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Mapping breeding birds in a re-naturalized historical fortress: composition, structure and considerations about abundance vs. biomass comparisons

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Abstract - Using the mapping method, I obtained data about a rich, even and diversified breeding bird assemblage inhabiting an abandoned and re-naturalized historical military fortress (Rome, central Italy). Fortress and the surrounding parks host a large number of edge-mosaic, forest and synanthropic species (often localized at urban scale as *Dendrocopos minor* and *Columba palumbus*) due to a large availability of many sub-habitats and related niches (walls, cavities, tree holes, mature trees, mowed meadows, hedgerows, and deep moats). In this regard, this historical site may be considered a "key-stone structure" at the landscape scale (i.e., a mature forest/rocky patch embedded in an agro-mosaic suburban mosaic). The application of the Abundance/Biomass Comparison (ABC) evidenced a dominant role of large body mass species. The underlying logic behind this approach assumes that, generally, in less disturbed environments species with higher trophic level (and higher body mass) dominate: the increase in frequency of these larger species induce early cumulating biomass curves. However, in our anthropized case study, this assumption seems not valid since many large body mass species (as *Columba livia* dom., *Psittacula krameri* and *Corvus cornix*) show a low trophic level (e.g. granivorous or homnivorous): i.e. body mass is not an indicator of trophic level. Therefore, the pattern reported by ABC curves evidence only a dominance of large body mass species without implications on the trophic level and, consequently, on the disturbance acting on the assemblage. In this regard, assumptions linked to the ABC curves are probably not universal but only limited to specific taxa and contexts.

Key-words: Keystone structure, diversity, evenness, Whittaker plot, Abundance-Biomass Comparison, central Italy.

Riassunto - Il mappaggio degli uccelli nidificanti in una fortezza storica ri-naturalizzata: composizione, struttura e considerazioni sulle comparazioni tra abbondanze e biomasse.

Utilizzando il metodo del mappaggio, è stata inquadrata la struttura di una comunità di uccelli nidificanti in una fortezza militare abbandonata e ri-naturalizzata, collocata nell'area suburbana di Roma (Italia centrale). La comunità è ricca, diversificata e ben equipartita, grazie alla presenza di numerosi sub-habitats e relative nicchie ecologiche (mura, alberi maturi e relative cavità, siepi, prati e fossati) e include specie ecotonali, sinantropiche e di ambienti agro-forestale, anche localizzate alla scala urbana (es., *Dendrocopos minor* e *Columba palumbus*). In tal senso, questo sito storico può essere considerato una struttura ecosistemica 'chiave' alla scala di paesaggio. L'applicazione delle curve di Comparazione Abbondanza - Biomassa (ABC) ha evidenziato un ruolo dominante delle specie di maggior peso corporeo. La logica sottintesa a questo approccio assume che, in linea generale, negli ambienti maturi e poco disturbati, le specie di alto livello trofico (e con più elevato peso corporeo) sono dominanti: in tali ambienti l'aumento in frequenza delle specie di maggiori dimensioni corporee può mostrare curve di biomassa che cumulano prima delle curve di abbondanza. Tuttavia, almeno considerando gli uccelli degli ambienti antropizzati, questo assunto può non essere valido dato che molte specie di elevato peso corporeo (come, ad esempio, *Columba livia* dom., *Psittacula krameri* e *Corvus cornix*) mostrano un basso livello trofico (erbivori e/o onnivori) e sono strettamente sinantropiche. Pertanto, in questo caso di studio, le curve ABC indicano solo una dominanza delle specie ad elevato peso corporeo (ed elevata biomassa a livello di comunità) senza implicazioni sul livello trofico e, conseguentemente, sul livello di maturità e di disturbo. Gli assunti collegati alle curve ABC non sono probabilmente universali ma applicabili solo a determinati gruppi e contesti e ulteriori ricerche comparative sono necessarie.

Parole chiave: struttura 'chiave', diversità, equiripartizione, Whittaker plot, Comparazione Abbondanza-Biomassa, Italia centrale.

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INTRODUCTION

Historical buildings and other anthropogenic structures can offer a large number of ecological opportunities, both permanent and temporary, for bird species at urban scale (e.g., Blanco *et al.,* 1997; Skórka *et al.*, 2018). In the case of abandoned historical buildings, churches, and other monuments, one can witness re-naturalization processes with the starting of native and/or anthropogenic plant successions (Jim & Chen, 2011; Celesti-Grapow & Ricotta, 2021), increasing the availability of habitats and niches even for not strictly synanthropic species. These anthropic settlements can be re-colonized by plant and animal communities, also of conservation interest, so much so that they are included in protected natural areas (e.g., Battisti *et al.*, 2017). In this regard, studies on bird species or communities inhabiting historical-architectural structures, even in the phase of renaturalization, have occasionally been carried out (e.g., Monaghan & Coulson, 1977; Sumasgutner *et al.*, 2014; for Italy: Biondi & Cannavicci, 2001; Arcamone & Paesani, 2003; Grosso & Battisti, 2018).

