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Changes in breeding bird communities of two urban parks in Wrocław across 40 years (1970–2010): before and after colonization by important predators

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Abstract: Bird censuses were carried out in two parks of Wrocław, a down-town one (Słowacki Park, 7–7.5 ha) and in a 17 ha section of the larger Szczytnicki Park, once a riparian forest. In the first one, counts were performed each year in 1970–1999 and 2008–2010, while in the second one during 1970–1974, 1986–1988, 2000–2002 and 2009–2010. Territory mapping method (8–10 to 10–12 visits/season) was applied by the same observer, recently using a hearing apparatus and visiting plots more often. The parks differ by: (a) Słowacki Park – tree stand with few bushes planted before 1900, intensive human presence, with Hooded Crows *Corvus cornix* present since 1972, (b) Szczytnicki Park – high luxuriant tree stand with few bushes on alluvial soils,, moderate numbers of visitors and predators arrived mostly in the late 1970s (two marten species, sporadic raptors and Hooded Crows). In both areas usually a few to a dozen of artificial nest boxes were present. Due to war devastations, both parks were in a "wild" state till the 1960s. After restored predation an overall density of breeding birds dropped in Słowacki Park from c. 294 to 173 p/10 ha, with significant declines of previously abundant species (Wood Pigeon *Columba palumbus,* Collared Dove *Streptopelia decaocto,* Rook *Corvus frugilegus*, Jackdaw *C. monedula*, Blackbird *Turdus merula,* Tree Sparrow *Passer montanus*). Reduction of prey species was diversified in time: vulnerable (Wood Pigeon) declined soon after arrival of crows, other ones after their replenishment. In Szczytnicki Park, with a more stable tree stand, avifauna has changed considerably: over a dozen of species have disappeared, some are close to local extinction, while 6–8 new ones have settled. After arrival of predators some common species ceased to breed (Tree Sparrow, Jackdaw*)* or their abundance declined by 2–3 times (turdids, columbids). Overall density has dropped from 230 to 145–149 p/10 ha. Main declines in this bird assemblage occurred during the 1980s (arrival of Pine Martens *Martes martes*) and in 2008–2010 (replenished Hooded Crows). Records of predator attacks on bird nests/broods confirmed this pressure. Antipredator behaviour in some prey species persisted for years after Pine Marten disappearance.

Zmiany w zespołach lęgowych ptaków dwóch parków Wrocławia w okresie 40 lat (1970–2010): przed i po przybyciu ważnych drapieżników. Abstrakt: Wieloletnie liczenia ptaków lęgowych prowadzono w śródmiejskim Parku Słowackiego oraz części starego Parku Szczytnickiego ze strefy miejskiej, stosując tę samą odmianę metody kartograficznej. Prócz położenia parki różniły się: (a) P. Słowackiego (7, potem 7,5 ha) – nieco młodszy drzewostan z lokalnymi krzewami, liczniejszą obecnością ludzi, dawniej brakiem drapieżników, od r. 1972 zasiedleniem przez wrony siwe *Corvus cornix*, (b) Park Szczytnicki (badano 17 ha) – stary drzewostan dawnego lasu łęgowego, z nielicznymi krzewami, mniejszą liczbą ludzi, z wzrastającą liczbą drapieżników (kuny, wrony, ptaki szponiaste). W obu znajdowało się zwykle poniżej kilkunastu skrzynek lęgowych. Wojenne wyludnienie miasta i

zdziczenie parków hamowało synurbizację awifauny do lat 1960.; potem szereg gatunków poczęło zwiększać liczebność. W P. Słowackiego zespół ptaków tworzyła fluktuująca liczba gatunków lęgowych, których łączne zagęszczenie wzrosło średnio do 294 p/10 ha, by po rozmnożeniu się wron obniżyć do 173 p/10 ha, wobec regresu gatunków licznych (grzywacz *Columba palumbus,* sierpówka *Streptopelia decaocto,* gawron *Corvus frugilegus*, kawka *C. monedula*, kos *Turdus merula,* mazurek *Passer montanus*). W P. Szczytnickim spadki zagęszczenia (z 230 do 145–149 p/10 ha) początkowo najbardziej dotyczyły dziuplaków, grzywacza i kosa. Wycofało się kilkanaście gatunków lęgowych (kawka, mazurek oraz inne mało liczebne), 2–3-krotnie spadła liczebność drozdów i gołębi, a przybyło 6–8 nowych. Obserwacje ataków na lęgi ptaków potwierdzają wniosek, że silne spadki w latach 1980. nastąpiły tu po przybyciu kun leśnych *Martes martes*, a regres ptaków wijących gniazda otwarte w latach 2000. po wzroście liczby wron. Reakcja na zagrożenie drapieżnictwem zdaje się utrzymywać u gatunków-ofiar przez wiele lat po zniknięciu kun leśnych.

