities along urban gradients (e.g. Luniak 1996; Blair 2001; Marzluff et al. 2001; Clergeau et al. 2006; Sorace and Gustin 2010), data on the response of species of conservation concern to different degrees of urbanisation is still limited.

21.2 Methods

Data on 40 parks and surrounding built areas of 27 Italian towns were obtained from published urban atlases of breeding birds (25 out of 40 parks; see Sorace and Gustin 2009, 2010) and personal communication of Italian ornithologists (15 parks; see Fig. 21.1 and, for the features of these parks and relative towns, Table 21.1). Most study parks are characterised by meadows (in some cases, very large, e.g. P. Mario Carrara, P. delle Cascine, Villa Pamphili), tree rows and woods (including often old trees, e.g. P. del Popolo, P. Ducale, P. Cittadella, P. delle Cascine, Villa Groppallo, Villa Borghese, P. di Capodimonte). Some parks contain other natural habitats like old woods (e.g. Bosco Negri), rivers and wetlands (e.g. P. Mario Carrara, P. Lambro, P. delle Cave, P. della Vernavola, P. Ducos, P. Golena del Po, P. Fluviale, P. Ducale of Parma). In few parks, orchards and vegetable gardens (e.g. P. Pini) and agricultural patches (P. Fluviale) are present.

In our analysis, we included species that were surely breeding (e.g. nest) and species probably breeding (e.g. singing male). The presence of nocturnal breeding species was not investigated because the research effort for these species differed between the studied towns. As species of conservation concern, we considered those birds included in the Annex I of EC Directive 2009/147/CE and/or in the categories 1–3 of the Species of European Conservation Concern (SPEC; BirdLife

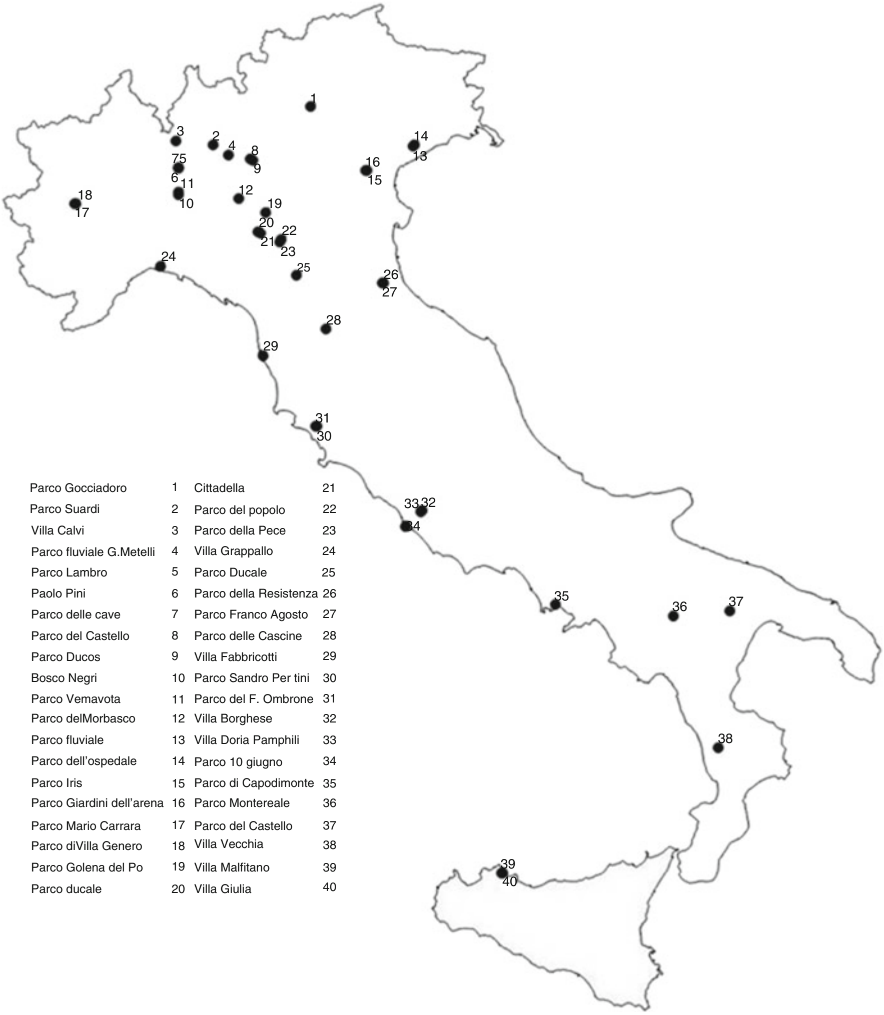

Fig. 21.1 Map of the cities in Italy where the 40 studied parks were located

International 2004). Although *Sturnus vulgaris* is SPEC 3, it was not considered among the species of conservation concern, because the Italian populations of this Passerine are increasing (BirdLife International 2004; Brichetti and Fracasso 2013).

Richness of all bird and conservation concern species was compared between the parks and the surrounding built areas (500-m buffers). The 500-m area surrounding parks is not completely built-up, but encompasses a wide range of habitat types including wetland, woodland, riverine habitats, farmland and even other parks and private gardens. In particular, for the areas surrounding the parks, the percentage of built area was on average 58.9 % (±17.7 SD) with green areas measuring on average 24.2 ha (±19.5 SD) (for comparison the mean size of parks was