In the suburban belt of Rome (central Italy), a series of fortresses ('Forti') were built at the end of the 19th

Century to defend the city (Pompeo, 1999). These anthropogenic structures, of considerable extension (each one about 10 ha-wide and larger when including the external appurtenances) were used until the recent post-war period and still today some host military headquarters (Cajano, 2006). Once their defensive role or military structure ended, a large number of these fortresses were gradually abandoned and, in some cases, totally or partially transformed into public urban parks. In the last three decades, some of the abandoned fortresses have been progressively re-naturalized spontaneously or re-vegetated with ornamental tree species and represent interesting green areas in the Roman urban landscape (Pompeo, 1999).

In this work, I studied the structure of a breeding bird community inhabiting a historical fortress, partly abandoned and in phase of spontaneous naturalization, partly destined to a public park and located in the western sector of the city of Rome. This historical structure is adjacent both to an urbanized area and a nature reserve. To study structural traits of this assemblage, I performed two diversity-dominance (*sensu* Magurran, 2004) approaches: the first illustrating the evenness of the species, through their frequency distribution (Whittaker plot), the second evidencing the patterns in abundance vs. biomass (Abundance/Biomass Comparison). Some considerations about this last approach and its implication in disturbance ecology (Battisti *et al.,* 2016) have been reported.

STUDY AREA

'Forte Bravetta' is one of the 15 fortresses of Rome (central Italy), located in the western sector of the metropolitan area, at the border of the "Valle dei Casali" nature reserve (41°52'01.5"N; 12° 25'27'5" E; Fig. 1).