Most quantitative studies of urban bird communities lasted only for a few years, assuming that such a sample satisfactorily describes a "typical" state of a local avifauna. It was also expected that such results will be valid for a long time, chiefly if obtained from urban parks with an old tree stand and thus with little or no successional change. Yet, empirical testing of such an assumption is needed because urbanized areas are undergoing deep transformations. In spite of a Erz's (1966) remark, that urban areas evolve into something like a "climax state", best exemplified by the down-town conditions, in a long time perspective also down-town habitats undergo "successional" changes due to replacement of housing by business functions, or of horse-driven traffic by automobiles. Given these changes, only some old urban parks, established 150 years or so ago, in spite of fluctuating horticultural treatments, may retain their quite stable structural and trophic characteristics for longer periods, thus recalling the nature reserves.

In a small sample of longer-than-20-year studies of bird communities of urban parks (Abs & Bergen 1999, Ptaszyk 2003, Biaduń 2004, 2009, Luniak et al. 2007, Tomiałojć 2007, Grochowski & Szlama 2011), changes reported the most often were of a trivial type: either triggered by an ageing of once young tree stands, or caused by an expansion of urban development into the park boundaries. Therefore, it is of interest to study changes in bird communities occurring in old parks with no deeper transformation in their tree-stand structure nor trophic properties. This paper presents results of long-term bird censuses carried out in such urban parks of Wrocław. It shows how local bird communities have been changing since early 1970s, while facing both colonization and increase in number of important nest predators: Hooded Crows *Corvus cornix* and martens (chiefly Pine Marten *Martes martes*).

Study area

In Wrocław, a SW Polish city of c. 630 thousand inhabitants, bird counts were carried out in two parks situated 2 km apart but differing by their location within urban area, as well as somewhat in the age and structure of tree stands (Photo 1 and 2). A small Słowacki Park was established in c. 1846 on the edge of medieval-based town (according to a plan by J. Schneider). It was enlarged in 1900 and 1945, and currently represents a typical green area at the edge of a down-town. The second area, in 1717 a riverine forest on the Odra/Oder riverbed, during mid-19th century became a Szczytnicki Park though still situated 2 km outside the town, amongst an open farmland (A. Eltzner's panorama,1870). It is now surrounded by a wide zone of urban development of the 1920s. In an old literature there are some hints about birds of both areas, mainly from the 1950s (Szarski 1955, Dyrcz 1963, J. Okulewicz, unpubl. data), but also from an earlier period (Merkel 1921, 1930) for Szczytnicki Park.

Photo 1 and 2. Two typical parts of the Wrocław parks: down-town Słowacki Park (upper) and resembling an old forest part of extensive Szczytnicki Park (below) (fot. L. Tomiałojć) – *Dwa typowe fragmenty badanych parków: śródmiejskiego Parku im J. Słowackiego (powyżej) oraz przypominającej stary las części Parku Szczytnickiego (u dołu)*

Słowacki Park. In contrast to an earlier study (Tomiałojć & Profus 1977), data from a slightly larger plot were taken into account (bird numbers have been extracted anew from old census maps for the 7-ha area, instead of 6.3 ha), and since the 1980s study plot has expanded up to 7.5 ha. Nevertheless, the numbers of breeding pairs are comparable directly between two periods (between which park's area differs), as no birds nested in the past on the recently added territory. Bird density was calculated based on the current size of the park, assuming arbitrarily the year 1985 as the moment of change, when a weedy wasteland surrounding the park was gradually planted with trees and included into park, or transformed into neighboring lawns and parking sites. Updating earlier description, other changes in the habitat were as follows: a) erecting a building in the park, the main nesting site of three species (House Sparrow *Passer domesticus,* Black Redstart *Phoenicurus ochruros,* Common Swift *Apus apus*); b) local and temporary regrowth of a bush and young tree layer (during 1973–1981 over 0.2 ha, and 1990–2006, 2008–2009 over 0.7 ha); c) erecting 15 nest boxes in 1973 (destroyed soon after) and 20 street lanterns used by Tree Sparrows *P. montanus* for nesting; d) threefold increase of human penetration, often with dogs, and a heavy motorized traffic along the neighbouring streets (up to 80 vehicles/min. in rush hours). In spite of sporadic removal of a few old trees and planting the new ones, the structure of the tree stand remained basically the same, besides an addition of 25 ornamental spruces. The main biological change to this area, was its colonization by Hooded Crows, and their subsequent replenishment (Table 1).