Table 21.1 Features of the study parks and of the relative towns

Town	Park	Latitude	Longitude	Altitude (m a.s.l.)	Park size (ha)	Distance from the centre (km)	Town size (km^2)	Number of inhabitants	Population density
Trento	Parco Gocciadoro	46° 03.393′	11° 8.244′	194	22	1.9	40.0	11,5905	2897.62
Cantù	Villa Calvi	45° 43.049′	09° 6.908′	369	0.93	0.1	9.6	39,900	4178
Bergamo	Parco Suardi	45° 42.093′	09° 40.592′	249	2.2	0	38.7	1,18,786	3069.4
San Donà di Piave	Parco dell'Ospedale	45° 38.016′	12° 34.472′	3	6.5	0.75	12.1	41,702	3446.45
San Donà di Piave	Parco Fluviale	45° 37.568′	12° 34.017′	3	8.8	0.5	12.1	41,702	3446.45
Palazzolo sull'Oglio	Parco Fluviale G. Metelli	45° 35.788′	09° 53.183′	166	10	3	5.9	20,040	3379.42
Brescia	Parco del Castello	45° 32.486′	10° 13.544′	149	9.6	0	18.2	1,92,749	10590.6
Brescia	Parco Ducos	45° 31.654′	10° 15.009′	149	5.5	3	18.2	1,92,749	10590.6
Milano	Parco Lambro	45° 29.695′	09° 15.096′	122	90	6	105.0	13,58,627	12939.30
Milano	Parco Paolo Pini	45° 28.608′	09° 11.523′	122	8	9	105.0	13,58,627	12939.30
Milano	Parco delle Cave	45° 28.176′	09° 5.997′	122	130	10	105.0	13,58,627	12939.30
Padova	Parco Giardini dell'Arena	45° 24.697′	11° 52.795′	12	2.7	0.5	42.0	2,13,594	5085.57
Padova	Parco Iris	45° 23.584′	11° 53.930′	12	3.25	2.5	42.0	2,13,594	5085.57
Pavia	Parco Vernavola	45° 12.364′	09° 10.015′	77	35	2.5	62.9	84,000	1335.45
Pavia	Bosco Negri	45° 10.248′	09° 8.677′	77	34	2	62.9	84,000	1335.45
Cremona	Parco del Morbasco	45° 08.172′	10° 0.909′	45	9.5	1.5	10.3	72,000	6990.3
Torino	Parco Mario Carrara	45° 06.491′	07° 38.688′	239	83.7	4	106.6	9,08,551	8522.99

(continued)

Table 21.1 (continued)

Town	Park	Latitude	Longitude	Altitude (m a.s.l.)	Park size (ha)	Distance from the centre (km)	Town size (km^2)	Number of inhabitants	Population density
Torino	Parco di Villa Genero	45° 03.431′	07° 42.578′	239	4.3	2.5	106.6	9,08,551	8522.99
Casalmaggiore	Parco Golena del Po	44° 55.841′	10° 27.893′	26	200	0.5	6.0	15,348	2558
Parma	Parco Ducale	44° 48.303′	10° 18.905′	57	208	1	35.0	1,89,151	5404.31
Parma	Cittadella	44° 47.535′	10° 19.893′	57	120	1.2	35.0	1,89,151	5404.31
Reggio Emilia	Parco del Popolo	44° 42.146′	10° 37.839′	58	7.6	0	56.8	99,528	1751.94
Reggio Emilia	Parco della Pace	44° 40.805′	10° 37.107′	58	4	2.8	56.8	99,528	1751.94
Genova	Villa Groppallo	44° 22.942′	09° 2.605′	19	3.6	10	57.0	6,08,826	10681.16
Pavullo nel Frignano	Parco Ducale	44° 20.196′	10° 50.014′	710	35	0.4	5.0	17,463	3492.6
Forlì	Parco della Resistenza	44° 12.970′	12° 2.912′	34	9.45	0.2	42.3	1,17,859	2789.56
Forlì	Parco Franco Agosto	44° 12.800′	12° 1.811′	34	26	1.5	42.3	1,17,859	2789.56
Firenze	Parco delle Cascine	43° 47.010′	11° 13.012′	50	118	3	102.0	3,76,498	3691.16
Livorno	Villa Fabbricotti	43° 32.190′	10° 18.974′	3	5.4	0.85	38.1	160,937	4219.64
Grosseto	Parco del F. Ombrone	42° 45.389′	11° 7.410′	10	10	1	14.7	82,284	5597.55
Grosseto	Parco Sandro Pertini	42° 45.331′	11° 6.142′	10	6.4	1.1	14.7	82,284	5597.55
Roma	Villa Borghese	41° 54.773′	12° 29.112′	20	79	2	360.0	43,21,244	12003.45
Roma	Villa Doria Pamphili	41° 53.346′	12° 26.775′	20	187	2.5	360.0	43,21,244	12003.45

Lido di Ostia	Parco 10 giugno	41° 43.923′	12° 17.805′	1	20	0.9	10.3	90,000	8780.49
Napoli	Parco di Capodimonte	40° 52.036′	14° 14.947′	4	130	2.6	117.0	9,93,386	8490.4
Matera	Parco del Castello	40° 39.826′	16° 36.355′	401	80	1.1	6.3	60,556	9612.06
Potenza	Parco Montereale	40° 37.984′	15° 47.909′	819	40	0.8	10.0	66,405	6640.5
Cosenza	Villa Vecchia	39° 17.896′	16° 15.224′	238	3	0.7	37.2	67,910	1823.5
Palermo	Villa Malfitano	38° 07.400′	13° 20.482′	14	7	0.8	158.9	6,55,979	4128.77
Palermo	Villa Giulia	38° 06.806′	13° 22.537′	14	6.2	0.02	158.9	6,55,979	4128.77

44.3 ha ± 63.4). In the majority of small parks (16 out of 20 parks with surface < 10 ha), green areas in the 500-m buffer were larger than park size. The role of some park features (size, distance from the centre) and town features (latitude, longitude, altitude, n. of inhabitants, town size, population density) on richness of all bird and conservation concern species was investigated too. The analysis was repeated for some functional groups of species. In particular, bird species were subdivided in four ecological groups according to their feeding habitat (wetland, 20 species; open habitat, 38 species; aerial, 10 species; wood, 33 species) and four groups according to their nesting site (ground, 14 species; building, 17 species; tree, 36 species; bush, 13 species). Grouping was based on Cramp and Simmons (1977, 1980, 1983), Cramp (1985, 1988, 1992, 1993) and Cramp and Perrins (1993, 1994a, b). In the grouping based on nesting site, *Cuculus canorus* and *Muscicapa striata* (due to their not univocal choice) and wetland species were not considered. For the 12 cities including more than one study park (Table 21.1), the above-reported comparisons were carried out also between the most central and the most peripheral park (or the most central and the most peripheral 500-m buffer).

