AREA-EFFECT IN BREEDING BIRD COMMUNITIES OCCURRING IN AN ARCHIPELAGO OF URBAN HOLM OAK FRAGMENTS (ROME, CENTRAL ITALY)

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ABSTRACT. – We carried out a study on breeding bird communities occurring in an archipelago of 32 holm oak fragments in an urbanized landscape (Rome, central Italy). The log-transformed species-area relationship is comparable with other “insular” situations obtained from analogous mainland fragmented landscapes. We observed a quick decrease of species number when area size is lower than 2 hectares, with a significant threshold at 1 ha, unlike rural areas in which a quick species decrement occurs on a higher area size range (<10 hectares). Species appear differently sensitive to area size of the fragments with significant responses in Dendrocopos major, Aegithalos caudatus, Sitta europaea, Parus major, Certhia brachydactyla and Fringilla coelebs. Considering the recreational role of the biodiversity for human populations inhabiting large metropolitan areas, the threshold in size (about 1 ha in fragment area) evidenced in this study may be useful for urban park management strategies.

INTRODUCTION

In insular biogeography, the relationship between habitat area and number of species is a widely studied issue, also extended to mainland fragmented landscapes (MacArthur & Wilson 1967, Diamond 1975, Watling & Donnelly 2006).

Area size of wood fragments represents the main predictor of species abundance and richness in many taxa occurring in fragmented landscapes. Among vertebrates, the effect of area size on number of species has been largely studied in birds (e.g., Galli et al. 1976, Ambuel & Temple 1983, Opdam et al. 1984, Blake & Karr 1987, Haila et al. 1993, McCollin 1993, Celada & Bogliani 1993, Hinsley et al. 1995, Bellamy et al. 1996a, 1996b, Frank & Battisti 2005, Lorenzetti & Battisti 2006).

In mainland landscape fragments, larger habitat fragments may include more opportunities in terms of habitat diversity and, consequently, resources, niches and general suitable conditions when compared to smaller fragments, thus hosting a larger number of species (Wiens 1989, Opdam et al. 1994).

Following habitat fragmentation, species with restricted habitat requirements tend to decrease in their spatial distribution range (e.g., decreasing their area of occupancy), abundance and, eventually, to become extinct. In this sense, a special issue concerns the area-sensitivity properties of the species, with “area-sensitive species” being those showing a lower reproductive and pairing success with a decrease in habitat area size and/or those species being frequently absent in small fragments (Villard 1998, Villard et al. 1999). Therefore, area-sensitivity is a species-specific feature linked to the minimum area required for an individual of a given species to establish a territory or to carry out a set of ecological functions (Wiens 1989, Bäßi 2004, Henle et al. 2004). Species may be sensitive to both type and degree of habitat heterogeneity, and minimum area requirement of a species may also depend on the structure and heterogeneity of a habitat remnant (Tews et al. 2004). In general, area-sensitive species are situated at high trophic levels and are characterized by narrow niche breadth, being also habitat specialists and with medium-large body size (e.g., Henle et al. 2004, Ewers & Didham 2006), whilst generalist species, linked to the edge habitats, increase in smaller fragments (non area-sensitive edge species; Bellamy et al. 1996a). Sensitivity of single species to habitat area loss in heterogeneous and/or fragmented landscapes has been widely studied (Andrén 1994, Wiens 1976, Fahrig 1997, 2003), especially in forest fragments embedded in natural or seminatural landscapes (Wilcove et al. 1986, Haila et al. 1993, Lorenzetti & Battisti 2006).

Urban parks represent a particular type of forest fragment. Indeed, they may be considered, as “habitat islands” included in highly anthropized matrices (Fernández-Juricic & Jokimäki 2001). Therefore they have been largely studied to explore patterns in species and abundance when changing their area size e.g., for their implications.
for nature conservation in urban areas (e.g., species-area effect, the role as remnant refugia or stepping-stones for area-sensitive species: e.g., Davis & Glick 1978, Gilpin 1980, Fernández-Juricic & Jokimäki 2001, Prugh et al. 2008)

In this paper we studied the patterns of richness and abundance of a set of breeding birds sampled in holm oak (Quercus ilex) wood fragments of different area size (and “archipelago” of urban parks), included in a large urbanized landscape. In particular, the aim of this study was to investigate the changes in species richness and abundance related to changes in area size and analyze them in terms of species-specific sensitivity, operating a distinction between area-sensitive and non area-sensitive species.