Szczytnicki Park (c. 150 ha). A 17 ha fragment of the park, best preserving the features of a riverine forest *Fraxino-Ulmetum*, was censused. Since ca. 1880 it was turning into a typical urban park (Merkel 1921, 1930), later drained up (reduction of old river bed) and changed into an oak-hornbeam stand on a dry substrate. In the early 1930s (according to an old photo by Eysymont & Urban 2008) its main character was almost identical with the present state, i.e. old tree stand devoid of bush layer. During the 1950s it turned "wild", with luxuriant bush layer of *Cornus* sp. and *Sambucus nigra* (Dyrcz 1960, 1963). Out of dozens of very old oaks and lime trees (Tomiałojć & Profus 1977), one fourth fell down during wind storms and was successively removed in the late 1980s and 1990s, but this loss has been compensated by ageing of trees and the holes excavated by six woodpecker species. The numbers of nest boxes for small hole-nesters were: 15 during 1970s, a few during 1980s, ca. 30 around 2000, and six recently. Since modernization of the park during 1968–1970, its tree stand, scarce bush layer of *Ribes* sp., *Symphoricarpus* sp. and *Rhododendron* sp., partly raked litter and rarely mown lawns, lasted for 40 years almost unchanged. The number of visitors doubled (many with dogs), and the number of vehicles passing the neighboring street increased to 12 per minute. The main biological change was the appearance of Pine Martens around 1978. They were repeatedly seen during 1986–1988 and 2000–2001, but not later. At least since 1958 single pairs of Hooded Crows have been known to breed there (Dyrcz 1963), but this species became numerous only recently.

Methods

Own bird censuses carried out during 1970–1973 served as a reference point to present studies (Tomiałojć & Profus 1977). In Słowacki Park counts were continued each year except 1974 until 1999, and repeated in 2008–2010. In a part of Szczytnicki Park counts were repeated during 1986–1988 (Cisakowski 1992), and by myself in 2000–2002 and 2009–2010. Always the same version of combined mapping technique was applied. This technique is characterized by a large amount of time spent on active searching for bird nests and contemporary records of singing males (Tomiałojć 1980, Tomiałojć & Profus 1977). Du-

Table 1. Numbers of breeding pairs in Słowacki's Park (7 ha, since 1985 – 7.5 ha). + territory partly within the park boundaries, m – stationary male. Trend: I – increasing, D – declining, F – fluctuations, S – stable. ID referes to increasing and then declining trend. Standardized regression analysis slopes found to be statistically significant at P<0.05 are marked as * while at P<0.001 as **

Tabela 1. *Liczebność ptaków lęgowych (liczba par) w Parku Słowackiego (7 ha, od r. 1985 – 7,5 ha). + terytorium niewielkim fragmentem wewnątrz powierzchni, m – stacjonarny samiec. Trend: I – wzrost, D – spadek, F – fluktuacje, S – stabilność. ID znaczy najpierw wzrost potem spadek. Trendy statystycznie istotne przy P< 0,05 oznaczono jako *, przy P<0,001 jako **. (1) – gatunek, (2) – liczba gatunków, (3) – liczba par*

Species (1)	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
C. palumbus	49	50	45.5	38	34	26	28	24	19	16.5	15	14	15	15	11
S. decaocto	1–2	2	1–2	2	?	3	6	9.5	9	8	9	9	7	5	5
S. vulgaris	36	37	36	54	?	55	57	46	55	52	61	54	62	54	55
P. montanus	13	17	14	24	?	28	38	35	47	33	31	34	30	46	43
P. domesticus	3	1	3	2	?	1	1	3	5	5	8	8	10	8	8–9
C. monedula	14	15	16	20	?	21	15	16	18	12	15	16	18	20	16
C. frugilegus	24	22	11	12										1	
C. cornix			**+**	**+**	**1**	**1**	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**3**	**4**
T. merula	7	8.5	8	10	?	12.5	10.5	9	13	10	11	10	11	10	10
F. coelebs	6	6	5–6	4	?	4	4	3	3	4	4	5	7.5	8	8
P. major	5	5	7	6	?	4–5	5	5	5	5	6	8	7.5	8.5	8
C. caeruleus	4	5	4	5	?	4	4	4	4	5	3.5	6–7	6–7	7	5.5
P. palustris	1	1			?								1?		
S. europaea	1	1	1	1	1	1			1	1			1–2	1	1
C. brachydactyla					?		1	1				1	1	1	
M. striata	3–4	2–3	3	2.5	?	1	3	2	2	1	4	3–4	4	3	3
H. icterina	3	3–4	5	3	?	4	3–4	2	2	5	6	4	7	5	4
S. atricapilla					?	1	1	1	1	3	1	2	1	3	1–2
S. curruca	1	1	1	1	?	2	1	1	2–3	2–3	2	2	1	2	2.5
S. communis					1	0.5		1	1	1					
C. chloris	3	3	3	4	?	3	4	3	4	1?	4	5–6	7–8	7	7
C. carduelis	2	1	2–3	2	?	3–4	3	1	1	1	3	5–6	4	2	3
S. serinus	1	1–2	1–2	2	?	2.5	1	1	1	2	5	4	3	4	7