Pairwise comparisons were carried out with *T*-test for dependent samples. When data were not normally distributed (Kolmogorov–Smirnov test), in spite of data transformation attempts (Fowler and Cohen 1995), non-parametric tests were used (Wilcoxon matched-pairs test). Comparisons for the relative frequencies of single species between the parks and the 500-m buffers or between the most central and the most peripheral park were conducted by means of χ^2 test with Yates correction. Simple linear regressions were performed between some independent variables (i.e. those ones describing park and town features, see above) and the number of species per park of the following group: all species, all species of conservation concern, species belonging to different ecological groups, species of conservation concern belonging to different ecological groups and families of species of conservation concern. However, autocorrelation between variables might complicate the correct interpretation of results. Therefore, when more than one independent variable was significantly related to one of the considered parameters of bird community, a multiple regression analysis (forward stepwise) was carried out.

Since the use of the data of more parks for some towns might affect the results, we repeated the statistical analyses also with two 27-park subsamples. In both cases, only one park per each town with two to three study parks was considered: in the first subsample, the most central park was taken into account (27-park sample A); in the second subsample, the most peripheral park (27-park sample B). The majority of results obtained with samples A and B were similar to those obtained for the 40-park sample, with a reduction of significance levels most likely due to the smaller sample. Therefore we did not report them.

If not specified otherwise, values presented throughout are means ± SD or median with interquartile range (i.r.). Statistical analysis was performed with Statistica software package (StatSoft Inc. 1984–2000).

21.3 Results

On the whole in the 40 parks and surrounding 500-m buffer, 101 breeding species were recorded including 40 nonpasserines (39.6 %) and 61 passerines (60.4 %) (Table 21.2). In the parks, 94 species were observed among them; the most frequent (>30 parks) were in decreasing order *Sylvia atricapilla* (39 parks), *Parus major* (39), *Serinus serinus* (38), *Carduelis chloris* (38), *Turdus merula* (35), *Passer italiae* (34), *Fringilla coelebs* (34), *Carduelis carduelis* (34) and *Streptopelia decaocto* (32) (Table 21.2). In the 500-m buffers, 89 species were found among them; the most frequent were *Streptopelia decaocto* (38), *Corvus cornix* (37), *Apus apus* (36), *Sylvia atricapilla* (36), *Parus major* (36), *Passer italiae* (36), *Serinus serinus* (34), *Carduelis chloris* (34), *Delichon urbicum* (33), *Turdus merula* (33), *Carduelis carduelis* (31) and *Columba livia* var. *domestica* (30) (Table 21.2).

The mean number of species per park (25.6 ± 8.4) and in relative 500-m buffer (25.7 ± 8.9) was not significantly different ($t_{39} = 0.08$, $P = 0.93$). Moreover, the differences between the parks and relative 500-m buffers for the mean number of open-habitat species ($t_{39} = 1.22$, $P = 0.23$), the median number of wetland species in the parks ($Z_{40} = 0.41$, $P = 0.68$), the median number of ground-nesting species ($Z_{40} = 0.63$, $P = 0.53$), the mean number of bush-nesting species ($t_{39} = 1.40$, $P = 0.17$) and the mean number of tree-nesting species ($t_{39} = 1.41$, $P = 0.17$) were not significantly different (Figs. 21.2 and 21.3). However the mean number of woodland bird species was higher in the parks than in relative 500-m buffer ($t_{39} = 2.09$, $P = 0.04$), whereas the median number of aerial species ($Z_{40} = 4.49$, $P = 0.000007$) and the mean number of building-nesting species ($t_{39} = 5.39$, $P = 0.000004$) was lower in the parks (Figs. 21.2 and 21.3).

In three cases, the relative frequencies of single species were significantly higher in the 500-m buffers than in the parks: *Apus apus* ($\chi^2_1 = 11.96$, $P = 0.0005$), *Delichon urbicum* ($\chi^2_1 = 20.3$, $P = 0.0000006$) and *Corvus cornix* ($\chi^2_1 = 4.24$, $P = 0.039$) (Fig. 21.3). The relative frequency of *Picus viridis* was higher in the parks being on the verge of statistical significance ($\chi^2_1 = 3.72$, $P = 0.053$; Fig. 21.4).

In the 12 towns in which more parks were investigated, the differences between the most central and the most peripheral park for the (i) richness, (ii) the number of species of the four functional groups based on feeding habitat and (iii) the number of species of the four groups based on nesting site were not significant; in addition, the relative frequencies of single species did not significantly change between the two kinds of parks (data not shown). Similar results occurred for the 500-m buffers (data not shown).