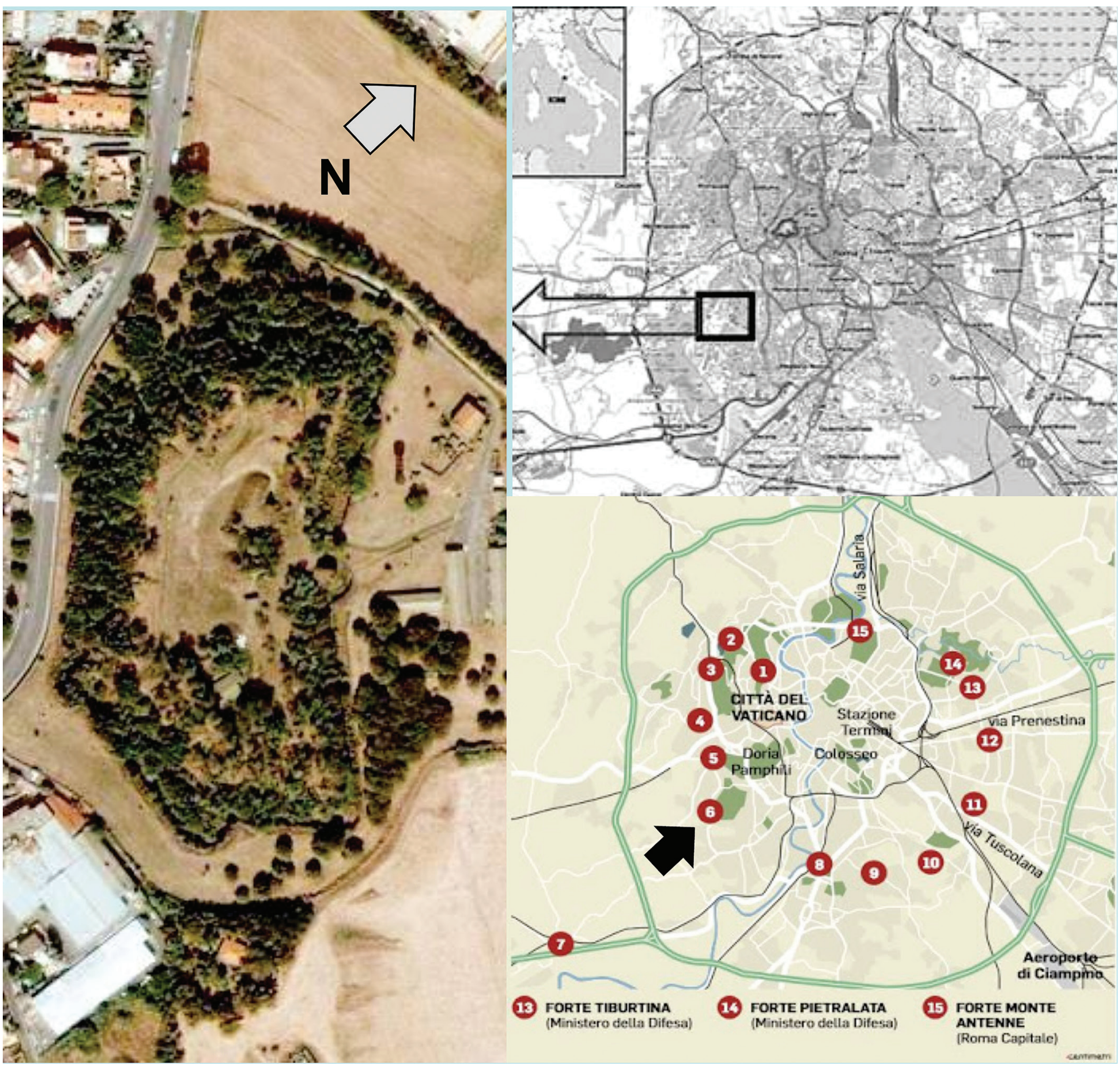

Fig. 1 -The study area: "Forte Bravetta" historical fortress (on the left; Source: Google Earth; scale: 1 cm = 50 m. Rigth: top: location inside the Rome; down: the historical military fortress surrounding Rome; black row shows 'Forte Bravetta'). / Area di studio: sito storico di Forte Bravetta (a sinistra; fonte: Google Earth; 1 cm = 50 m. A destra, in alto: localizzazione nell'area di Roma; in basso: localizzazione rispetto ai forti militari attorno a Roma; la freccia nera, indica il Forte Bravetta).

It was built starting in 1877 and finished in 1883, on an area of approximately 12 ha, including the external belt. During the period of the German occupation of Rome, it was used as a place of execution of the death sentences of the Special Court for the Defense of the State (by order of the Germanic Military War Tribunal and at the hands of the Gestapo). Between 1944 and 1945 there were also executed fascists sentenced to death by the High Court of Justice for the sanctions against fascism (Pompeo, 2000; 2012; Cajano, 2006).

The internal part of the fortress is occupied by meadows which have been progressively invaded by a synanthropic/native vegetation mainly consisting of *Robinia pseudoacacia, Laurus nobilis, Quercus ilex* and *Q. pubescens*, which has colonized part of the walls and the perimeter ditch (Fig. 2a). The external part hosts a native and ornamental arboreal vegetation, mainly located from the post-war period onwards. Considering species with n>5 trees, *Tilia* sp. and *Celtis australis* were the commonest species (each one> 30%; n = 261; Fig. 2b). *Melia azedarach* and *Celtis australis* showed the highest diameter at breast heigth (dbh> 40 cm). Difference among species-specific dbh was significant ($H = 75.92$, $p < 0.001$, Kruskall-Wallis test for equal medians; Tab. 1; Fig. 3). These trees alternate with mowed meadows with the presence of herbaceous species typical of ecotonal, ruderal and trampled environments of the 'Campagna Romana' (e.g., *Allium roseum, Leopolda comosa, Raphanus raphanistrum, Anagallis foemina, Lotus ornithopoides, Cichorium intybus, Silene* cfr. *alba, Galactites tomentosus, Lathyrus* sp., *Vicia* sp., *Urospermum dalechampii, Plantago major, Calamintha nepeta, Asparagus* sp., *Avena* sp., *Dasypyrum villosum, Poa* sp., *Bellis perennis, Borago officinalis, Geranium* sp.) with both native (*Paliurus spina-christi, Crataegus* sp., *Rubia peregrina, Spartium junceum*) and ornamental (*Ligustrum japonicum*) shrub species. In the neighbouring areas there are large areas of non-irrigated arable land, hedgerows, farmhouses, remnant forest patches with *Quercus* sp. and *Ulmus* sp. dominant (see Fanelli & Bianco, 2007), included in the "Valle dei Casali" nature reserve (Regional Law n. 29/1997; 42% non-irrigated lands on 468 ha). Breeding birds in this reserve and surrounding areas have been largely studied by Sorace (1999, 2001), Sarrocco *et al.* (2002), and Battisti & Mandolini (2018). Climate is Mediterranean (transitional; Blasi & Michetti, 2002). Soils are of alluvial origin (clayey and sandy; Marra & Rosa, 1995).