P. pica	0.5	0.5	+						1	1	0.5	1	0.5	0.5	1
Ph. ochruros	1	1	1	1	?	1	1	1	1	1	1	1	1	2	1.5
Ph. phoenicurus			1		?			1?							
F. hypoleuca	1m				?	1	1								1
Ph. collybita													1m	1m	
G. glandarius		1	+	1	1	1	1	1	1						
S. aluco		+	+	1	1	1	+	1				1	1		
A. platyrhynchos			1		?		1	1				1	+	2	1
L. megarhynchos					?			1m				+	0.5		
A. palustris															
A. apus															
T. pilaris															
N of species (2)	22	23	23	22	?	24	24	26	24	22	20	23	27	25	23
N of pairs (3)	180.5	185.5	172	195.5	?	182.5	191.5	174.5	198.5	171	193	200.5	214	224	207.5

Table 1 continued:

Species (1)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2008	2009	2010	Trend
C. pal.	9	6	6	7.5	8	7	12	8	7	8	6.5	8	7	7	8	8.5	9	9	D**
S. dec.	6	6	6	6	7.5	6.5	8.5	5.5	8	9.5	8	7	8	7	4	1	0.5	1	ID*
S. vul.	47	31	44	48	43	44	39	45	52	54	47	46	33	34	44	29	33	24	D**
P. mon.	43	35	29	22	29	33	29	23	43	43	44	26	26	22	28	10[1]	18	21	F
P. dom.	4	4–5	5	6	8	4	12	7	8	14	9	14	10	9	12.5	12	10–11	11	I**
C. mon.	13	15	21	13	17	12	8	9	10	11.5	11	11	10.5	8	10	6	6	6	D**
C. fru.				2				1	3	1									D
C. cor.	**4.5**	**3**	**3**	**4**	**3.5**	**3.5–4**	**4**	**5.5**	**4**	**4**	**5**	**3.5**	**4**	**4.5**	**6.5**	**8**[2]	**9**[2]	**8**[2]	**I****
T. mer.	12	10.5	11	9.5	13	9	12	10	7.5	10	10	8.5	8	7	9	3.5	4	1	D**
F. coel.	7	5	5	6	9.5	7	7	6.5	7	8	6	8	6.5	6	7.5	5	5	4	F
P. maj.	6–7	11.5	8	11	10	9.5	9.5	10.5	10.5	11	11	8	6.5	11	10.5	7	7.5	10	I**
C. caer.	6	5	5.5	7	4	6	10	7	7.5	7	8	9	4	6	9	8	7	10	I**
P. pal.				0.5	1														D

Species (1)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2008	2009	2010	Trend
S. eur.	1m	2	1	1	1	1	2	2	2	2	2	2	2	2	1.5	1	2	2	I**
C. bra.	1	2	1	1	1	1.5	1			1	1	1				1–1.5			F
M. str.	4	2	1–2	4	3	2–3	3	4	3	2	2–3	3	2	2	2				D*
H. ict.	6	4	4	5	5	3	3	3	5	2	2	6	5	4	3	5	4	4	F
S. atr.	3.5	3	2.5	2	3	3	4	7	4.5	5	4	6	6.5	7	8	7	5–6	4	I**
S. cur.	2	1	2	3	1.5	2	3	+	1	1	2	2	1	3	2	1	1	1	F
S. com.			1		1	1	0.5	1	1	1	1	0.5	0.5				0.5		F
C. chl.	5	9.5	7–8	8–9	8.5	10.5	9.5	14	13	12	9	13	10.5	11	9	7.5	8	6	I**
C. car.	1				2	2–3	4.5	6	4	5	5	4	3	4	5	3	1	1	F
S. ser.	8–9	8	5	5.5	6–7	6–7	7	5–6	5	7	8	12	5	7	4	2	1	2	F
P. pica	0.7	1	1.5	0.5	1	0.5	0.5		0.5		+	0.5		0.5	0.5	0.5	0.5	0.5	S
Ph. och.	1	1	1	2.5	1.5	2	1	1	1	1	1	1	1	2	2	1	1	0.5	F
Ph. phoe.																			
F. hyp.															1m				
Ph. col.				1	1m		1	1		1	1				1				F
G. gla.																			
S. alu.								+							1	+			
A. pla.	1	2	1	1	1	1	2	2	2	1	1	1	1	2	1	1	2	2	I**
L. meg.														1	1	1m	1m		
A. pal.										1		2			1				
A. apus													1		1	1			
T. pil.														1					
N of species (2)	24	22	23	25	26	25	25	23	24	26	24	25	24	24	28	25	23	21	F
N of pairs (3)	187.5	168	172.5	177.5	190.5	179	193	185.5	209.5	223	202.5	203	162	168	194	130	137	128	D*

