Mapping bird assemblages in a Mediterranean urban park: Evidence for a shift in dominance towards medium-large body sized species after 26 years

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ABSTRACT. We assessed the structure of the breeding bird assemblage in a Mediterranean urban park in 2012, and compared it with data gathered in the same area in 1986. Since 1986, Wryneck (*Jynx torquilla*) territories have disappeared from the study area, while breeding pairs of Green Woodpecker (*Picus viridis*) and the introduced Rose-ringed Parakeet (*Psittacula krameri*) have colonized the park. We observed a significant decrease in density of the Italian Sparrow (*Passer italiae*) and a significant increase in Starling (*Sturnus vulgaris*). At the assemblage level, overall bird densities decreased but total bird biomass increased due to the increase in density of (often cavity-nesting) medium to large body sized species (such as woodpeckers, Rose-ringed Parakeet and Starling). A presumed increase in mature tree availability and in predation by synanthropic species (e.g. crows) may explain the high density and biomass of primary and secondary cavity nesters characterized by medium-to-large body sizes. The decline of Sparrows and Wryneck may reflect the decreasing trend at the continental scale.

KEY WORDS: mapping method, long time span, *Jynx torquilla*, *Psittacula krameri*, *Sturnus vulgaris*, *Passer italiae*

INTRODUCTION

Urban parks have been considered important green areas that, embedded in anthropized landscapes, host specific bird assemblages (Beissinger & Osborne, 1982; Fernández-Juricic & Jokimäki, 2001; Kelcey & Rheinwald, 2005; Chace & Walsh, 2006; Clergeau et al., 2006; Ortega-Álvarez & MacGregor-Fors, 2009; Ramalho & Hobbs, 2012). In this sense, several studies have evidenced their peculiar composition and structure (for central and northern Europe: De Graaf et al., 1991; Jokimäki & Suhonen, 1993; for Mediterranean: Fernández-Juricic, 2000; Sorace & Gustin, 2008; Fraissinet & Fulgione, 2008; see also for review: McKinney, 2002; Clergeau et al., 2006). In particular, in the last decades several generalist synanthropic species, both native and non-native, have increased in density in urban areas, changing the total richness and inducing evident turnovers in species assemblages (Sorace & Gustin, 2008). Among them, species such as parakeets, starlings and crows may be considered as urban exploiter species, while many specialized species have shown a progressive decline (Palomino & Carrascal, 2006). Although these changes are documented in literature (Kelcey & Rheinwald, 2005; McCaffrey & Mannan, 2012), empirical research comparing bird assemblages over large time spans is scarce, at least for Mediterranean urban parks.

In 1986, breeding birds were censused in a large urban park of central Italy (Rome) using a mapping method (Battisti, 1986). After 26 years (2012) we carried out a comparable study in the same site, using the same protocol by the same researcher (CB). This comparison allowed us to detect changes in density at species level, and in structure at assemblage level over this long time span (1986-2012). Data were analyzed using a bi-variate metric of diversity (Abundance/Biomass curves) based on a comparison of cumulative species abundance and biomasses, used to detect structural changes at community level (Warwick & Clarke, 1994; Magurran, 2004).

MATERIAL AND METHODS

The area studied was inside the Villa Doria Pamphili (Rome, central Italy), a large historical urban park (120 hectares, 50 m a.s.l.; Site of Conservation Interest 'Habitat' Directive 92/43/CEE; Code IT6003052; 41°53' N, 12°27' E). Inside the park, we identified a study area (17.96 ha wide) characterized by native (*Quercus ilex*, *Q. pubescens*, *Q. petrae* and, secondarily, *Ulmus campetris, Laurus nobilis, Cercis siliquastrum*) and ornamental trees (*Pinus pinea, Cedrus libanotica*, *Aesculus hippocastanum, Robinia pseudoacacia, Cupressus* sp., *Ailanthus altissima*) surrounded by mowed grasslands (mainly Graminaeae, Malvaceae, Compositae; Celesti-Grapow, 1995).