MATERIAL AND METHODS

Selection of wood fragments: study area corresponds to an archipelago of 32 oak wood fragments embedded in the urban landscape of Rome (central Italy), a metropolitan area 360 km²-in size that includes a heavily anthropized matrix (about 165 km²), green areas (historic villas, archaeological areas, meadows and uncultivated peripheral areas: about 175 km²) and a large river (Tevere). Altitude range between 15 and 139 m a.s.l.

Despite the impact of human presence and environmental degradation, natural phytocenoses include residual areas of forest, shrubland, riparian shrubland and rupetral vegetation, which spread mosaic-like right up to the centre of the city and connect outward with the fields and pastures of the Roman countryside. From the phytoclimatic point of view, the area under study is part of the Mediterranean transition zone (meso-mediterranean thermotype - average or lower hilly belt, subhumid umbrous-type, xerotheric/mesaxeric region; Blasi 1994).

Further data on the study area are in AA. VV. (1991), Cignini et al. (1995), Santori (1996).

Wood fragments studied ranged between 0.15 and 15 ha and are mainly composed by an autochthonous oak dominant species, the holm oak (Quercus ilex), belonging approximately to the same age classes (mainly ranging between 30 and 50 cm in diameter breast height; Arca, unpublished data). We calculated the area size (in hectares) of each fragment using a mapping software (GIS Mapinfo of Rome) scale 1:10,000. We assumed that the matrix surrounding each fragment was constant and comparable being composed from relatively spreadly urban settlements and infrastructures.

Bird sampling: we carried out the bird sampling in breeding period utilizing the line transect method (Jarvinen & Vaisanen 1973; Bibby et al. 2000), largely utilized in ornithological studies also in fragmented habitats (e.g., Villard 1998). We defined a line transect along the main longitudinal axis of each holm oak fragment (length range: 30-535 m). From 15 March to 10 June 2004, we walked along each transect at constant speed (about 1.5 km/h) for three randomly selected times in different visits belonging to different periods (I: early spring: 15 March-7 April; II: 23 April-18 May; III: 24 May-10 June). During the transect we checked any bird individual (at left and right) inside a fixed main belt of 25 m. We reported the records (number of individuals and species per fragment) on a data sheet.

Data analysis: for each fragment we obtained as dependent variables: (i) the number of breeding bird species (S), and (ii) a species-specific linear density index (d, as number of individuals/km). Then, we defined three classes of fragment area size (I: 0-1 ha; II: > 1-2 ha; > 2 ha) and calculated, for each of them, the mean number of sampled species (Smean) and the mean abundance (dmean).

Following the theory of insular biogeography (MacArthur & Wilson 1967, Margules & Usher 1981), applied to mainland (Diamond 1975), we calculated the log-transformed species-area relationship, as LogS = 0.26logA + c, where S and A are, respectively, the number of breeding bird sampled species and the area size of each fragment. To explicit the species data accumulation when increasing the area size of the fragments, we reported in a diagram the untransformed species-area relationship. Such a relation (MacArthur & Wilson 1967) is widely known with regard to its application on land ecosystems (compare for example, Diamond 1975) and, specifically, urban ecosystems (Niemelä 1999, Crooks et al. 2004, Fernández-Juricic 2004).

As regards data processing we performed a statistical analysis using: (i) the non-parametric Spearman rank correlation test to assess the significativity of the relationship between area size and number of species in the holm oak archipelago, and (ii) the non parametric Mann-Whitney U and Kruskal-Wallis tests when comparing the Smean and dmean values. We used the SPSS 11.5 for Windows software (SPSS Inc. 2003). Alfa was set at 0.5.

RESULTS

In spring 2004 we observed 26 breeding bird species in the whole of “archipelago” of 32 urban holm oak fragments. Among them, 17 were sampled in fragments smaller than 1 ha, 21 in fragments between 1 and 2 ha and 23 species in fragments larger than 2 ha (Table I).

Number of species was directly correlated to area size of the fragments (r = 0.74, p < 0.01). The log-transformed relationship species-area was LogS = 0.26logA + 0.98 (z value = 0.26; Fig. 1).