Considering data of the 40 study parks, species richness was positively related to altitude, park size and number of inhabitants (Table 21.3). However, the relationship with park size was not significant in the multiple regression analysis ($t_{36} = 1.83$, $P = 0.08$). Other positive relationships were observed between population density and the number of open-habitat species; latitude and the number of aerial species; and altitude and the number of woodland species, ground-nesting

Table 21.2 Number of parks and relative 500-m buffers in which each species was recorded

	Parks	500-m buffer		Parks	500-m buffer
Cygnus olor	0	2	*Luscinia megarhynchos*	17	16
Anas platyrhynchos	12	9	*Phoenicurus ochruros*	7	10
Coturnix coturnix	0	2	*Phoenicurus phoenicurus*	18	19
Phasianus colchicus	8	9	*Saxicola torquatus*	3	5
Tachybaptus ruficollis	1	1	*Turdus merula*	35	33
Podiceps cristatus	1	0	*Turdus philomelos*	2	2
Phalacrocorax carbo	1	0	*Monticola solitarius*	3	7
Ardea cinerea	3	0	*Cisticola juncidis*	5	4
Ixobrychus minutus	2	0	*Cettia cetti*	7	10
Pernis apivorus	2	1	*Acrocephalus palustris*	2	1
Milvus migrans	2	1	*Acrocephalus scirpaceus*	1	0
Circus pygargus	0	1	*Acrocephalus arundinaceus*	2	0
Buteo buteo	4	5	*Hippolais polyglotta*	5	3
Accipiter nisus	2	7	*Sylvia cantillans*	0	1
Falco tinnunculus	11	14	*Sylvia atricapilla*	39	36
Falco naumanni	1	1	*Sylvia melanocephala*	9	11
Falco subbuteo	4	3	*Phylloscopus bonelli*	1	0
Falco peregrinus	0	3	*Phylloscopus sibilatrix*	0	1
Gallinula chloropus	15	15	*Phylloscopus collybita*	9	6
Fulica atra	3	0	*Regulus ignicapilla*	12	7
Charadrius dubius	1	1	*Regulus regulus*	2	2
Actitis hypoleucos	1	0	*Muscicapa striata*	27	26
Larus michahellis	2	5	*Aegithalos caudatus*	25	22
Columba palumbus	17	14	*Poecile palustris*	2	3
Streptopelia turtur	7	6	*Periparus ater*	6	9
Streptopelia decaocto	32	38	*Cyanistes caeruleus*	27	28
Columba livia domestica	24	30	*Parus major*	39	36
Psittacula krameri	4	3	*Sitta europaea*	12	8
Cuculus canorus	12	6	*Certhia brachydactyla*	15	11
Apus apus	21	36	*Remiz pendulinus*	2	2
Apus pallidus	2	7	*Oriolus oriolus*	6	5
Apus melba	0	3	*Lanius collurio*	2	2
Alcedo atthis	8	7	*Garrulus glandarius*	11	13
Merops apiaster	1	1	*Pica pica*	23	23
Upupa epops	9	4	*Corvus cornix*	29	37
Caprimulgus europaeus	1	1	*Corvus monedula*	9	14
Picus viridis	17	8	*Sturnus vulgaris*	26	29

(continued)

Table 21.2 (continued)

	Parks	500-m buffer		Parks	500-m buffer
Dendrocopos major	21	17	*Sturnus unicolor*	1	0
Dendrocopos minor	3	1	*Passer italiae*	34	36
Jynx torquilla	19	13	*Passer montanus*	26	24
Galerida cristata	2	1	*Passer hispaniolensis*	2	2
Alauda arvensis	1	4	*Fringilla coelebs*	34	29
Ptyonoprogne rupestris	1	6	*Serinus serinus*	38	34
Hirundo rustica	18	22	*Carduelis chloris*	38	34
Delichon urbicum	12	33	*Carduelis carduelis*	34	31
Motacilla flava	1	1	*Carduelis cannabina*	1	1
Motacilla cinerea	8	8	*Loxia curvirostra*	1	1
Motacilla alba	18	21	*Coccothraustes coccothraustes*	1	0
Cinclus cinclus	1	1	*Pyrrhula pyrrhula*	2	0
Troglodytes troglodytes	20	12	*Emberiza cirlus*	2	2
Erithacus rubecula	15	10			

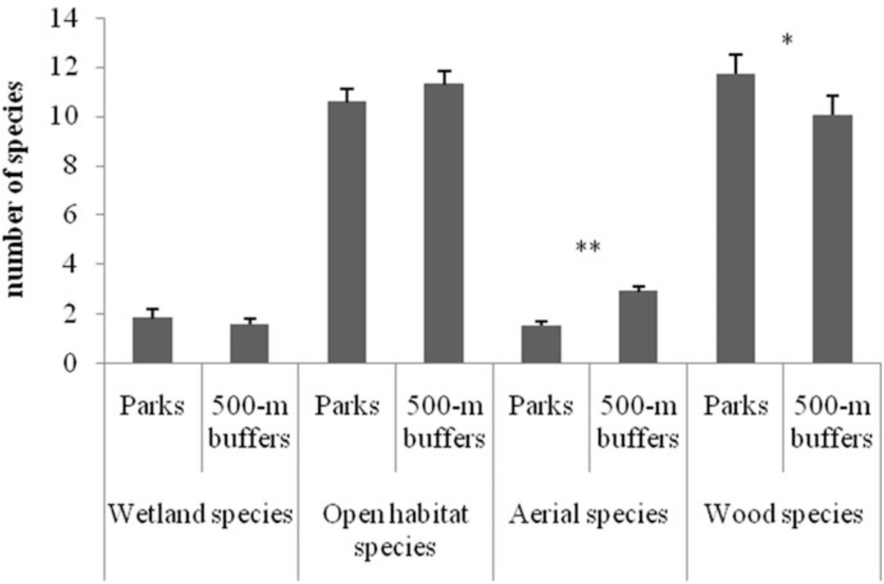

Fig. 21.2 Mean (+ SE) number of species for the wetland, open-habitat, aerial and wood groups in parks and in relative 500-m buffers. *$P < 0.05$; **$P < 0.01$