Fig. 2 - a) External walls and ramparts of 'Forte Bravetta' (Rome, central Italy) with meadows and tree plants (*Robinia pseudoacacia*, *Quercus ilex*, *Laurus nobilis* and others; see study area) along the re-naturalized slopes. b) A glimpse of the surrounding urban park to 'Forte Bravetta' with mature ornamental trees (*Celtis australis*, *Tilia* sp. and others). In the background, the perimeter wall of the Fort with edge-shrubby species (*Rubus* sp., *Spartium junceum*, *Crataegus* sp. and others; see study area). / a) Mura esterne e bastioni del Forte Bravetta (Roma, Italia centrale) con prati e specie arboree (*Robinia pseudoacacia*, *Quercus ilex*, *Laurus nobilis* e altre; cfr. area di studio) lungo i versanti ri-naturalizzati. b) Uno scorcio del parco urbano limitrofo al Forte Bravetta con alberi ornamentali (*Celtis australis*, *Tilia* sp. e altre). Sullo sfondo, il muro perimetrale del Forte con specie ecotonali arbustive (*Rubus* sp., *Spartium junceum*, *Crataegus* sp. e altre; cfr. area di studio).

MATERIALS AND METHODS

Protocol

To obtain data about the structure of breeding bird assemblage, I carried out a mapping method (Bibby *et al.,* 2000) in a 11-ha wide area characterized by the 'Forte Bravetta' and the neighbouring urban park (excluding 1 ha of an internal not accessible core area). During the 2021 spring seasons (from 18 April to 31 May), several periodic field visits (n=17) were carried out (about 17 hours of sampling). In each visit, I collected data following a nonlinear transect (about 700 m-long) in the morning (07.00-

Tab. 1 – Native and ornamental tree species occurring in the Forte Bravetta (Rome, central Italy): mean dbh: diameter at breast heigth (in cm; and ± standard deviation, s.d.); n (number of plants); fr: relative frequency on the total. / Specie di alberi autoctoni e ornamentali presenti nel sito di Forte Bravetta (Roma, Italia centrale): mean dbh: diametro medio a petto d'uomo (in cm, e ± deviazione standard, s.d.); n: numero di piante; fr: frequenza relativa sul totale.

Tree species	mean dbh (± s.d.)	n	fr
Tilia sp.	31.96 (± 17.85)	97	0.378
Celtis australis	40.75 (± 14.81)	79	0.303
Ulmus sp.	12.23 (± 6.54)	26	0.1
Quercus sp.	35.32 (± 21.10)	19	0.073
Laurus nobilis	12.29 (± 6.02)	14	0.054
Robinia pseudoacacia	31.83 (± 21.49)	12	0.046
Melia azedarach	51.8 (± 7.82)	5	0.019
Ailanthus altissima		1	0.004
Cupressus sp.		1	0.004
Morus sp.		1	0.004
Quercus suber		1	0.004
Prunus dulcis		1	0.004
Eriobotrya japonica		1	0.004
Ficus carica		1	0.004
Prunus sp.		1	0.004
Olea europaea		1	0.004
N		261	1

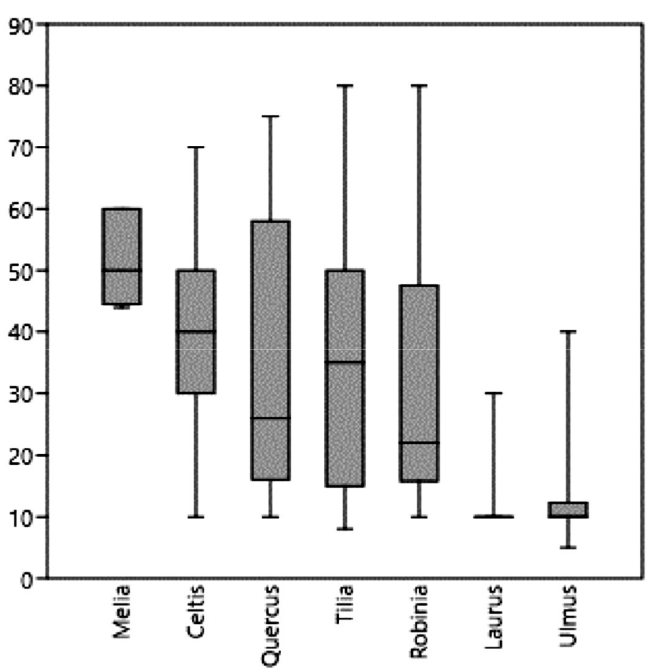

Fig. 3 - Mean diameter (in cm, at the breast height) of tree species occurring in the "Forte Bravetta" (Rome, central Italy). Box plots (with standard deviation, s.d., and interquartile range) refer to the tree species with >5 plants. / Diametro medio (in cm, a petto d'uomo) delle specie di alberi presenti a Forte Bravetta (Roma, Italia centrale). I box plots (con deviazione standard e range interquartile) si riferiscono alle specie con campione > 5 piante.

