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High density of bird and pest species in urban habitats and the role of predator abundance

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A low abundance of predators has been considered an important factor influencing a number of ecological phenomena in urban environments including, in particular, the high population density of some bird and pest species. A low abundance of predators in urban parks also supports the habitat island approach to natural areas in cities since reduced numbers of predators are usually found on islands. Few studies have simultaneously investigated the abundance of birds and their predators in an urban context. The results of this study confirm that the densities of pests (i.e., Feral Pigeons, Starlings, rats, Western House Mice) and most bird species are higher in open-land habitats of urban parks and agricultural urban parks than in open-land habitats in the nearby countryside. Additionally the density of predators (i.e., Kestrels, nocturnal raptors, crows, rats, foxes, cats and dogs) was higher in urban parks. The hypothesis that one of the main causes of some urban ecological phenomena is the scarce predator abundance has to be investigated.

1. Introduction

The role of predation as a potential factor regulating prey populations has long been a topic of debate. It has been shown that predation can have differing effects on demographic parameters of animal species (Lack 1966, Begon *et al.* 1986, Martin & Clobert 1996). Our interest in the importance of predation as a regulating factor of bird populations in urban environments arises from several arguments. Firstly, the higher population density of some bird species in urban natural areas when compared with similar areas in the countryside (Tomiałojć & Profus 1977, Hough 2000) has been related to the lower abundance of predators (Erz 1966, Tomiałojć 1985, Luniak & Muslow 1988). This higher density may alternatively be explained by the warmer microclimate and by greater food availability (Lancaster & Rees 1979, Jokimäki & Suhonen 1998), a parameter considered by most authors to be the main factor limiting animal populations (Lack 1954, Newton 1979, Martin 1987). Other authors suggest that interplay of food and predation is the most important factor in regulating animal abundance (McNamara & Houston 1987, Karels *et al.* 2000).

Secondly, a lower number of predators in urban parks would also support the theory of island biogeography as applied to natural areas in cities (Cody 1971, MacArthur *et al.* 1972, Jokimäki 1999) or a habitat island approach (Fernández-Juricic & Jokimäki 2001). On islands, a scarcity of predators, lower species diversity, and a higher abundance of individuals is often observed compared to the adjacent mainland.

Fig. 1. Study area map. UP = 'Villa Pamphili' urban park; AUP = 'Valle dei casali' urban-agricultural park; AA = 'Portuense' agricultural area.

Finally some pest species, such as Feral Pigeons *Columba livia*, Starlings *Sturnus vulgaris*, crows, rats, and Western House Mice *Mus domesticus* live at higher densities in cities (e.g. Palmer 1973, Richards 1989, Jokimäki & Suhonen 1998). Some researchers have suggested that this may be related to a lower predation pressure in urban environments, and that increasing predator populations in cities might help to control pest species (Hough 2000).

The main aim of this paper is to test if the high density of bird and pest species observed in cities is due to a low incidence of predation resulting from low numbers of predators. To test this hypothesis, the abundance of bird and pest species, and their predators were investigated in the openland of two urban parks and in the nearby countryside.

2. Methods

2.1. Study areas

The research was carried out between April 1998 and January 1999 in three areas in and around Rome (Fig. 1): (1) the urban park 'Villa Pamphili' (hereafter: UP; 180 ha), (2) the agricultural urban park 'Valle dei Casali' (hereafter: AUP; 200 ha; 200 m distant from UP), (3) the agricultural areas close to the 'Portuense' avenue (hereafter: AA; 400 ha; about 5 km from UP and AUP). Agricultural urban parks and urban parks are the two more common kinds of natural areas in Rome. UP is one of the typical Villas of Rome. It was declared an urban park in the 60s. Inside the park, openland habitats are uncultivated and their only management is grass cutting carried out 8–10 times a year. According to the land use map of UP, 46.4% of the area consists of meadows, 37.9% of woods, and 15.7% of bushes or meadow with scattered trees. Citizen diurnal access is unlimited and during some days (e.g., week-ends, particularly in spring time) citizen presence is very high. AUP was declared a protected area in 1991 and since then building has been prohibited. AUP represents a typical example of the agricultural areas included in the urban territory. According to the land use map of AUP, 53.2% of the area is occupied by open-land habitats, 37.9% by bushes, meadow with scattered trees, reduced reed thickets and orchards, and 8.9% by woods. In AUP and AA, open-land habitats consist of sheep pastures and intensively cultivated areas with cereal crops. However, in AA there are fewer hedges and small woods bordering cultivated and pasture areas. AA is a typical example of the intensive agricultural use of most countryside surrounding Rome. According to the Corine Land Cover database (see Krynitz 2000), 63.6% of the area is occupied by cultivated and pasture patches, 21.6% by quarries of gravel, 13.2% by natural areas, 1.6% by industrial and commercial areas.