Breeding bird assemblages were monitored by means of a mapping census method (Bibby et al., 2000; Sutherland 2006). During the 2012 breeding seasons (March-June), a number of periodic visits (n = 12) were carried out with a sampling effort (25 hours of field sampling) comparable to the research effort carried out in 1986 (12 visits; 25 hours). During each visit, the observer collected data following a non-linear transect (about 2,500 m-long; speed: 1.5 km/hour) in the early morning (07.00 -10.00 a.m.) covering all the study area. Contacts (i.e. records of each individual breeding bird) were noted on a local map (scale 1:2,000, Technical Regional Map; Regione Lazio, 1990). The primary and secondary tree vegetation was the same as in 1986, and no evident changes in their relative abundance had occurred when compared to 2012. No form of wood coppicing or clearing had been carried out in the period between the two surveys (Celesti Grapow, 1995; Carbone & Frassineti, 2001; Ricotta *et al.,* 2001).

Species-specific maps were created and species-specific territories were obtained following the clustering procedure described in Bibby *et al.* (2000). We considered a "territory" as a range area where a territorial species pair was considered to breed (Bibby *et al.*, 2000). Due to the limited vocalizations or territoriality of some species (e.g. sparrows *Passer* sp., Hooded Crow *Corvus cornix*, Rose-ringed Parakeet *Psittacula krameri*) an estimated value of density of such species was drawn from the counting of the individuals and checking for their nests. Species with crepuscular or nocturnal activity (e.g. Strigiformes and Caprimulgiformes) and individuals flying very high (> 25 m) were not considered. For nomenclature we refer to Italian Sparrow *Passer italiae* since Hermansen *et al.* (2011) established definitively that this species is a stabilized hybrid.

We analysed data at assemblage and species levels for both time periods. We refer to the term "assemblage" to indicate a set of taxonomically related species that co-occur at a given time and spatial scale in a site (Verner, 1984; Fauth et al., 1996). The following parameters were calculated: (i) species richness, as the number of species occurring in the study area for the overall assemblage (STot); (ii) total number of breeding pairs (Ntot) and breeding pair density (D), this last expressed as number of territories (i.e. breeding pairs)/10 ha and calculated for each species and all species (DTot); (iii) relative frequency for each species both in abundance (f_A as the ratio: D/DTot; species with $f_A > 0.05$ were considered dominant species; Turček, 1956) and biomass (f_B as the ratio: species-specific body weight/total biomass); (iv) Shannon diversity index (H'; Shannon & Weaver, 1963, as $H = -\Sigma f_A \ln f_A$); (v) total biomass (TB; both at species and assemblage level), corresponding to the sum of body weight of all censused individuals, expressed in g). To calculate the biomass values, mean body mass values were obtained from Cramp & Simmons (1977, 1980, 1983), Cramp (1988) and Cramp & Perrins (1993). For each species in the assemblage, we additionally obtained their cumulative frequency for abundance and for biomass. We then ranked the cumulative frequencies from the most to the least important along the x-axis in a Cartesian space in order to obtain two curves, for cumulative abundance and for biomass (ABC curves; Warwick, 1986; Magurran, 2004). In particular, species abundance curves indicate the relative distribution of the spatial niche of the species (using abundance as a proxy), while biomass curves indicate the relative distribution of the energy flow in the assemblage, according to the trophic resources used by species (Magurran, 2004). The ABC approach has been applied in several animal assemblages (Penczak & Kruk, 1999; Magurran & Phillip, 2001; Prete et al., 2012), but rarely in birds (e.g., Benassi et al., 2009).

The comparison between relative frequencies in abundance of each species in paired years (1986 *vs* 2012; only for species with at least a census of > 5 total pairs) was tested using χ^2 test. We performed the Kolmogorov-Smirnov test (two-tailed) to compare the diversity indices and the frequency distribution between curves (1986 *vs* 2012). We used statistical package Primer version 4.02i for Windows and SPSS 13.0 for Windows (SPSS Inc. 2003). Significance levels were set at $p < 0.05$. We checked for data reliability (controlling for standardization, replication, data-independence) following Battisti *et al.* (2014).

RESULTS

In the 2012 breeding season, we sampled 20 breeding species (compared to 23 in 1986; Table 1). Comparing data between years, in 2012 we no longer observed Wryneck *Jynx torquilla,* which had been present in 1986, and we recorded pairs of Green Woodpecker *Picus viridis* and Rose-ringed Parakeet for the first time in 2012. We observed a significant decrease in frequency of abundance ($P<0.05$) for Italian Sparrow and Wryneck and an increase for Starling *Sturnus vulgaris* ($P<0.05$) and Rose-ringed Parakeet ($P<0.01$; χ^2 test; Table 1). At assemblage level, we also observed contrasting trends among parameters: from 1986 to 2012, the total density decreased and the total biomass increased (Table 1). In 2012, 36.8% of total biomass was related to only two cavity nester species (Starling and Rose-ringed Parakeet). Cavity nesters markedly increased their total frequency in biomass (1986: 0.353; 2012: 0.549).