11.00 h a.m.) covering the whole 11 ha-study area (Bibby *et al.*, 2000). Contacts (i.e. records of each individual bird) were noted on a local map (scale 1: 2,000 from 1: 10,000 Technical Regional Map; Regione Lazio, 1990). To measure the diameter at breast heigth (dbh, in cm) of tree plants I used a professional dendrometric calliper. To sample birds visually, I used a professional binocular Leica 8x30.

Data analysis

First, data have been analysed at the species level. Species-specific maps were created and species-specific territories (for territorial species) were obtained following the clustering procedure described in Bibby *et al.* (2000). One point was given to territories (i.e., clusters of individual species-specific contacts) completely inside the study area and 0.5 point to edge territories (i.e. clusters of contacts partially included in the 11-ha study area; Bibby *et al.*, 2000). We considered a "territory" as a range area inside which a (territorial) species pair was considered to breed (i.e., one territory = one breeding pair; Bibby *et al.*, 2000). For gregarious and other non-territorial species, we obtained an estimation based on numbers of individuals recorded during the field sampling. Birds flying higher than 25 m or considered vagrants, wintering or in migration were not considered. From the records, I obtained a density estimation following Bibby *et al.* (2000).

At the community level, the following parameters were calculated: n: number of records; p: number of species-specific breeding pairs; (ii) D: breeding pair density, as a measure of normalized abundance, expressed as number of breeding pairs/10 ha and calculated both for each species and all species (Dtot) (iii) relative frequency for each species (fr) as the ratio: D/Dtot. To calculate the biomass values, mean body mass values were obtained from Cramp & Simmons (1977, 1980, 1983), Cramp (1988) and Cramp & Perrins (1993). When available we used biomass data available for an area immediately surrounding (Villa Pamphili; Battisti & Dodaro, 2016). We obtained a value of species-specific consuming biomass (Cb; in g/10 ha; calculated as: $Cb = Scb^{0.7}$; Salt, 1957), where Scb, or standing crop biomass, is the total body mass of all censused individuals, expressed in g/10 ha). We used Cb more than Scb, because this parameter is directly proportional to energy removed by individuals from environment, therefore better explaining the specific variations of metabolic rhythm related to individual size (Bock & Linch, 1970). After, I obtained the relative frequency in Cb for each species (frCb) expressed as the ratio: species-specific Cb/total Cb.

At assemblage level, I calculated the Shannon-Wiener diversity index (H'; Shannon & Weaver, 1949, as $H' = -\Sigma fr \times \ln fr$, where fr is the frequency of i^{th} species; see Spellerberg & Fedor, 2003), and the evenness index ($J = H'/H'max$, where H' is the Shannon diversity index and $H'max = \ln S$; Pielou, 1966; review in Magurran, 2004).

To assess the pattern in frequency distribution of the species, I performed a diversity/dominance diagram (or Whittaker plots; Magurran, 2004), In this regard, relative frequencies of each species have been ranked. Shape and slope of point line, obtained by comparing ranks and relative frequencies, allows inferring general property of the assemblages, illustrating the evenness (i.e. the pattern in frequency distribution of species) with implications on level of maturity and stress on the communities (Magurran, 2004).

Finally, I performed an Abundance/Biomass Comparison (or ABC curves; Warwick, 1986; Clarke, 1990; review in Magurran, 2004) ranking the cumulative frequencies both for density (i.e., the normalized abundance) and biomass (in this case, Cb) and obtaining a curve (and the better-fit lines with equations and R^2 values, expressing the data variance). When abundance and biomass curves are compared, we may obtain information on the level of relative dominance of large vs. small body mass species with structural and ecological implications (e.g., on the maturity and role of anthropogenic disturbances affecting the assemblages; Battisti *et al.*, 2016). Indeed, the ABC curves are based on a general assumption that in human-disturbed habitats, small-sized species (i.e., with low body mass and low trophic level) tend to increase in their abundance. Consequently, the abundance curves approach an asymptote before the biomass curves. On the contrary, in mature and undisturbed habitats the opposite pattern may be observed, with the biomass curves cumulating before the abundance curves, an indication that a higher number of large body mass species of high trophic level occur in more complex and diverse assemblages (Magurran, 2004): in these conditions, abundance frequencies are more evenly distributed when compared to biomass frequencies. Early cumulating abundance curves may indicate that the resources are used by few dominant (i.e., more abundant) and generalist species with a broad spatial niche, while early cumulating biomass curves may indicate that species with a higher biomass largely occur in the assemblage (Clarke & Warwick 2001; Magurran, 2004).