2.2. Breeding Communities

In order to avoid the confounding factor of habitat-type, avian breeding community censuses were performed only in open-land habitats, where arboreal or bush cover was lower than 10%. In each study area 14 point count stations were established (100 m-radius from the observer and 10 min long)(Sorace *et al.* 2000b). The use of a fixed-radius sampling protocol ensured that the birds recorded were using the habitat under investigation (Drapeau *et al.* 1999). In AUP and AA, seven point count stations were established in cultivated as well as pasture areas. The point counts were repeated three times (in April, May and June 1998), in the early morning of working days (6.30–10.00 a.m.), on sunny days, without heavy wind. Each round was completed within a week. To reduce the influence of the surrounding habitat on data collection, the immediate surrounding of the census points (at least within 200 m from the census point) were open-land habitats. One point (one pair) was given to a singing bird, a pair, a family group, and a bird carrying food for the young, and 0.5 points to observed individuals and to birds uttering vocalisations different from species song (Blondel *et al.* 1981).

The highest number of pairs recorded was kept for each species in each of the 14 point counts carried out in one study area. The number of censused pairs of one species in each of the three study areas was calculated as the mean number of pairs recorded in the different point counts. Abundance (A) was the sum of these means. The body mass of each species, for use in calculating biomass (in kilograms), was obtained from the files of a local association of ringers, while the body mass of the Feral Pigeon was as reported in Sorace *et al.* (1997).

2.3. Predators

The following species or groups of them were taken into account as possible predators of birds in the study areas: Kestrels *Falco tinnunculus* (Village 1990), owls and woodpeckers (Cramp 1985), magpies and crows (Erikstad *et al.* 1982, Goodwin 1986, Fernández-Juricic & Jokimäki 2001), rats (Blondel 1985, Courchamp *et al.* 1999), foxes *Vulpes vulpes* (Harris 1986), mustelids (Blondel 1985), cats (Fitzgerald 1988), and dogs (Boitani *et al.* 1995, Yanes & Suárez 1996). Kestrels and owls (Tawny Owl *Strix aluco*, Barn owl *Tyto alba*, Little Owl *Athene noctua*) were included because in the study areas their predation upon birds may be considerable (Manganaro *et al.* 1990, Manganaro *et al.* 1999, Fattorini *et al.* 1999). Squirrels were not taken into account because they are present in few sites of the territory of Rome that do not include the study areas (Cignini *et al.* 1997).

Data on the abundance of crows (Carrion Crow *Corvus corone cornix*, Magpie *Pica pica* and Jackdaw *Corvus monedula*) woodpeckers, and Kestrels were collected during the same period as the point counts carried out for breeding birds. Nocturnal raptors were censused by means of the playback recording technique (Sarà & Zanca 1989). The species were stimulated after dusk for five minutes (alternating one min of emission and one of listening) and every calling response or observed individual was recorded as one pair. The

Little Owl was stimulated in June 1998 from 10 point counts in each study area. The Tawny Owl was stimulated in the same month from 5 point counts in woods or thickets close to the open-land. The playback recording technique is not applicable to the censusing of the Barn Owl (Sarà & Zanca 1989). Therefore, recordings of individual or spontaneous Barn Owl song were counted during the 10 evening point counts arranged to census Little Owls.