Diversity index H' showed a weak, not significant change between 1986 and 2012 (H' = 2.73 *vs* H' = 2.69; Z = 0.384, P = 0.998; Kolmogorov-Smirnov test). The ABC curves show that (i) biomass curves are higher when compared to abundance curves in both years; (ii) curves for 2012 (abundance and biomass) cumulate early when compared to curves for 1986. Differences between biomass cumulative curves are significant (Z = 1.991, P = 0.003; Kolmogorov-Smirnov test; Fig. 1).

DISCUSSION

Our data show that over a 26-year period, quantitative changes in breeding bird assemblages occurred in our study area, but these differences were mainly driven by the population trends of a limited set of species. Some species, occurring in 1986, showed a significant decline in their frequency (such as sparrows) or were not recorded at all in 2012 (Wryneck). Other species newly appeared (Rose-ringed Parakeet, Green Woodpecker) or significantly increased both in density and in their frequency (Starling). Rose-ringed Parakeet, absent in 1986 but dominant in 2012, was introduced into European urban areas in the 1980s (Czaijka *et al.*, 2011) and shows a recent and strong expansion in Italy (Mori *et al.*, 2013). This parakeet is considered a new invasive alien species occurring in urban European ecosystems where it can compete

TABLE 1

Breeding bird species of the Villa Doria Pamphili urban park (Rome, central Italy) for 1986 (data from Battisti 1986) and 2012 (original data). C = cavity nester species. Ntot = total number of breeding pairs, D = species density (pairs/10 ha), f_A = relative frequency in abundance (in bold, the dominant species: fi>0.05), f_B = relative frequency in biomass; TB = total biomass (in g). Values of χ^2 (comparison between frequency in abundance) were reported only for species with at least >5 total pairs censused; * = P<0.05; ** = P<0.01).

	1986					2012					
Species	Ntot	D	f_A	TB	f_B	Ntot	D	f_A	TB	f_B	χ^2 test
Sylvia atricapilla	38.5	21.4	**0.177**	643.2	0.087	28	15.6	**0.166**	468.6	0.057	0.125
Troglodytes troglodytes	30.5	17	**0.14**	271.7	0.037	19.5	10.9	**0.116**	173.5	0.021	0.297
Passer italiae (C)	15.5	11.1	**0.092**	668.4	0.091	3	1.7	0.018	100.6	0.012	4.917*
Serinus serinus	15.5	8.6	**0.071**	155.3	0.021	4	2.2	0.023	40.2	0.005	3.657
Turdus merula	15	8.3	**0.069**	1219.1	0.166	10	5.6	**0.06**	817.8	0.099	0.047
Parus major (C)	14	7.8	**0.064**	280.4	0.038	13	7.2	**0.077**	260.2	0.032	0.047
Fringilla coelebs	12.5	7	**0.057**	292.3	0.04	7.5	4.2	0.045	174.4	0.021	0.114
Sturnus vulgaris (C)	10	5.6	0.046	946.9	0.129	20	11.1	**0.118**	1883	0.228	4.711*
Cyanistes caeruleus (C)	9.5	5.3	0.044	105.8	0.014	15	8.4	**0.089**	166.7	0.02	1.728
Jynx torquilla (C)	8.5	4.7	0.039	312.2	0.042						5.354*
Erithacus rubecula	6.5	3.6	0.03	115.8	0.016	8	4.5	0.048	143.3	0.017	0.177
Certhia brachydactyla (C)	5	2.8	0.023	44.5	0.006	5.5	3.1	0.033	48.7	0.006	0.131
Regulus ignicapilla	5	2.8	0.023	27.8	0.004	7	3.9	0.041	38.7	0.005	0.441
Passer montanus (C)	5	2.8	0.023	127.9	0.017						2.349
Carduelis chloris	4.5	2.5	0.021	120.5	0.016	3.5	1.9	0.02	93.9	0.011	
Luscinia megarhynchos	2	1.7	0.014	66.8	0.009	1	0.6	0.007	21.9	0.003	
Cettia cetti	3	1.7	0.014	46.8	0.006						
Corvus cornix	3	1.7	0.014	1686.7	0.229	3	1.7	0.018	1657.3	0.201	
Carduelis carduelis	2	1.1	0.009	35.5	0.005	4	2.2	0.023	71.9	0.009	
Sylvia melanocephala	2	1.1	0.009	26.6	0.004						
Muscicapa striata	2	1.1	0.009	32.2	0.004						
Dendrocopos major (C)	1.5	0.8	0.007	117.6	0.016	3	1.7	0.018	245.5	0.03	
Aegithalos caudatus	1	0.6	0.005	7.8	0.001	2	1.1	0.012	14.5	0.002	
Picus viridis (C)						3	1.7	0.019	668.2	0.081	
Psittacula krameri (C)						9	5	**0.053**	1152.6	0.14	8.844**
Total	212	121.1	1	7351.8		169	94.1	1	8241.4		