[1] Tree Sparrows in other years: 2003 – 14 pairs (after Mazurek 2003 msc), 2005 – 15 nests, 2006 – 16–17 p, 2007 – 12 p
[2] Plus 2–3 Hooded Crow pairs attempting to breed and a dozen or so of non-breeders

ring a single visit the coverage of one hectare took 10–15 minutes. The number of visits per season increased from 9–10 during early censuses to 10–12 more recently to compensate for a deteriorated observer's visual and hearing abilities (the latter supported by hearing apparatus Cielo Life). Single counts were sporadically made by other observers.

Because two census plots constitute a very scarce material for checking statistical significance of differences found, the conclusions were drawn not from single-year data, but from mean values for 3–5-year periods. Though the values are not independent, this should help to avoid judgments from exceptional figures. The similarity of species composition between compared communities was calculated using an old Renkonen index (Re), which is a sum of identical (minimal) values of percentage share in two samples. Species turnover rate between the two seasons was calculated after formula by Abs and Bergen (1999):

$$T = (J+E) \times 100/(S_1+S_2),$$

where J means number of new species in season II, E – number of species lost between seasons I and II, S_1 and S_2 – numbers of all breeding species in the season I and season II respectively. As the T index value depends on fluctuating number of species breeding from year to year, to stabilize results, mean numbers of breeding species calculated from 3–5 year periods were compared. Calculations were also repeated for combinations of years forming a "pentade" (e.g. 1994–1998 or 1995–1999). Values of T index averaged this way were less prone to express year-to-year variation, but were rather focused on permanent changes occurring over longer time scale.

To reveal an existence of (statistically significant) long-term trends in bird abundance the standardized regression slopes were calculated following formulas in STATISTICA for Windows ver. 6.0 (1996).

Results

Species composition of two communities

Bird community composition in both Wrocław parks has appeared fairly stable in time. Even in an isolated small Słowacki Park, theoretically susceptible to species loss, the species composition has changed little throughout 40 years (average species turnover rate T=21%, span 16–26). For Szczytnicki Park this index was equally low (T=21%, span 20–22.4), while in Gliwice park it was slightly higher (T=27%, own calculation).

Słowacki Park. Its bird community was fairly stable (Table 1), in spite of some changes in park structure and character of surroundings. Number of breeding species fluctuated strongly (21–28) yet around a similar level. The park area was colonized by three synurbic species (before the beginning of this study by Mallard *Anas platyrhynchos*, then by Hooded Crow and Blackcap *Sylvia atricapilla*), while four species ceased to breed (Rook *C. frugilegus,* Jay *Garrulus glandarius,* Marsh Tit *Poecile palustris,* Common Redstart *Ph. phoenicurus*). Even fairly conspicuous changes in the number of potential nest sites had a limited influence on the number of breeding species, e.g. temporary regrowth of local bushes allowed only for a sporadic nesting of single pairs of Chiffchaff *Phylloscopus collybita,* Marsh Warbler *Acrocephalus palustris* and Nightingale *Luscinia megarhynchos*. The development of ornamental spruces during the 1980s triggered an increase in the number of Greenfinches *Carduelis chloris* and Serins *Serinus serinus*. Likewise, the introduction of street lanterns (1973), and their reconstruction (1995) to prevent birds from nesting, changed the number of nesting sites for small hole-nesters, yet without attracting new species.

Szczytnicki Park. The number of species breeding within the 17 ha plot varied between 30 and 39 (exceptionally 26), and quantitative composition was changing considerably (Table

Table 2. Average breeding densities (p/10 ha) in Słowacki's Park in the down-town of Wrocław (7 ha, after 1985 – 7.5 ha) during seven 3–5 year long periods. Trends: D – declining, I – increasing, S – stable, F – fluctuating. N – breeder new to the park. Other denotations as in Table 1.
Tabela 2. *Średnie zagęszczenie (par/10 ha) ptaków w Parku Słowackiego w siedmiu okresach. Przed rokiem 1985 dane przeliczono na 7 ha, późniejsze na 7,5 ha. Trendy: D – spadkowy, I – wzrastający, S – stabilny, F – fluktuacje. N – gatunek nowo przybyły jako lęgowy. (1) – gatunek, (2) – średnia liczba gatunków, (3) – średnie zagęszczenie par/10 ha. Pozostałe oznaczenia jak w tabeli 1*