Rodent presence was investigated by means of Barn Owl pellets (Glue 1967, Wendland 1981). Barn Owl pellets were collected during the spring-summer 1998 from inside agricultural and abandoned buildings. Since pellets were not found in UP during the study period, for this area data from pellets collected in the spring of 1992 were used. In Central Italy yearly differences in small mammal community composition are low. For example, the affinity index between seasons ranged from 0.5 to 0.6, whereas the affinity index between years ranged from 0.7 to 0.9 (Contoli 1980). Therefore, the different year of pellet collection should not seriously affect the results. The number of individuals was determined by means of jaw computation (Toschi & Lanza 1959, Toschi 1965, Chaline *et al.* 1974), which provides an accurate picture of eaten prey (Shawyer 1994).

The number of dogs and cats was recorded along a 4 km transect that included the areas where the breeding bird census was carried out. Transects were walked, in the morning, five times (3 in spring 1998 and 2 in winter 1998–1999). Each time, transects were carried out within a week in all areas. Fox and mustelid concentration was evaluated by counting faeces along the same 4 km transect. The assumptions of this method are the random distribution of faeces, the detection of all faeces, the population stability while sampling is carried out. They are often not met in practice (Beltrán *et al.* 1991). Therefore, this method may be only used to evaluate the relative abundance of medium-size mammal predators (Pullianen 1981, Beltrán *et al.* 1991).

For each species the mean of the individuals or faeces recorded in the five transect sessions was calculated. The figure obtained was divided by the transect length to calculate the number of individuals per kilometre (Beltrán *et al.* 1991).

2.4. Statistical Analysis

Data were analysed by non-parametric tests with Yates and Bonferroni correction where appropriate (Siegel 1980). The Kruskal-Wallis test was used to compare the values of abundance, richness and biomass per point count in the three study areas, while the Mann-Whitney test was used to compare the same values between two areas. A χ^2 test was used to compare counts of small mammals. Since a higher abundance in a study area might stem from both a higher richness and different bird community composition (i.e. one or more species exclusive to an area where they are particularly abundant), the abundance of species shared by all areas was also compared. Data on repeated counts of dogs, cats and foxes were analysed by the Friedmann test when comparing all study areas and by the Wilcoxon test when comparing two areas. Two-tailed probabilities are reported throughout, apart from comparison regard-

Table 1. Parameters of bird breeding community in the study areas calculated excluding predators (i.e. raptors and crows). Parameters are reported as means (± SD) per point count. Abundance (pairs/point count) and Biomass (kg) are reported taking into account either all species of each area or only species shared by all study areas. UP = Urban Park; AUP = Agricultural Urban Park; AA = Agricultural Area. Within a row different letters superscript are significantly different (P < 0.05).

	UP (180 ha)	AUP (200 ha)	AA (400 ha)
Abundance (all species)	$15.9^{a} \pm 4.9$	$22.8^{b} \pm 11.7$	$11.8^{c} \pm 3.8$
Abundance (shared species)	$15.4^{a} \pm 4.6$	$21.3^{a} \pm 11.8$	$10.6^{b} \pm 3.6$
Biomass(all species)	$1.17^{a} \pm 0.77$	$1.98^{a} \pm 3.06$	$0.43^{b} \pm 0.34$
Biomass(shared species)	$1.16^{a} \pm 0.76$	$1.90^{a} \pm 3.05$	$0.36^{b} \pm 0.35$
Richness	$10.6^{a} \pm 2.0$	$13.2^{b} \pm 2.8$	$8.9^{c} \pm 3.2^{c}$
Number of point count stations	14	14	14

ing abundance and biomass of both bird and pest species. A lower abundance and biomass of these species in AA compared to the other two sites are expected (see references in the introduction) and one-tailed probabilities are reported. All statistics were conducted by means of Windows Statistica software.

3. Results

3.1. Breeding community and pest species

Excluding predators (i.e. Kestrel and crows), bird abundance per point count was significantly higher in AUP and UP than in AA ($H_{2,42}$ = 15.3, P = 0.0002; Table 1). Biomass results were similar ($H_{2,42}$ = 19.2, P = 0.0001; Table 1). Abundance per point count was also significantly higher in AUP than UP, whereas significant differences for biomass values between these two parks were not observed (Table 1). Richness was higher in AUP than in UP and AA ($H_{2,42}$ = 14.6, P = 0.0007; Table 1). Although richness was higher in AA than in UP (Table 2), the number of species per point count was higher in UP than in AA (Table 1). Excluding predators, 83.3% of species shared by all areas were more common in the two urban parks than in AA (Table 2). Abundance per point count of species shared by all areas was statistically significantly higher in AUP and UP than in AA ($H_{2,42}$ = 17.2, P = 0.0001; Table 1). Biomass

Table 2. Mean number of individuals per point count for each species, total of these means (Abundance), and number of species (Richness) in the three study areas. The first 17 species in the table are those shared by all study areas (see Table 1 for symbols).