with many primary and secondary hole-nesting species (DODARO & BATTISTI, 2014). The Green Woodpecker has shown a moderate increase at the continental scale in recent years (GREGORY *et al.*, 2007), and the appearance of the species in our study area corroborates such a continent-wide increase. Starlings are among the most common secondary cavity-nesters in Europe (FEARE, 1984; KOENIG, 2003), breeding in central Italy from the 1970s and nowadays occurring almost everywhere as a breeder (CECERE *et al.*, 2005). Interestingly, while starlings are known to compete for nesting cavities with Rose-ringed Parakeets (DODARO & BATTISTI, 2014, see also STRUBBE & MATTHYSEN, 2007; 2009a; 2009b; CZAIJKA *et al.*, 2011; NEWSON *et al.*, 2013), both species have become more common in our study area, probably because tree maturation may have increased the availability of suitable nesting cavities. Similarly to the European Sparrow, the

Italian Sparrow significantly declined from 1986 to 2012, supporting the evidence of its general decline in the last decade (SUMMER-SMITH, 2003; BRICHETTI *et al.*, 2008; CAMPEDELLI *et al.*, 2012).

Different factors and processes at different scales may act to determine the observed patterns, as stated for urban parks in non-Mediterranean contexts (e.g. JOKIMÄKI, 1999). At the local scale, the availability of large native and ornamental trees (and their maturation over the last 26 years), combined with the ability of Rose-ringed Parakeets to enlarge cavities for nesting (ORCHAN *et al.,* 2013), may explain the occurrence and high density of several medium-large cavity nesters (ANGELSTAM & MIKUSIŃKI, 1994; MIKUSIŇSKI *et al.*, 2001; PASINELLI, 2007; STRUBBE & MATTHYSEN, 2007; ZANGARI *et al.*, 2013), while the decline of sparrows and Wryneck follows a larger scale (continental) process (GREGORY *et al.*, 2007; REIF, 2013).

Although the number of species slightly decreased from 1986 to 2012, the biomass at assemblage level increased because of an increase in the density of medium-large bodied species (such as woodpeckers, Rose-ringed parakeet, Starling). The ABC curves (Fig. 1) emphasize the different ecological roles that the biomass and abundance parameters have at community level. When compared to 1986, assemblage energy flow has been progressively controlled by a set of medium-large bodied species. Interestingly, the two more common medium-large species (Rose-ringed Parakeet and Starling) are also cavity nesters, and total frequency in biomass of cavity nesters has markedly increased from 1986 to 2010. Presumably, in urban habitats, where egg and juvenile predation by crows and other synanthropic predators (rats, feral cats) can be very high, this ecological trait could be selectively favored (CROCI *et al.,* 2008; JOKIMÄKI & HUHTA, 2000; JOKIMÄKI *et al.,* 2005; SERESS & LIKER, 2015).