To quantitatively assess differences between abundance and biomass curves, I performed a W statistic (Clarke, 1990) as: $W = \Sigma\ (FrCb - Frd)/50(S-1)$, where S is the number of species. W ranges from –1 to +1, with positive values if the biomass curve is above the abundance curve, implying assemblages dominated by large body mass species (Magurran, 2004). On the contrary, negative values of W reveal an abundance curve consistently above the biomass curve, implying small body mass-dominated assemblages.

I performed (i) a χ^2 test, to compare frequency values (Yates' correction for paired frequencies), and a non-parametric Kruskall-Wallis for equal medians, to compare averaged values among >2 cases (Dytham, 2011). To perform the analyses, we used the statistical package PAST 4 for Windows (Hammer *et al.*, 2001). Alpha level was set at 0.05.

RESULTS

During the study period, 40 species have been recorded (26 species, using the mapping method with 92 pairs for n = 661 contacts; density: 83.64 pairs/10 ha; Total Scb: 16954.75 g/10 ha; Total Cb; 1876.18 g/10 ha; Tab. 2). Nine species were dominant. Other breeding species were also contacted in the neighbouring areas, both strictly synanthropic (*Myiopsitta monachus, Hirundo rustica, Apus apus, Larus michahellis*), and related to the agro-forest mosaics of the Roman countryside (*Falco tinnunculus, Oriolus oriolus, Sylvia cantillans, Pica pica, Passer montanus*) and edge-wet environments (*Cettia cetti*). Some species have been considered wintering and migratory (*Phylloscopus collybita, P. sibilatrix, Muscicapa striata, Merops apiaster*).

At the structural level, assemblage showed a Shannon-Wiener diversity of H'=2.913. Whittaker plot showed an even frequency distribution (as confirmed by the high evenness J index near 0.9), with *Sylvia atricapilla* ranking as first dominant species (Fig. 4). Differences in relative frequency between paired ranked species were ever not significant ($p>0.05$; χ^2 test).

Abundance-Biomass Comparisons showed the biomass curves early cumulating when compared to the abundance (i.e., density) curves (Fig. 5; better-fit polynomial curves; abundance: $Frd_{cum} = -0.002\ rank^2+0.078rank+0.108$; $R^2 = 0.99$; $FrCb_{cum} = -0.002rank^2+0.07rank+0.285$; $R^2 = 0.95$). W statistic value was positive (>0) indicating a role in dominance of large body mass species.

DISCUSSION

Abandoned historical sites in urban towns can mitigate the expected negative impacts of urbanization making available small patches of vegetation, walls, cavities and other suitable habitats and niches for a large number of bird species (e.g., Belcher *et al.*, 2019; Bhakti *et al.*, 2019). In this work, I obtained data about a rich, even and diversified breeding bird assemblage located in a large abandoned and re-naturalized historical fortress and surrounding urban park. This assemblage hosts edge-mosaic, forest and synanthropic species, typical of the heterogeneous plain and hilly agro-forest landscapes of central Italy (see Sorace, 1999, 2001; Sarrocco *et al.*, 2002; Taffon & Battisti, 2005; Battisti & Mandolini, 2018).

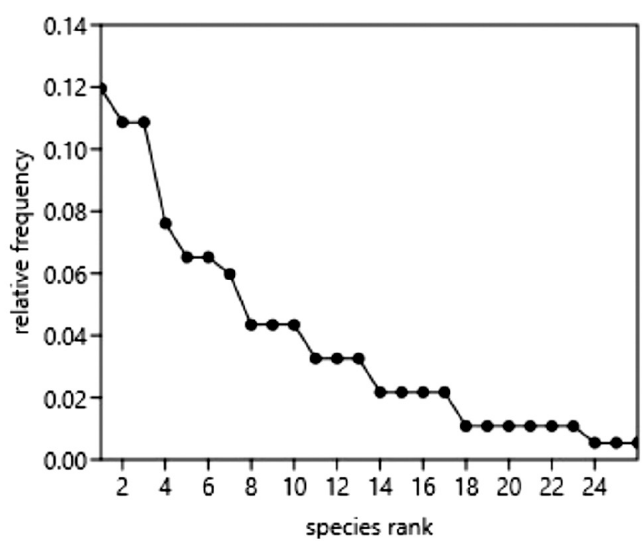

Fig. 4 - Diversity-dominance diagram (Whittaker plot, modified). Points represent the ranked relative frequency in density of each species. / Diagramma diversità-dominanza (Whittaker plot, modificato). I punti rappresentano le frequenze relative in densità di ciascuna specie, ordinate in modo decrescente.