	UP	AUP	AA
Feral Pigeon *Columba livia*	2.64 ± 3.56	5.14 ± 10.8	0.50 ± 1.29
Fan-tailed Warbler *Cisticola juncidis*	0.57 ± 0.62	2.14 ± 0.60	2.21 ± 0.58
Italian Sparrow *Passer italiae*	1.79 ± 0.47	1.82 ± 0.46	1.89 ± 0.59
Starling *Sturnus vulgaris*	2.04 ± 0.69	1.79 ± 1.33	0.18 ± 0.37
Blackbird *Turdus merula*	1.43 ± 0.73	1.46 ± 0.80	0.61 ± 0.68
Goldfinch *Carduelis carduelis*	1.32 ± 0.42	1.21 ± 0.43	1.11 ± 0.66
Wren *Troglodytes troglodytes*	0.71 ± 0.73	1.14 ± 0.72	0.14 ± 0.36
Sardinian Warbler *Sylvia melanocephala*	0.21 ± 0.43	1.11 ± 0.56	0.36 ± 0.63
Greenfinch *Carduelis chloris*	0.71 ± 0.73	1.04 ± 0.89	0.64 ± 0.53
Serin *Serinus serinus*	1.04 ± 0.75	0.89 ± 0.84	1.00 ± 0.90
Blackcap *Sylvia atricapilla*	1.04 ± 0.63	0.86 ± 0.57	0.14 ± 0.36
Cetti's Warbler *Cettia cetti*	0.29 ± 0.47	0.71 ± 0.99	0.36 ± 0.50
Stonechat *Saxicola torquata*	0.29 ± 0.43	0.61 ± 0.49	0.36 ± 0.53
Pied Wagtail *Motacilla alba*	0.36 ± 0.50	0.50 ± 0.52	0.29 ± 0.43
Nightingale *Luscinia megarhynchos*	0.36 ± 0.50	0.46 ± 0.66	0.29 ± 0.47
Tree Sparrow *Passer montanus*	0.39 ± 0.49	0.29 ± 0.51	0.50 ± 0.52
Great Tit *Parus major*	0.21 ± 0.43	0.11 ± 0.29	0.07 ± 0.27
Bee-eater *Merops apiaster*		0.18 ± 0.37	0.36 ± 0.53
Skylark *Alauda arvensis*		0.25 ± 0.38	0.29 ± 0.43
Crested Lark *Galerida cristata*		0.36 ± 0.50	0.18 ± 0.32
Corn Bunting *Miliaria calandra*		0.21 ± 0.43	0.07 ± 0.27
Turtle Dove *Streptopelia turtur*		0.11 ± 0.29	0.14 ± 0.31
Quail *Coturnix coturnix*		0.07 ± 0.27	0.07 ± 0.27
Red-backed Shrike *Lanius collurio*		0.11 ± 0.29	
Blue Tit *Parus caeruleus*	0.04 ± 0.13	0.04 ± 0.13	
Hoopoe *Upupa epops*		0.04 ± 0.14	0.04 ± 0.13
Collared Dove *Streptopelia decaocto*		0.04 ± 0.13	
Chaffinch *Fringilla coelebs*	0.11 ± 0.29		
Spotted Flycatcher *Muscicapa striata*	0.32 ± 0.54		
Abundance	15.86	22.79	11.79
Richness	20	27	24

results were similar ($H_{2,42}$ = 17.1, P = 0.0002; Table 1). Differences for abundance and biomass values between AUP and UP were not statistically significant (Table 1).