Species (1)	1970– –1973	1975– –1979	1980– –1984	1985– –1989	1990– –1994	1995– –1999	2008– –2010	Trend
C. palumbus	61.8	32.4	20.0	9.7	11.2	9.7	11.8	D*S
S. decaocto	2.5	10.1	10.0	8.4	10.1	9.0	1.1	IFD
S. vulgaris	58.2	75.7	81.7	56.8	62.4	54.4	38.2	ID
P. montanus	24.3	51.7	52.6	42.1	45.6	38.9	21.8	IFD
C. monedula	23.2	23.4	24.3	21.0	13.5	13.5	8.0	SD*
C. frugilegus	24.6		0.3	0.5	1.3			D
C. cornix (N)		**2.0**	**5.1**	**4.8**	**5.6**	**6.3**	**11.1**	**I****
T. merula	12.0	15.7	14.8	14.0	14.9	12.9	5.6	ID
F. coelebs	7.3	5.1	9.3	8.7	9.5	9.0	6.2	S
P. major	8.0	7.0	10.8	12.5	13.6	12.5	10.6	I
C. caeruleus	6.4	6.0	8.3	7.3	10.0	9.6	11.1	I*
H. icterina	5.2	4.7	7.4	6.4	4.3	5.3	5.8	F
C. chloris	4.5	4.3	8.8	10.4	15.7	14.0	9.5	I*
C. carduelis	2.5	2.7	5.0	0.8	5.8	5.6	2.2	F
S. serinus	2.1	2.1	6.6	8.9	8.3	9.6	2.2	F
M. striata	4.1	2.6	5.0	4.4	3.9	3.0		FD
P. domesticus	3.2	4.3	12.1	7.3	12.0	14.5	14.9	I*
S. europaea	1.4	0.8	1.0	1.6	2.4	2.5	2.2	I*
Ph. ochruros	1.4	1.4	1.7	1.8	1.6	1.8	1.1	S
A. platyrhynchos	0.3	0.3	0.8	1.6	2.1	1.6	2.2	I*
S. atricapilla (N)		2.0	2.4	3.7	6.2	8.4	7.3	I**
S. curruca	1.4	2.6	2.7	2.5	1.9	2.6	1.3	F
S. communis		1.3		0.5	1.2	0.5	0.2	F
S. aluco	0.3	0.6	0.6			0.2		D
P. pica	0.3	0.6	1.0	1.2	0.4	0.4	0.6	S
G. glandarius	0.8	1.1						D*
P. palustris	0.7		0.3	0.4				D
Ph. phoenicurus	0.3							D
F. hypoleuca	+	0.6	0.3			0.2		F
Ph. collybita (N)			0.6	0.5	0.8	0.5		I
C. brachydactyla (N)		0.6	0.9	1.6	0.9	0.5	0.5	F
L. megarhynchos (N)		0.3	0.15			0.5		F
A. palustris (N)					0.2	0.8		?
A. apus (N)						0.4	0.4	I*
T. pilaris (N)						0.2		?
Mean N of species (2)	22.5	24.0	23.6	24.6	24.6	25.0	22.6	S
Mean density p/10 ha (3)	262	262	294	239	264	248	175.5	ID

Table 3. Number of breeding pairs in the oldest part (17 ha) of Park Szczytnicki, once a riparian forest. Data for 1986–1988 after Cisakowski (1992). + less than half of a territory within the plot. Other denotations as in Table 1

Tabela 3. *Ptaki lęgowe na powierzchni badawczej (17 ha) w Parku Szczytnickim (pierwotnie las łęgowy). Dane z lat 1986–1988 wg Cisakowskiego (1992). + oznacza mniej niż połowę terytorium w obrębie badanej powierzchni. (1) – gatunek, (2) – rok, (3) – liczba gatunków, (4) – liczba par. Pozostałe oznaczenia jak w tabeli 1*