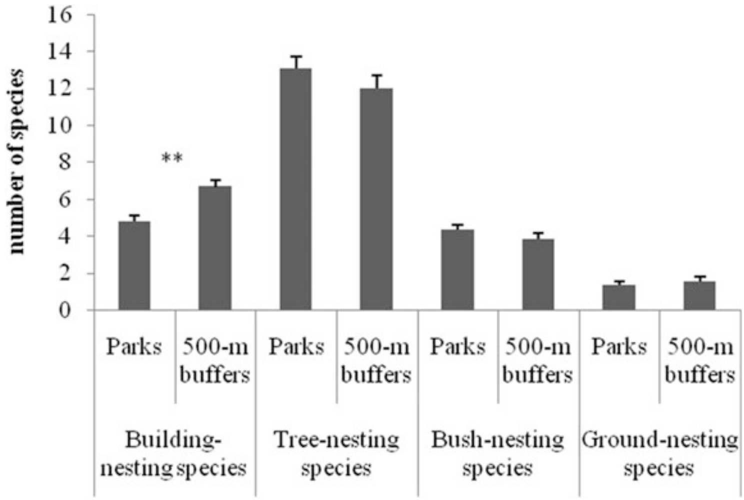

Fig. 21.3 Mean (+ SE) number of species for the ground-nesting, bush-nesting, tree-nesting and building-nesting groups in parks and in relative 500-m buffers. **$P < 0.01$

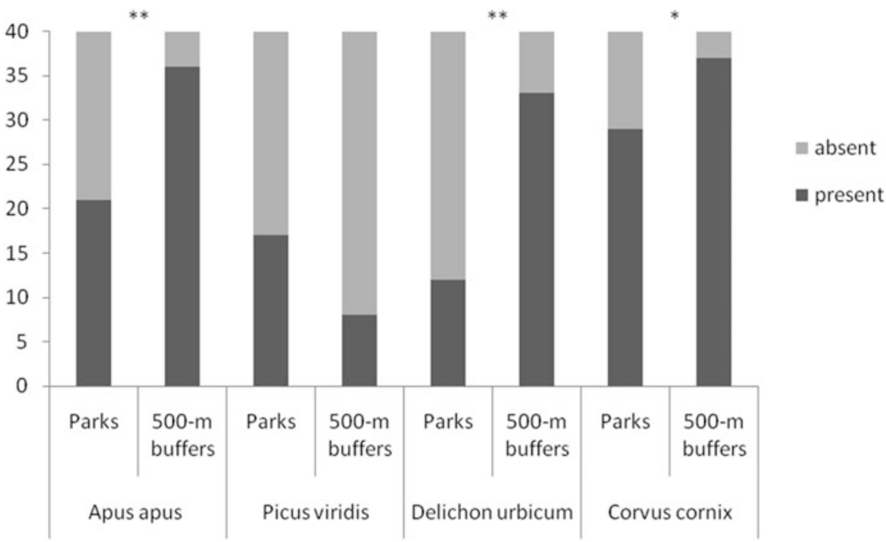

Fig. 21.4 Number of the 40 parks and 500-m buffers in which *Apus apus*, *Delichon urbicum*, *Corvus cornix* and *Picus viridis* were present.*$P < 0.05$; **$P < 0.01$

species and tree-nesting species (Table 21.3). The number of wetland species was positively related to park size, distance from the centre and number of urban inhabitants (Table 21.3). However, number of inhabitants did not enter in the model of multiple regression analysis. The number of bush-nesting species was positively related to town size and number of inhabitants and negatively to latitude

Table 21.3 Significant correlations between independent variables (see methods) and the number of species per parks of different bird groups

Relationships for parks					
Independent variable	Bird group	*r(X,Y)*	r^2	*t*	*P*
Altitude	All species (richness)	0.48	0.23	3.38	0.0017
Park size	*All species (richness)*	0.34	0.11	2.19	0.0344
N. of inhabitants	All species (richness)	0.34	0.12	2.25	0.0300
Latitude	Aerial species	0.34	0.12	2.26	0.0297
Population density	Open-habitat species	0.38	0.14	2.50	0.0169
Altitude	Woodland species	0.58	0.34	4.42	0.0001
Park size	Wetland species	0.42	0.18	2.85	0.0071
Distance	Wetland species	0.35	0.13	2.34	0.0249
N. of inhabitants	*Wetland species*	0.34	0.12	2.23	0.0316
Latitude	*Bush-nesting species*	−0.31	0.10	2.03	0.049
Town size	*Bush-nesting species*	0.33	0.11	2.17	0.036
N. of inhabitants	*Bush-nesting species*	0.34	0.11	2.21	0.033
Altitude	Ground-nesting species	0.37	0.14	2.45	0.019
Altitude	Tree-nesting species	0.55	0.31	4.09	0.0002
Town size	*Building-nesting species*	0.41	0.17	2.74	0.009
N. of inhabitants	Building-nesting species	0.46	0.21	3.17	0.003
Population density	*Building-nesting species*	0.49	0.24	3.45	0.0014
Relationships for 500-m buffers					
Altitude	Arial species	0.42	0.18	2.86	0.007
Longitude	Woodland species	−0.32	0.10	−2.10	0.043
Town size	Wetland species	0.33	0.11	2.12	0.040
Altitude	Building-nesting species	0.32	0.10	2.09	0.044

In italic, the not significant relationships in the multiple regression analysis

(Table 21.3). However, only town size entered in the model of multiple regression analysis, but the relationship was not significant ($t_{36} = 1.93$, $P = 0.06$). The number of building-nesting species was positively related to town size, number of inhabitants and population density (Table 21.3). However, only town size and number of inhabitants entered in the model of multiple regression analysis, but the relationship was significant exclusively for number of inhabitants ($t_{36} = 2.06$, $P = 0.047$). Considering data of the 500-m buffers, positive relationships were observed between town size and the number of wetland species and altitude and the number of both aerial species and building-nesting species (Table 21.3). Conversely, a negative relationship was observed between longitude and the number of woodland species (Table 21.3).