Differences among Smean values in the three area size classes are significant (H = 20.283; p < 0.01; Kruskal-Wallis test) with the higher value in the area size class > 2 ha (0-1 ha: 7 ± 2.20; > 1-2 ha: 12.17 ± 1.83; > 2 ha: 14.5 ± 3.77). We observed a threshold in Smean value between the size classes 0-1 and > 1-2 ha (U = 3.566, p < 0.01), while we did not observe a statistical difference between the size classes > 1-2 and > 2 ha.

At species level, Streptopelia decaocto, Dendrocopos major, Aegithalos caudatus, Sitta europaea were sampled
only in fragments larger than 2 ha (Table I). Moreover, we observed a significant decrease in $d_{\text{mean}}$ of *Columba livia* forma domestica when increasing the area size from fragments smaller than 1 ha to fragments larger than 2 ha; we also observed a significant increase in three forest species: *Parus major*, *Certhia brachydactyla* and *Fringilla coelebs* (Table I).

**DISCUSSION**

Increasing the area size of the holm oak fragments, number of species significantly increase. In the species-area relationship, $z$ value is included in the range known for ecological islands (0.17-0.72, Begon et al. 1989, see the review in Watling & Donnelly 2006), analogously to data-set obtained from others urban fragment archipelagos (e.g., Niemelä 1999, Fernández-Juricic 2001).
Holm oaks are woods with a low habitat and structural heterogeneity (e.g., Garcia & Retana 1996, Pulido et al. 2001, Cierjacks & Hensen 2004), especially when undergrowth clearing is carried out (Camprodon & Brotons 2006). Since area size is strongly and directly correlated to habitat heterogeneity (MacArthur & Wilson 1967, Tews et al. 2004), the increase of holm oak fragment area positively affect their internal heterogeneity, so increasing the availability of resources and niches for more specialized species. Consequently, an increase either of the probability of occurrence of individuals (and breeding pairs) or the total number of species may be observed progressively increasing the fragment area size.

Furthermore, under 2 hectares the curve indicates a quick reduction of species number, whilst between 2 and 10 hectares the number of species tends to cumulate, analogously with evidences from others urban areas (e.g., Fernández-Juricic & Jokimäki 2001). In particular, we observed a significant threshold in mean number of species between the lower size classes (i.e., 0-1 and > 1 ha). The comparison between data belonging to “archipelagos” of urban landscapes and analogous samples of fragments of non-urban environments, shows as in the latter the thresholds occur between 10 and 100 hectares (Moore & Hooper 1975, Lorenzetti & Battisti 2006). The anticipated accumulation occurring in archipelagos included in urbanized landscapes may be the consequence of a lower number of bird species breeding in urban forest fragments with the absence (or occasional occurrence) of species at higher trophic level (e.g., woodpeckers, hawks etc.). Moreover, the presence of a very different surrounding matrix (urbanized vs. agricultural) may imply different dispersal patterns, habitat availabilities and connectivity, limiting factors for the breeding bird species occurring in the rural or urban isolated fragments (Sisk et al. 1997, Bélisle & Desrochers 2002, Arendt 2004, Chace & Walsh 2006).

Species appear differently sensitive to area size of the fragments. Columba livia forma domestica is the only taxon decreasing their mean density when increasing the area size because of their high synanthropy and generalism (e.g., Johnston & Janiga 1995, Sacchi et al. 2002, Razzetti et al. 2004; for the nomenclature see also Battisti & Zapparoli 2011). A set of species occurred only in the larger fragments while others increase their mean density when increasing the area size. Some of these species cover territory or home range wider than 1-2 hectares (e.g., woodpeckers); therefore it is presumed we do not find individuals of these species within smaller fragments. Except for Streptopelia decaocto, a synanthropic dove linked to urbanized habitats, all the species are widely known as strictly forest area-sensitive and/or interior species in fragmentation studies (Dendrocopos major, Aegithalos caudatus, Sitta europaea, Parus major, Certhia brachydactyla and Fringilla coelebs; e.g., Hinsley et al. 1995, Matthysen et al. 1995. Bellamy et al. 1996a, 1996b, Matthysen & Adriaensen 1998).

Considering the recreational role of the biodiversity for human populations inhabiting a large metropolitan area (an intrinsic value and an ecosystem service; McKinney 2002, Wallace 2007) and the concern on the homogenization and decreasing value of the bird component (Blair 2001, Clergeau et al. 2006), the threshold in size (about 1 ha in fragment area) evidenced in this study may be useful for holm oak park management strategies focused on an increase in species richness in this type of forest remnant ecosystems (see also Niemelä 1999).

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