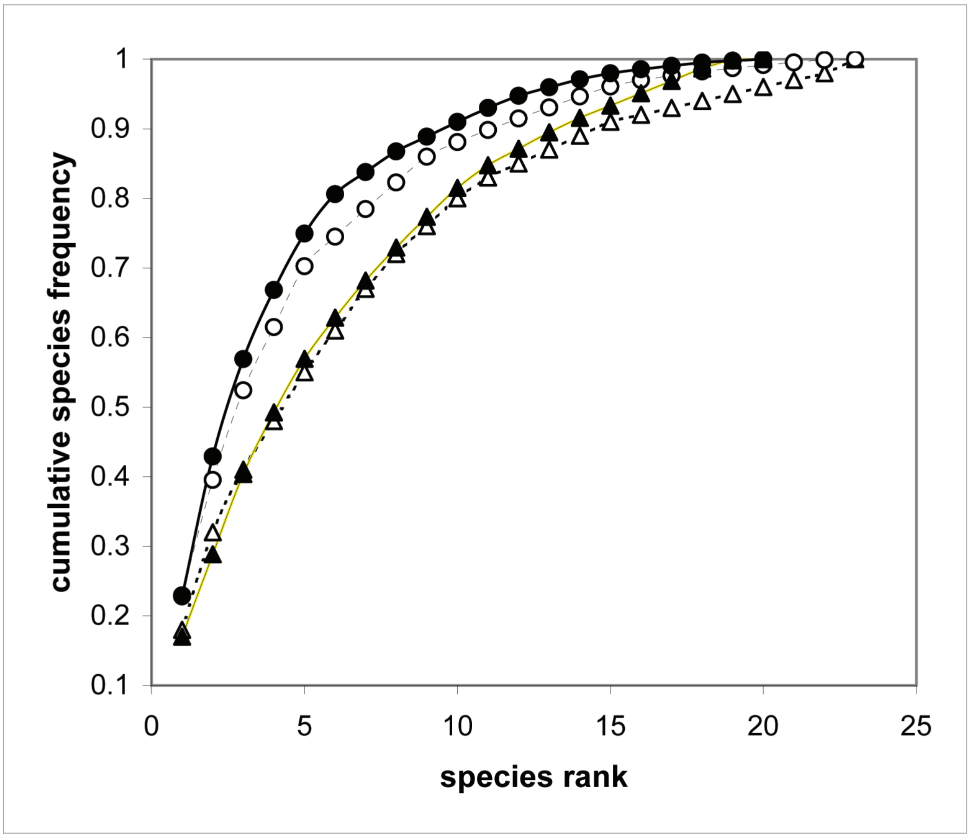

Fig. 1. – Abundance-Biomass Comparisons (ABC curves) for the breeding bird assemblages in Villa Pamphili urban park (central Italy). Circles: biomass cumulative frequency; triangles: abundance cumulative frequency (white and dashed lines: 1986; black and continuous lines: 2012).

When abundance and biomass curves are compared, we then may obtain information on the structure of assemblages, i.e. if dominated by small bodied and highly abundant species or by large bodied and less abundant species. When biomass curves cumulate before the abundance curves, it is an indication that a higher number of relatively large bodied species occur in a more mature assemblage (MAGURRAN, 2004). In our case, in both years we observed biomass curves cumulating before the abundance curves. Nevertheless, this trend appears to be more prominent in 2012 when the biomass curve cumulated significantly earlier when compared to data sampled 26 years earlier. Early-cumulating biomass curves may indicate that more individuals with larger body size (and dominant in biomass) occur in the assemblage. Following this model, we observed that bird assemblages progressively changed toward species with larger body size and lesser abundance.

It should however be noted that our data may be affected by some weaknesses: i) it has been evidenced that the sampling performance of the same observers changes during large time spans (observer effect; see MAGURRAN *et al.*, 2010); ii) our data belong to a single urban park and, therefore, may be affected by local environmental constraints and casual factors; iii) within our time span, we carried out the study in two years only. Nevertheless, our data have some points of strength: i) this is the first study carried out over a large time span in a Mediterranean urban park that highlights changes in assemblage structure with a shift toward medium-large bodied species; ii) we confirmed, at a local level, changes in density matching analogous trends at a larger scale: i.e. an increase for Rose-ringed Parakeet (see MORI et al., 2013; PYŠEK & HULME, 2011) and a decrease for Italian Sparrow and Wryneck (see GREGORY et al., 2007); iii) for Starling, a species stable or moderately declining at continental scale (GREGORY et al., 2007; FREEMAN et al., 2007), we observed an increase in density matching the national trend (CAMPEDELLI et al., 2012); iv) finally, at assemblage level, we confirmed the general pattern described from REIF (2013) at continental scale, i.e. smaller body sized species are declining while species with larger body sizes have increased or at least shown a less negative trend.

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