On the whole in the 40 parks and surrounding 500-m buffer, 29 breeding species of conservation concern were recorded including 16 nonpasserines (55.2 %) and 13 passerines (44.8 %) (Table 21.4). Out of the 29 species, 25 were observed in the parks and 26 in the 500-m buffers (see Table 21.2). Mean number of species of conservation concern per park (5.7 ± 2.8) and in relative 500-m buffer (6.0 ± 2.9) were not significantly different ($t_{39} = 0.77$, $P = 0.44$). In addition, the differences

Table 21.4 Species of conservation concern recorded in the 40 study parks

Family	Species	Annex I Dir. 2009/147/CE	SPEC
Phasianidae	*Coturnix coturnix*	–	3
Ardeidae	*Ixobrychus minutus*	X	3
Accipitridae	*Pernis apivorus*	X	–
Accipitridae	*Milvus migrans*	X	3
Accipitridae	*Circus pygargus*	X	–
Falconidae	*Falco tinnunculus*	–	3
Falconidae	*Falco naumanni*	X	1
Falconidae	*Falco peregrinus*	X	–
Scolopacidae	*Actitis hypoleucos*	–	3
Columbidae	*Streptopelia turtur*	–	3
Alcedinidae	*Alcedo atthis*	X	3
Meropidae	*Merops apiaster*	–	3
Upupidae	*Upupa epops*	–	3
Caprimulgidae	*Caprimulgus europaeus*	X	3
Picidae	*Picus viridis*	–	2
Picidae	*Jynx torquilla*	–	3
Alaudidae	*Galerida cristata*	–	3
Alaudidae	*Alauda arvensis*	–	3
Hirundinidae	*Hirundo rustica*	–	3
Hirundinidae	*Delichon urbicum*	–	3
Turdidae	*Phoenicurus phoenicurus*	–	2
Turdidae	*Monticola solitarius*	–	3
Sylviidae	*Phylloscopus bonelli*	–	2
Sylviidae	*Phylloscopus sibilatrix*	–	2
Muscicapidae	*Muscicapa striata*	–	3
Paridae	*Poecile palustris*	–	3
Laniidae	*Lanius collurio*	X	3
Passeridae	*Passer montanus*	–	3
Fringillidae	*Carduelis cannabina*	–	2

Species included in the Annex I of EC Directive 2009/147/CE and/or in the categories 1–3 of the Species of European Conservation Concern (SPEC; BirdLife International 2004) were considered

between the parks and relative 500-m buffers for the median number of species of conservation concern belonging to the wetland, open-habitat, woodland, ground-nesting, tree-nesting and bush-nesting species were not significantly different (data not shown). However in the parks, as compared to the relative 500-m buffers, the median number of aerial species of conservation concern (1.0, i.r. = 1.0 versus 2.0, i.r. = 1.0; $Z_{40} = 3.85$, $P = 0.0001$) and the mean number of building-nesting species of conservation concern (1.8 ± 1.1 versus 2.6 ± 1.3; $t_{39} = 3.96$, $P = 0.0003$) were lower. The differences between the parks and relative 500-m buffers for the median number of species of conservation concern grouped per family were usually not significant except the median number of Picidae species that was higher in the parks (1.0, i.r. = 1.0) than in relative 500-m buffer (0, i.r. = 1.0; $Z_{40} = 2.43$, $P = 0.02$), and the median number of Hirundinidae species that was lower in the parks (1.0, i. r. = 1.0) than in relative 500-m buffer (1.5, i.r. = 1.0; $Z_{40} = 3.74$, $P = 0.0002$).

In the 12 towns in which more parks were studied, the differences between the most central and the most peripheral park for the number of species of conservation concern and among them for those ones belonging to the four functional groups of species based on feeding habitat and the four groups based on nesting site were not significant; in addition the relative frequencies of single species or grouped in families did not significantly change between the two kinds of parks (data not shown). Similar results occurred for the 500-m buffers (data not shown).

Considering data of the study parks, the number of species of conservation concern was positively related to altitude, distance from the centre and population density (Table 21.5). However, the relationship with distance from the centre was not significant in the multiple regression analysis ($t_{36} = 1.39$, $P = 0.17$). The number of open-habitat species of conservation concern was positively related to distance from the centre, population density and number of inhabitants (Table 21.5). However, only the relationship with population density ($t_{36} = 3.38$, $P = 0.002$) was significant in the multiple regression analysis. Another positive relationship was observed between altitude and the number of woodland species of conservation concern (Table 21.5). The number of wetland species was positively related to park size and number of inhabitants (Table 21.5). However, both relationships were not significant in the multiple regression analysis ($t_{36} = 1.71$, $P = 0.10$ and $t_{36} = 1.25$, $P = 0.22$, respectively). The number of tree-nesting species was positively related to altitude and population density (Table 21.5). However, only altitude entered in the model of multiple regression analysis, but the relationship was not significant ($t_{36} = 1.65$, $P = 0.11$). The number of building-nesting species was positively related to town size, number of inhabitants, population density and distance from the centre (Table 21.5). However, only number of inhabitants entered in the model of multiple regression analysis, but the relationship was not significant ($t_{36} = 1.33$, $P = 0.19$). The number of Falconidae species of conservation concern was negatively related to latitude and positively related to distance from the centre, population density, town size and number of inhabitants (Table 21.5). However, number of inhabitants did not enter in the model of multiple regression analysis, while the relationship with population density was not significant ($t_{36} = 1.65$, $P = 0.11$). The number of Picidae species of conservation concern was positively related to distance from the centre and population density (Table 21.5). However, both relationships were not significant in the multiple regression analysis ($t_{36} = 1.51$, $P = 0.14$ and $t_{36} = 1.09$, $P = 0.28$, respectively). The number of Turdidae species of conservation concern was positively related to latitude and altitude (Table 21.5). Both relationships were confirmed in the multiple regression analysis (data not shown). Considering data of the 500-m buffers, positive relationships were observed between latitude and the number of woodland species of conservation concern and altitude and the number of Turdidae species (Table 21.5). The number of Falconidae species of conservation concern was negatively related to latitude and positively related to longitude (Table 21.5). However, longitude did not enter in the model of multiple regression analysis.