Tab. 2 - Breeding bird species occurring in the Forte Bravetta (Rome, central Italy): n: number of records; p: number of pairs; frp: relative frequency in pairs); D: density (pairs/10 ha); Cb: consuming biomass (g/10 ha); frCb: relative frequency in consuming biomass. Species in decreasing order of density. / Specie di uccelli nidificanti nel sito di Forte Bravetta (Roma, Italia centrale): n: numero di contatti; p: numero di coppie; frp: frequenza relativa del numero di coppie; D: densità (numero di coppie/10 ha); Cb: biomassa consumante; frCb: frequenza relativa in biomassa consumante. Le specie sono ordinate in numero decrescente di densità.

Species	**n**	**p**	**frp**	**D**	**Cb**	**frCb**
Sylvia atricapilla	127	11	0.12	10	54.27	0.029
Columba livia dom.	81	10	0.109	9.091	412.79	0.220
Sturnus vulgaris	54	10	0.109	9.091	170.09	0.091
Troglodytes troglodytes	67	7	0.076	6.364	25.42	0.014
Cyanistes caeruleus	55	6	0.065	5.455	26.66	0.014
Turdus merula	38	6	0.065	5.455	107.80	0.058
Parus major	31	5.5	0.06	5	37.86	0.020
Corvus cornix	44	4	0.044	3.636	309.05	0.165
Erithacus rubecula	32	4	0.044	3.636	21.96	0.012
Serinus serinus	12	4	0.044	3.636	18.71	0.010
Sylvia melanocephala	20	3	0.033	2.727	18.77	0.010
Streptopelia decaocto	15	3	0.033	2.727	109.39	0.058
Carduelis carduelis	11	3	0.033	2.727	22.98	0.012
Columba palumbus	14	2	0.022	1.818	191.31	0.102
Dendrocopos major	9	2	0.022	1.818	49.99	0.027
Passer italiae	11	1	0.011	0.909	16.48	0.009
Regulus ignicapilla	6	2	0.022	1.818	7.57	0.004
Certhia brachydactyla	5	2	0.022	1.818	10.54	0.006
Picus viridis	8	1	0.011	0.909	61.26	0.033
Dendrocopos minor	3	1	0.011	0.909	14.46	0.008
Chloris chloris	3	1	0.011	0.909	14.10	0.008
Motacilla alba	5	1	0.011	0.909	14.06	0.008
Aegithalos caudatus	4	1	0.011	0.909	5.63	0.003
Phasianus colchicus	3	0.5	0.005	0.455	117.77	0.063
Luscinia megarhynchos	2	0.5	0.005	0.455	7.52	0.004
Streptopelia turtur	1	0.5	0.005	0.455	29.74	0.016
Total	661	92	1	83.636	1876.18	1

This fortress shows many sub-habitats, and peculiar niches, that may be opportunistically used by different species, often localized at urban scale. For example, the historical structure and surrounding park make available many specific opportunities (e.g., cavities in the walls and on ornamental trees) for hole-nesting species (e.g., for *Columba livia* dom.*, Passer italiae, Sturnus vulgaris, Psittacula krameri, Certhia brachydactyla*, paridae and picidae, these last also including species of ecological interest as *Dendrocopos minor*, highly localized at regional level; Bernoni & De Santis, 2011). Moreover, the deep (>10 m) moat surrounding the perimetral walls of the fortress was characterized by a humid and sciaphilous environments with suitable ecological conditions for undergrowth species, as *Erithacus rubecula*, a common species mainly wintering in Rome but breeding only in localized shady mesothermophilous sites (Casalini & Zapparoli, 1997). A part picidae, other forest-interior species are present (for example, *Columba palumbus*, recently expanding its range inside Rome; Ammann *et al.*, 2017). In this regard, the fortress and the surrounding urban park may be considered a "keystone structure" (sensu Tews *et al.*, 2004) at the landscape scale being considered a mature forest/rocky patch embedded in a large suburban agromosaic mosaic.