Abundance per point count of Feral Pigeons was higher in AUP and in UP than in AA ($H_{2,42}$ = 9.3, P = 0.004; Table 2). Starling results were similar ($H_{2,42}$ = 21.8, P = 0.0000; Table 2). Differences between AUP and UP for the abundance of these two species were not statistically significant ($Z_{14,14}$ = 0.2, P = 0.85 and $Z_{14,14}$ = 0.7, P = 0.46, respectively; Table 2). Numbers of Brown Rat *Rattus norvegicus*, Black Rat *R. rattus* and Western House Mice pooled together were higher in AUP than in AA (χ^2_1 = 4.3, P = 0.02), while other differences between study areas were not significant (Table 3).

3.2. Predators

Counts of Kestrels were higher in AUP than in AA and above all in UP ($H_{2,42}$ = 7.0, P = 0.03; Fig. 2). Differences for number of kestrel per point count between AA and both AUP and UP were not statistically significant (Fig. 2). The mean number of Little Owl pairs recorded per evening point count were not different across sites ($H_{2,30}$ = 2.8, P = 0.24; Fig. 2). Barn Owls were observed in AA and in AUP respectively in three and two evening point counts (Fig. 2) while in UP they were not observed. The Tawny Owl was more abundant in UP than in AUP ($Z_{5,5}$ = 2.1, P = 0.04; Fig. 2), while in AA they were not found. Woodpeckers were not recorded. The abundance

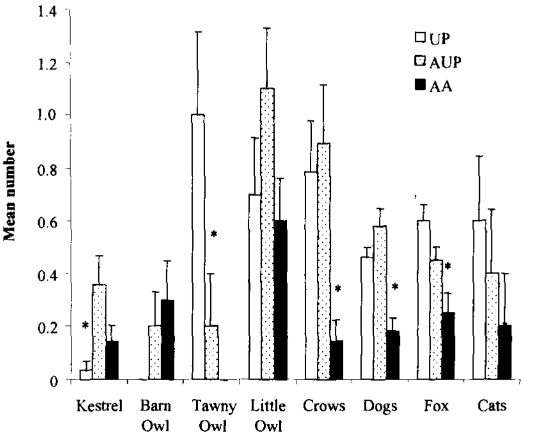

Fig. 2. Mean number (±SE) of different predators in both the urban park (UP), the agricultural urban park (AUP), and the agricultural area (AA). For bird species mean number of individuals per point count is reported, while for dogs, cats, and fox faeces mean number of individuals per 4-km transect is reported. Actual number of dogs was divided by 10, while number of fox faeces was divided by 4. A bar indicated by * differs from other bars at the level P < 0.05.

of crows (Carrion Crow, and secondly, Magpie and Jackdaw) was lower in AA than both AUP and UP ($H_{2,42}$ = 9.4, P = 0.009; Fig. 2). Differences between AUP and UP were not statistically significant (Fig. 2). The number of cats observed in the study areas did not significantly differ between the study areas ($\chi^2_{2,5}$ = 1.5, P = 0.47; Fig. 2). The quantity of dogs was significantly higher in AUP and UP than in AA ($\chi^2_{2,5}$ = 8.3, P = 0.02; Fig. 2), while differences between AUP and UP were not statistically significant (Fig. 2). The mean

Table 3. Number and relative frequencies (fi) of small mammals found in pellets collected in the study areas (see Table 1 for symbols). Pest species (rats and Western House Mouse) are reported in the first three rows.

	UP	fi	AUP	fi	AA	fi
Brown Rat *Rattus norvegicus*	2	0.01	1	0.01	1	0.01
Black Rat *Rattus rattus*	8	0.04	5	0.06	6	0.04
Western House Mouse *Mus domesticus*	47	0.25	29	0.36	33	0.23
Savi's Pine Vole *Microtus savii*	79	0.42	28	0.35	74	0.52
Wood/Yellow necked Mouse *Apodemus* sp.	43	0.23	14	0.17	18	0.13
Pygmy White-toothed Shrew *Suncus etruscus*	5	0.03	2	0.02	3	0.02
Bi-coloured White-toothed Shrew *Crocidura leucodon*	1	0.01	–	–	–	–
Lesser White-toothed Shrew *Crocidura suaveolens*	4	0.02	2	0.02	5	0.04
Total	189		81		140	

number of fox faeces was higher in UP and, to a lesser extent, in AUP than in AA ($\chi^2_{2,5} = 8.6$, $P = 0.01$; Fig. 2). Differences for number of fox faeces between AUP and both UP and AA were not statistically significant (Fig. 2). Faeces of mustelids were not found.