Table 21.5 Significant correlations between independent variables (see methods) and the number of species per parks of different bird groups

Independent variable	Bird group	$r(X,Y)$	r^2	t	P
Relationships for parks					
Altitude	All conservation species	0.37	0.14	2.48	0.0178
Distance	*All conservation species*	0.39	0.15	2.63	0.0122
Population density	All conservation species	0.45	0.20	3.07	0.0039
Distance	*Open-habitat conservation species*	0.33	0.11	2.13	0.0401
Population density	Open-habitat conservation species	0.45	0.20	3.08	0.0038
N. of inhabitants	*Open-habitat conservation species*	0.31	0.10	2.02	0.0499
Altitude	Woodland conservation species	0.41	0.17	2.77	0.0087
Park size	*Wetland conservation species*	0.36	0.13	2.37	0.0231
N. of inhabitants	*Wetland conservation species*	0.31	0.10	2.03	0.0492
Altitude	*Tree-nesting conservation species*	0.55	0.31	4.09	0.0002
Population density	*Tree-nesting conservation species*	0.32	0.10	2.10	0.042
Distance	*Building-nesting conservation species*	0.46	0.21	3.22	0.0026
Town size	*Building-nesting conservation species*	0.44	0.19	3.02	0.0045
N. of inhabitants	*Building-nesting conservation species*	0.51	0.26	3.68	0.0007
Population density	*Building-nesting conservation species*	0.65	0.42	5.38	0.000005
Latitude	Falconidae conservation species	−0.36	0.13	−2.35	0.0238
Distance	Falconidae conservation species	0.51	0.26	3.61	0.0009
Town size	Falconidae conservation species	0.59	0.35	4.49	0.0001
N. of inhabitants	*Falconidae conservation species*	0.60	0.36	4.60	0.00005
Population density	*Falconidae conservation species*	0.60	0.36	4.64	0.00004
Distance	*Picidae conservation species*	0.40	0.16	2.71	0.0101
Population density	*Picidae conservation species*	0.36	0.13	2.37	0.0232
Latitude	Turdidae conservation species	0.32	0.10	2.05	0.0469
Altitude	Turdidae conservation species	0.42	0.18	2.86	0.0068
Relationships for 500-m buffers					
Latitude	Woodland conservation species	0.36	0.13	2.40	0.021
Latitude	Falconidae conservation species	−0.48	0.23	−3.33	0.002
Longitude	Falconidae conservation species	0.36	0.13	2.42	0.021
Altitude	Turdidae conservation species	0.57	0.32	4.22	0.0001
Latitude	Tree-conservation-nesting species	0.36	0.13	2.35	0.024

In italic, the not significant relationships in the multiple regression analysis

21.4 Discussion

Urbanisation is considered one of the strong forces causing biotic homogenisation and the loss of biodiversity leading to the reduction of populations of specialist and native species and to the expansion of generalist and exotic species (Blair 2001; Jokimäki and Kaisanlahti-Jokimäki 2003; Devictor et al. 2008; Sorace and Gustin 2008; van Heezik et al. 2008). Since data on exurban areas were not available for our data sample, we did not evaluate the entire "homogenisation effect" due to urbanisation. In any case, some our results seem to support the observation that urbanisation homogenises breeding bird communities. In particular, we observed few differences between Italian parks and surrounding 500-m buffer and reduced effects of park size and distance from the centre on the examined parameters of breeding bird communities (richness, number of species of conservation concern, frequency of some functional groups of species). Moreover, although based on a small sample (12 towns), no significant differences were highlighted between central and peripheral parks or central and peripheral 500-m buffers.

The woodland bird species was the only group that showed higher frequency in parks than in the 500-m buffers. Urban forestry sites can connect urban areas with the natural landscape promoting town penetration by several species (Miller 2005; Croci et al. 2008, Ortega-Álvarez and MacGregor-Fors 2009; Caula et al. 2010, 2014). In particular, urban parks, when managed for wildlife, have the potential to support species of conservation interest (Sorace and Gustin 2010; Lerman et al. 2014). Among them, in the present study, two woodpeckers of conservation concern (*Picus viridis*, *Jynx torquilla*) were more recorded in the study parks than in surrounding areas. Given the sensitivity of woodpeckers to habitat fragmentation (Hinsley et al. 1995; Frank and Battisti 2005), they should be scarcely present in towns. However, a limiting factor for woodpeckers is the availability of mature and decaying trees for feeding and nesting (McCollin 1993). In urban parks and in private gardens, the availability of mature and old trees may be higher than in the nearby countryside (Nilsson and Cory 2009 in Heyman 2011; Sorace and Gustin 2009; Carpaneto et al. 2010, but for dead wood see Hedblom and Söderström 2008). The habitat characteristics (the presence of mature trees, habitat heterogeneity and availability of insects) that satisfy the requirements of some species such as *Picus viridis* and *Jynx torquilla* (Cramp 1985; Südbeck 1994; Tomiałojć 1994) tend to disappear in areas subject to intensive agriculture. Urban parks and gardens might serve as refuges for these species, provided that they preserve such characteristics (see also Mörtberg and Wallentinus 2000; Fernández-Juricic and Jokimäki 2001; Marzluff 2001; Daniels and Kirkpatrick 2006; Sorace and Gustin 2010). According to Hedblom and Söderström (2010), the importance of urban woodland cover for some forest-breeding birds in towns increased when peri-urban woodland cover decreased, so to maintain populations of specialised forest birds in towns of southern and western Europe placed in farmland landscapes (with little peri-urban woodland) is most important to preserve any remaining woodlands in urban environments. In addition, large and old trees should be protected because they are of pivotal value in urban areas as keystone structures for bird species and, in general, wildlife (Harper et al. 2005; Carpaneto et al. 2010; Stagoll et al. 2012; Lerman et al. 2014). However, our results only partially support the suitability of parks for all woodland species. In particular, the fact that in the comparison between parks and relative buffers we did not find significant effects for the group of tree-nesting species and for most woodland bird species might be due to the presence of tree rows and green areas in the urban matrix around the parks that reduce fragmentation effects (Marzluff and Erwing 2001; White et al. 2005; Suarez-Rubio and Thomlinson 2009; Chiari et al. 2010; Litteral and Wu 2012).