Species (1)	Year (2)												Trend
	1970	1971	1972	1973	1986	1987	1988	2000	2001	2002	2009	2010	
S. vulgaris	100	106	115	133	89	93	89	108	128	91	100	110	F
P. montanus	47	49	65	69	6	3	2	4			1		D**
C. monedula	46	56	71	58	3	1	1						D**
C. palumbus	28	32	38	27	9	13	11	12	10.5	17	19.5	17	D*
T. merula	22	24	26	26	17.5	14	17	10	7.5	8.5	9	4.5	D**
F. coelebs	15	11.5	14.5	12	16.5	12.5	17.5	26.5	23.5	25.5	16	12	ID
P. major	18.5	19	20	19	18	23.5	26	26	23	19.5	30	12.5	F
C. caeruleus	17	14	19.5	20	11	10	17.5	16.5	18.5	17	20.5	9	F
P. palustris	1	+	1		1	1		+	+	0.5			D
F. hypoleuca	1	1		+	1	3	1	18	14	12	6.5	5	I*
F. albicollis							1	9	8	13.5	9	3	I**
S. europaea	8	7.5	5	8	6.5	5	4.5	9	8.5	8.5	7.5	9	F
E. rubecula	6.5	4	4.5	2	4.5	4.5	3.5	7	7	9	6.5	3	F
Ph. sibilatrix	6.5	3.5	2	1	7	6.5	8.5	3		3	1		D
M. striata	6.5	4.5	2	3	3	2	4.5	7	5	9	2		D
H. icterina	0.5	+			2	2	2	4.5	4.5	6.5	1	+	I
Ph. collybita	3.5	5	2	2.5	6	5	4	4.5	4	3	3	3	F
Ph. phoenicurus	3	2	1	1.5				4	4	2		+	F?
C. chloris	2	2	2	4	1	1	2	1	4	3	0.5	3	F
C. coccothraustes	1	1	2	1	4	6	2	1	3	2			ID
S. serinus	4	2	2	1	1	+	2	1.5	0.5				D**
C. carduelis	1	1						1		1			F
C. brachydactyla	3.5	2	3	2	3	2.5	2.5	2	2	1.5	0.5–1	1	D**
C. familiaris	1	+	0.5	0.5	1	1	2	2.5	1.5	1			F
S. atricapilla	9	6.5	7	3	6	7.5	10	18	14	15	15.5	12.5	I**
S. curruca	1	1	1		2	1	2	2.5	2		1	1	ID
S. borin	1.5	+	+			1	+						D
Ph. trochilus	+	+	+										D
R. regulus	0.5	+					1						D
R. ignicapilla								1	2	1			ID
T. philomelos[1]	5	2.5	4	3.5	3	1	1	0.5	1	1m	1m	+	D**
T. pilaris											2	+	I
O. oriolus	0.5	1.5	1		1	1	+	1.5	+	1	1	+	F
G. glandarius	1	1	1	2	2	2	2	1		1	1	1–1.5	ID
C. cornix	**2**	**1**	**3**	**1.5**	**2**	**1.5**	**2**	**3**	**+**	**1.5**	**4.5**	**10**	**FI**
S. aluco	1	1	1	2	1	1	1	0.5–1	0.5–1	0.5–1	0.5	1	D*

Table 3 continued

Species (1)	Year (2)												Trend
	1970	1971	1972	1973	1986	1987	1988	2000	2001	2002	2009	2010	
S. decaocto	+	1	2		2		1	1					D
A. platyrhynchos					7	8	4	2	2	1	6–7	7–8	I*
D. major	2	1	3	1.5	1	2	1	3.5	4	4.5	3	3	I*
D. medius	+	1	1	2	1	1	2	4	5.5	2	2–2.5	4	I**
D. minor	+	+	+	0.5	1	1	0.5	0.5	+				D
P. viridis	1	0.5	0.5	1	1	1	1	1	1	1	1	0.5	S
P. canus								0.5		0.5	+	1	I
D. martius					0.5	0.5	0.5	0.5	+	0.5	0.5	+	I*
P. modularis	0.5	0.5											D
L. megarhynchos	+	1	+	+	1	+	2				0.5		D
Ae. caudatus	1				0.5				+			+	F
P. pica						0.5	+						
C. canorus	1	1	1	0.5	1								D
B. buteo[2]								+					
N of species (3)	39	37	34	30	38	36	37	38	31	34	31	26	D
N of pairs (4)	369	369	419	408	244	239	252	321	307	284.5	274	233.7	D*

[1] A stationary male
[2] Unsuccessful breeding attempts in 1993 within the plot and in 2000 nearby

3). During 40 years, 6–8 new species settled (Mallard, Black Woodpecker *Dryocopus martius,* Grey-headed Woodpecker *Picus canus,* Collared Flycatcher *Ficedula albicollis,* Firecrest *Regulus ignicapilla,* Stock Dove *Columba oenas* and in the immediate neighborehood sporadic broods of Common Buzzard *Buteo buteo* and Sparrowhawk *Accipiter nisus*). Between 1970 and 2000, seven species ceased to breed (Jackdaw, Tree Sparrow, Lesser Spotted Woodpecker *Dendrocopos minor,* Magpie *Pica pica,* Cuckoo *Cuculus canorus,* Garden Warbler *Sylvia borin,* Dunnock *Prunella modularis,* Willow Warbler *Ph. trochilus*), despite a lack of significant changes in the park structure. Species loss has continued after 2000 when next 7 species disappeared from the census plot (Treecreeper *Certhia familiaris,* Song Thrush *Turdus philomelos,* Goldcrest *R. regulus,* Serin, Collared Dove *Streptopelia decaocto,* Marsh Tit *Poecile palustris,* Hawfinch *Coccothraustes coccothraustes*).