4. Discussion

The results support the idea that urban parks have a higher density of bird and pest species (i.e. Feral Pigeon, Starling, Carrion Crow, House mouse, Rats) compared to nearby countryside areas (Tomiałojć & Profus 1977, Luniak & Muslow 1988). Solonen (2001) noted in his 7-year nestbox study in southern Finland, that the average clutch size and fledgling production of the Great Tit *Parus major* and the Blue Tit *Parus caeruleus* was lower in the urban area than in the rural area. Urban Blue Tit and Great Tit average densities were respectively threefold and sevenfold that of rural areas. However, the annual nest predation rate was higher in the rural (9.3%) than in the urban areas (1.4%). Therefore other factors (interspecific competition, differences in bird densities between areas, food quality etc.) rather than nest predation might explain the difference in breeding success between urban and rural areas in Solonen's study. Some researchers suggest that a high density of birds in urban habitats is related to reduced predation and/or to wider availability of food resources (Lancaster & Rees 1979, Tomiałojć 1985, Luniak & Muslow 1988). In particular, according to the 'safe zones' hypothesis, in urban environments a low predation pressure is observed as an effect of the low abundance of natural predators (Tomiałojć 1982, Gering & Blair 1999, Kosiński 2001).

The results of the present study do not support the hypothesis that the high abundance of bird and pests species observed in cities is due to a low incidence of predation resulting from low numbers of predators. Overall, a higher density of predators (i.e. Kestrels, nocturnal raptors, crows, rats, foxes, cats, and dogs) was observed in the two urban parks compared to the agricultural area. Haskell *et al.* (2001) also found that the total number of predators increased with housing density. In their study sites in Tennessee, urbanization increased populations of most predators (Blue Jays *Cyanocitta cristata*, cats, Racoon *Procion lotor*, Opossum *Didelphis marsupialis*) but decreased populations of others (American Crow *Corvus brachyrhynchos*) and did not change the abundance of dogs.

With regards to the Rome metropolitan area, a high abundance of Kestrel, Tawny Owl, Little Owl, Jackdaw and rats is reported (Cristaldi & Ieradi 1993, Manganaro *et al.* 1996, Salvati & Vogel 1998, Salvati *et al.* 1999). Moreover, studies in other cities highlighted a strong concentration of other predators such as Sparrowhawk *Accipiter nisus*, Peregrine *Falco peregrinus*, Hobby *Falco subbuteo*, Merlin *Falco columbarius*, gulls, Racoon, and Beech Marten *Martes foina* (Peske 1992, Sodhi *et al.* 1992, Hardwick 1994, Riley *et al.* 1998). Also the numbers of crows and magpies (important nest predators) are increasing in cities (Gregory & Marchant 1995, Fernández-Juricic & Jokimäki 2001) and are higher in towns than in nearby countryside (Richner 1990, Jokimäki & Huhta 2000). Finally some studies report a very high nest predation rate in urban parks (Sasvari *et al.* 1995, Matthews *et al.* 1999, Jokimäki & Huhta 2000. See also Tomiałojć 1982, Adams 1994, Gering & Blair 1999, Kosiński 2001 for contrasting ideas).

A problem with the shown data might be that the survey method was ineffective in recording a few predators such as woodpeckers and mustelids, since these predators are surely present in the Rome territory (Boano *et al.* 1995, Amori *et al.* 1997). However, the author observed woodpeckers in the past only in the woods of the two study urban parks (UP and AUP) and never in the agricultural area (AA). With regards to mustelids, they were never recorded by the author in the study areas in spite of many past visits to them over the previous 20 years. Thus, if these mammals are present in the study areas, they are likely to be very scarce. It should be pointed out that snakes are sometimes important predators upon wood passerines in Mediterranean areas (Sorace *et al.* 2000a). Over the data collection for the present study only one Western Whip Snake *Coluber viridiflavus* was recorded in the agricultural urban park. Moreover, no reference reports a high density of snakes in Rome and the surrounding territory. However, the abundance of these predators and their impact upon avian preys in urban areas and in the nearby countryside has to be better investigated (Haskell *et al.* 2001).