For species belonging to other groups (open-habitat and wetland species, ground- and bush-nesting species, raptors), the presence of natural spaces is usually not sufficient to occupy urban sites. According to Sorace and Gustin (2010), the ecological requirements of most species of conservation concern are often incompatible with urban sprawl. In the present study, these species were very scarcely observed and showed in the parks a frequency similar to the surrounding areas. Large- and medium-sized raptors require large areas of contiguous habitat (Newton 1979; Phillips et al. 1984; Hostetler 2001; Marzluff 2001; Chace and Walsh 2006; including sectors with reduced human disturbance, see, e.g. Møller 2012), which urban areas, even in the presence of careful biodiversity protection efforts, cannot support. Conservation efforts for such species should focus on non-urban areas (but see Solonen 2008 for the presence in town of *Accipiter gentilis*, a forestal species). Towns offer few opportunities also for species linked to rural environments (see also Filippi-Codaccioni et al. 2008; Caula et al. 2010) and for species nesting and/or feeding on the ground or in low scrub (Luniak 1981; Marzluff 2001; Lim and Sodhi 2004). Although the decline of galliforms and passerines (Alaudidae, Passeridae, Fringillidae, Emberizidae) of farmland and open habitats (Tucker and Evans 1997; Robinson and Sutherland 2002; BirdLife International 2004) is attributed largely to agricultural intensification (Donald et al. 2001, Newton 2004, Vickery et al. 2004), urban growth may constitute a further dramatic threat for these species (Filippi-Codaccioni et al. 2008; Caula et al. 2010; Sorace and Gustin 2010).

The present investigation confirms that residential areas is a favourable environment for some species that feed on flying insects and, above all, place their nest on buildings (Emlen 1974; Allen and O'Conner 2000; Marzluff 2001). Several species such as *Falco tinnunculus*, swifts, *Columba livia*, *Passer domesticus* and *Sturnus vulgaris* respond positively to building features that provided nesting and resting places (Clergeau et al. 1998; Evans et al. 2009; Latta et al. 2013; Mikula et al. 2013). Therefore, the building features promoting the settlement of species of conservation concern such as *Falco naumanni*, *F. tinnunculus*, *Delichon urbicum*, *Monticola solitarius* and *Passer montanus* should be preserved or increased in urban areas. Besides the building-nesting species, we found that, as expected, the built areas favour also urban exploiters such as *Streptopelia decaocto* and generalist species such as *Corvus cornix* (McKinney 2002, 2006; Bonier et al. 2007; Sorace and Gustin 2008, 2009; Luck and Smallbone 2010).

In the present study, the town size (or variables related such as number of inhabitants or population density) seems to produce higher effects than park size and distance from the centre on the investigated parameters. The positive relationship between town size and richness of species was described and might be steeper in towns than for samples taken within the surrounding landscape or similar in cities and surrounding natural environments (MacGregor-Fors et al. 2011; Pautasso et al. 2011; Ferenc et al. 2014). Major town size might increase the spatial heterogeneity of habitats leading to a higher richness of species (Cadenasso et al. 2007; Ferenc et al. 2014), and this might partially explain our results.

Several studies reported a positive relationship between park size and richness of species that was clearly more marked as compared to our findings (e.g. Sarrocco et al. 2002; Evans et al. 2009; Bräuniger et al. 2010; Strohbach et al. 2013). However, the relationship may be modified by factors, such as human-induced disturbance, recreational use and seasonal variation (Fernandez-Juricic 2000; Caula et al. 2008, 2014; but see Murgui 2007, 2010) as well as the features of surrounding built matrix (Oliver et al. 2011; Latta et al. 2013; Nielsen et al. 2014). In addition, some studies highlighted that park age (or age of trees present inside it) may be a factor affecting mostly the richness of species more than park size and insulation degree (Fernandez-Juricic 2000; Miller et al. 2003; Biaduń and Zmihorski 2011).

Although the present study was not specifically addressed to investigate the effects of geographic variables (altitude, latitude, longitude), the results highlighted a more remarkable effect of altitude on the frequency of all species, including those ones of conservation concern, in parks than in relative 500-m buffers. The results obtained for latitude were less clear since significant relationships were observed for different groups either in parks or in relative 500-m buffers (except for the relationships with the frequency of Falconidae of conservation concern recorded in both environments), and the number of significant relationships was similar in parks and in relative 500-m buffers. Previous studies showed that the effect of geographic variables on urban bird communities can be reduced in more urbanised sectors (Jokimäki and Suhonen 1993; Jokimäki et al. 1996; Clergeau et al. 2001; McKinney 2006; Luck and Smallbone 2011; Ferenc et al. 2014). Sorace and Gustin (2008) observed that the similarity indices between towns were negatively correlated with differences in both latitude and altitude between towns in each urban sector, including town centres. However, according to the results obtained for the latitude variable by Clergeau et al. (2006), these authors showed that the values of the regression coefficient decreased in the more urbanised sectors.

In conclusion, Italian town parks and their surrounding built-up areas show similar avifauna. Parks appear to have a positive influence for the presence of woodland bird species and woodpeckers of conservation concern, whereas for some decreasing urban specialists, the built areas have a critical value for their settlement. It is important to observe that the study on the effects of parks on birds in Italian towns should be repeated with a new data sample based on species abundance rather than the simple recording of species presence since the two approaches might emphasise different results (Sorace and Gustin 2008).

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