Bird assemblage is highly diversified: diversity index (>2.9) is relatively high and comparable to bird communities inhabiting the neighbouring agro-forest mosaics (e.g., 2.7-2.9; Battisti & Mandolini, 2018) and urban par-

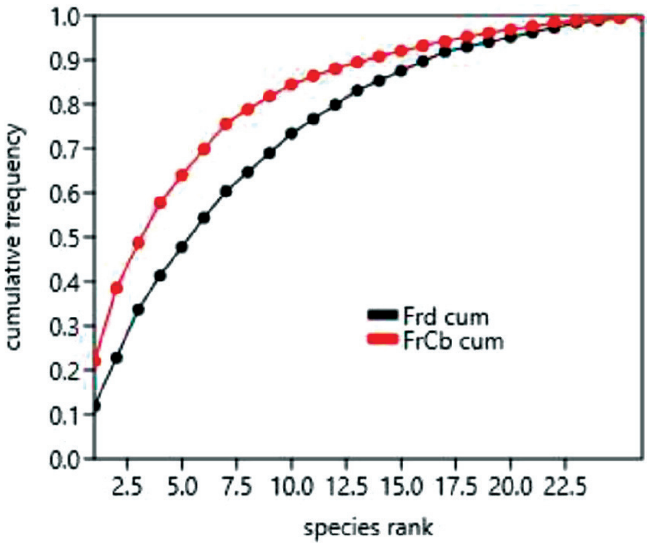

Fig. 5 - Frequency curves in Abundance-Biomass Comparison (ABC curves). Frd cum: cumulative frequencies in density; FrCb cum: cumulative frequency in consuming biomass. See methods for details. / Curve di frequenza nelle Comparazioni Abbondanza-Biomassa (curve ABC). Frd cum: frequenza cumulata delle densità; FrCb cum: frequenza cumulata nelle biomasse consumanti.

ks (e.g., 2.7; Battisti & Dodaro, 2016). Moreover, species show an even frequency distribution as illustrated by Whittaker plot and J index, therefore suggesting a mature community (see Wiens, 1992).

Abundance/Biomass Comparison evidenced a dominant role of large body mass species, as picidae, columbidae, *Psittacula krameri* and *Corvus cornix*. ABC approach has been largely applied in the studies about the role of disturbances in animal communities (for vertebrates, see: freshwater fish: Penczak & Kruk 1999; Magurran & Phillip, 2001; small mammals: Prete *et al.*, 2012; reptiles: Smith & Rissler, 2010; birds: Battisti, 2018). Following the ABC diagrams, disturbed assemblages will be characterized by dominant species with a lower biomass (and a lower trophic level) when compared to mature and undisturbed assemblage (Warwick, 1986). When the disturbances occur the distribution of biomass among species will be less even than the distribution of abundance: consequently, in ABC diagrams, the biomass curves will lie below the abundance curves (Magurran, 2004).

However, although in this case study, some medium-large species linked to mature environments occur (e.g., picidae) and might explain the ABC pattern observed, a cautionary interpretation of the results is needed. Indeed, the logic assumptions underlying the ABC diagrams (i.e., mature habitats with lower disturbance = dominance of larger body mass species = higher trophic level in the assemblages; Warwick, 1986) could be not applicable in anthropized contexts. Indeed, in these urban bird assemblages, body mass could be not a clear indicator of higher trophic level since many large body mass species (as *Corvus cornix*, *Columba livia* dom., and psittacidae) here occurring, are strictly synanthropic with an omnivorous diet and low trophic level. In this regard, a higher biomass at community level could not provide information about the level of disturbance affecting the assemblages. This lack in logic, yet reported for other anthropized bird assemblages (Battisti, 2018), is valid also for other taxa (e.g. small mammals) inhabiting human-dominated landscapes: for example, Prete *et al.* (2012) reported that in small mammal assemblages living in anthropized habitats, synanthropic omnivorous species of low trophic level and high body mass (*Rattus* spp.) dominated in stressed contexts and small carnivorous (as shrews, Soricomorpha) of higher trophic level but very low body mass, associated to undisturbed habitats, are scanty. In these disturbed assemblages, the increase in abundance of large species with higher body mass may correspond to early cumulating biomass curves that may be wrongly interpreted as typical of mature and low disturbed assemblages with a dominance of species having high trophic level.

Our data support other previous cautionary interpretation of ABC curves, yet suggested also for invertebrates (Warwick & Clarke, 1994; Solyanko *et al.,* 2011; Magurran, 2004). Therefore, the assumptions linked to the ABC curves are probably not universal but limited only to assemblages where species with higher body mass show also a higher trophic level. Further researches are necessary in this regard, comparing bird assemblages in human-dominated environments vs. mature pristine habitats.

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