Since the abundance of predators was higher in urban habitats than in nearby rural habitats, other factors such as better climatic conditions and greater food availability might explain the high density of bird and pest species in cities (Lancaster & Rees 1979, Jokimäki & Suhonen 1998). This high prey concentration might promote a higher predator density (Lack 1954, Newton 1979, Boutin 1990). It has been reported that some predators (i.e. Kestrel, Tawny Owl) changed their feeding items when moving from agricultural areas (rodents) to urban areas (passerine birds)(Lack 1966, Cramp 1985, Village 1990). However, this hypothesis requires a careful revision taking into account the complex interactions of prey-predators occurring in natural communities. Some species (e.g. magpies, crows) are important nest predators (Erikstad *et al.* 1982, Jokimäki & Huhta 2000), whereas other species (e.g. Falcons, Owls) could eat adult birds (Village 1990, Cramp 1985). These two groups of predators might have a different impact on urban bird communities and the heavier predators might have a lower abundance in urban environments. It should be noted that the invasion of magpies and crows in towns is a worldwide phenomena, whereas the invasion of other predators such as Falcons is a more restricted phenomena (see references above). However, this does not seem to be a problem for the present results because the abundance of both kinds of predators was high in the two urban sites. In every case, a better knowledge of feeding habits of urban predators and of their use of alternative artificial food sources (garbage, refuse containers) is necessary (Haskell *et al.* 2001, Kosiński 2001).

Predation pressure along an urban gradient is usually studied by means of either artificial nests or measuring predator abundance. Both approaches raise problems and in particular, regarding the latter, high predator concentration might not translate directly into high bird predation (Haskell *et al.* 2001). Moreover, some predators, such as raptors, crows and foxes, may exhibit an increased abundance in urban areas due to both reduced human persecution and the greater availability of breeding and resting sites (Newton 1979, Cramp 1985, Harris & Rayner 1986, Jokimäki 1999). For example, nest-box studies showed that nest-site availability is a limiting factor for raptor species such as the Barn Owl and Kestrel (Kaeser & Schmid 1989, Taylor & Walton 2000). Furthermore, animals can exist at high densities in "sink" habitats if there are many animals filling up the "source" habitat. So, the presence of predators in the urban zones could merely mean that the agricultural landscape was full (territorially) and subordinate birds came into the city. However, besides the species not recorded in the agricultural area (Tawny owl), the abundance of other species in this area is very low, so it does not seem to constitute for them a source habitat. This is the case, for example, of crows (0.14 pairs per point count) compared to the densities reported in literature (Cramp & Perrins 1998).

A habitat island approach may be useful for a correct management and conservation of urban birds (Fernández-Juricic & Jokimäki 2001). The higher density of individuals in the two urban parks than in nearby countryside areas supports the idea that the island biogeography theory may be applied to parks in urban environments (Cody 1971, MacArthur *et al.* 1972, Jokimäki 1999). However, on true islands, as compared to mainland, the increased abundance of individuals is related to a lower number of predator species and to niche enlargement phenomena (Cody 1971, MacArthur *et al.* 1972). Therefore, as far as predator abundance is concerned, the results of the present study do not support the application of the island biogeography theory to 'urban islands'. However, on true islands only large mammalian predators are usually absent (Sondaar 1977). Other carnivores, such as birds of prey, can pose a great threat to vertebrate prey species (Alcover & McMinn 1994). In some cases small- and medium-sized predators can be more common on islands than on the mainland thus constituting an important selective factor and even causing local species extinction (Johnson & Stattersfield 1990, Penloup *et al.* 1997, Courchamp *et al.* 1999). In the present study, only small- and medium-sized predators were observed. Thus, their higher abundance in the urban parks does not automatically rule out the application of the island biogeography theory to 'urban islands', but more detailed information on this subject is necessary.

As far as urban bird management is concerned, these findings suggest that, although it was shown that high predator density does not cause a general reduction of bird species abundance, the impact of predators upon species of conservationist concern needs to be better evaluated in an urban landscape (Jokimäki & Huhta 2000). In particular ground-nesters may be negatively affected by strong predation pressure (Jokimäki 1999, Jokimäki & Huhta 2000, Bro *et al.* 2001). Thus the control of predators might be appropriate in some urban habitats, rather than their promotion to reduce pest species abundance. Unfortunately, a limited knowledge is available on which species represent the most danger to birds (Haskell *et al.* 2001; see also above discussion). Some native predators might have a greater impact on bird clutches than the equivalent number of cats (Haskell *et al.* 2001). However, rates of bird predation and predators involved in nest predation may differ geographically. For example in Finnish towns predation on artificial ground nests was mainly due to corvids (Jokimäki & Huhta 2000), whereas cats probably caused most breeding failures in Krotoszyn (Poland) (Kosiński 2001).

Few urban studies related the abundance of birds to that of their predators (Jokimäki & Huhta 2000). Although conducting a similar investigation on a larger scale could be difficult, further research could confirm the results of the present study with a wider sample size and in other habitats and cities. In particular, an issue that should be investigated is that the present research was looking at an 'island' of habitat surrounded by increasing urbanization, following the 'Habitat Island approach'. It may be interesting to conduct some similar research looking at increasing urban land use, following the 'Countryside biogeography' approach (Daily 2001).

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Selostus: **Petojen runsauden vaikutus lintutiheyteen kaupunkiympäristössä**

Vähäistä petojen määrää pidetään merkityksellisenä kaupunkiekologisena ilmiönä. Petojen vähäisyyden on katsottu olevan yksi syy tiettyjen lintulajien suuriin tiheyksiin kaupunkialueilla. Tosin vain harvat tutkijat ovat selvittäneet yhtäaikaisesti kaupungissa pesivien lintulajien tiheyksiä ja niitä saalistavien petojen määriä kaupunkialueilla. Kaupunkien puistojen voidaan katsoa muistuttavan valtamerten saaria. Eristäytyneitä puistoja ympäröi monille lintulajeille elinkelvoton rakennettu kaupunkiympäristö. Valtameriympäristöstä johdettu saarimaantieteellinen teoria voisikin kirjoittajan mukaan olla sovellettavissa kaupunkiympäristöön. Kirjoittaja kartoitti vuosina 1998–1999 lintujen ja petojen määriä Roomassa kolmella erityyppisellä alueella: 1) kaupunkipuistossa (180 ha), 2) kaupunkialueella sijaitsevalla maanviljelysalueella (200 ha) ja 3) kaupungin lähistöllä sijaitsevalla maanviljelysalueella (400 ha). Lintulaskennat tehtiin ainoastaan tutkimusalueiden avomaa-alueilla. Jokaisella tutkimusalueella sijaitsi 14 laskentapistettä. Kustakin pisteestä laskettiin linnut kolme kertaa pesimäkauden aikana. Tutkimusalueilla pesivien lintujen lisäksi kirjoittaja selvitti potentiaalisten petojen määrän tutkimusalueilla. Tulokset osoittivat, että monien tuholaisiksi luokiteltavien eläinten (pulu, kottarainen ja kotihiiri) sekä useimpien lintulajien määrät olivat kaupunkialueilla korkeampia kuin kaupungin läheisellä maanviljelysalueella. Myös petojen määrä (tuulihaukka, pöllöt, varislinnut, rotat, kissa ja koira) oli kaupunkikoealoilla suurempi kuin kaupungin läheisyydessä sijaitsevalla maanviljelysalueella. Tässä mielessä kaupunkipuistot eroavat valtamerten saarista. Petojen runsas määrä ei siis johtanut potentiaalisten saalislajien alentuneisiin tiheyksiin kaupunkialueella. Tulokset kyseenalaistavat väitteen kaupunkiympäristöstä petovapaana vyöhykkeenä. Oletettavasti muutkin tekijät kuin vain petojen määrä vaikuttavat lajien runsauteen kaupunkiympäristöissä. Esimerkiksi runsas ravinnontarjonta ja kaupunkien lämmin pienilmasto voivat houkutella lintuja kaupunkeihin. Kirjoittaja toteaa, että tarvitaan lisätutkimuksia petojen ympäristönkäytöstä sekä ravinnonvalinnasta kaupunkiympäristössä.

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