Bird numbers in both parks: overall density and abundance of nesting guilds

The overall number of breeding pairs in Słowacki Park was increasing during first 15 years, reaching two highest values (averaged across four-year periods: 297 and 209 pairs during 1981–1984 and 1993–1996, respectively), but eventually declined to 130 pairs (a 38% drop). The change is highly statistically significant at regression slope –0.43; $P<0.001$. In the second park the overall breeding numbers started to decline earlier: the density dropped from an average of 230 p/10 ha during the 1970s to the level of 147 recently (Cisakowski 1992, Tables 3 and 4, the change statistically significant at regression slope –0.70; $P<0.001$). The most spectacular was a desertion of this park during the 1980s by an old colony of Jackdaws, as well as by very abundant for at least two decades Tree Sparrows. The overall density of the hole-nester guild partly recovered by 2000 owing to putting up some new nest boxes, which attracted flycatchers *Ficedula* sp. The abundance of all smaller than Starling hole--nesters, during four periods of censuses fluctuated as follows:

Table 4. Average breeding bird densities (p/10 ha) in a part of Szczytnicki Park during five periods. Data for 1958–1959 after Dyrcz (1963), 1970–1973 after Tomiałojć & Profus (1977), 1986–1988 after Cisakowski (1992). Qualitative estimates: C – several pairs, P – single pairs, A – non-breeding. Trends: E – extinct in the whole park, D – declining, I – increasing, S – stable, F – fluctuating. N – new breeder in the park

Tabela 4. *Średnie zagęszczenia (p/10 ha) ptaków lęgowych w części Parku Szczytnickiego w pięciu okresach. Dane z lat 1958–1959 wg Dyrcza (1963), dla 1970–1973 wg Tomiałojcia i adrzew (1977), adrzew lat 1986–1988 wg Cisakowskiego (1992). Opisowe oceny liczebności: C – kilka par, P – pojedyncze pary, A – brak lęgowych. Trendy: E – zanik w całym parku, D – spadkowy, I – wzrastający, S – stabilny, F – fluktuacje liczebności, N – nowy gatunek lęgowy. (1) – gatunek, (2) – lata, (3) – średnia liczba gatunków na sezon, (4) – ogólne zagęszczenie par/10 ha*

Species (1)	Years (2)					Trend
	1958–1959	1970–1973	1986–1988	2000–2002	2009–2010	
S. turtur, J. torquilla, T. troglodytes, S. nisoria, S. communis, L. fluviatilis, L. collurio, P. pyrrhula, E. citrinella	P	A	A	A	A	E
S. vulgaris	35.0	66.7	53.1	64.1	61.7	F
C. monedula	C	33.9	1.0			E
P. montanus	37.5[1)]	33.8	2.2	0.8	0.3	D
C. palumbus	12.5	18.3	6.5	7.6	10.7	D
T. merula	12.5	18.3	6.5	7.6	10.7	D
P. major	C	11.2	13.4	13.4	12.5	S
C. caeruleus	C	10.4	7.6	10.2	8.7	S
F. coelebs	22.5	7.8	9.1	14.8	8.2	DF
S. europaea	C	4.2	3.1	5.1	4.8	S
S. atricapilla	C	3.7	4.6	9.2	8.2	I
E. rubecula	C	2.4	2.3	4.5	2.8	DF
M. striata	C	2.3	1.9	4.1	0.6	F
T. philomelos	10.8	2.2	1.0	0.5	0.3	D
Ph. sibilatrix	C	1.9	4.3	1.2	0.3	DF
Ph. collybita	C	1.9	2.9	2.2	1.7	DS
C. chloris	P	1.8	0.8	1.8	1.0	F
C. brachydactyla	C	1.5	1.6	1.0	0.5	D
C. familiaris	?	0.3	0.8	1.0		F
S. serinus	P	1.3	0.6	0.4		F
C. cornix	**P**	**1.1**	**1.1**	**0.9**	**4.3**	**SI**
Ph. phoenicurus	C	1.0		2.0	+	DF
D. major	P	1.0	1.0	2.3	1.7	I
D. medius	?	0.5	0.8	2.2	1.8	I
C. coccothraustes	C	0.7	2.4	1.2		D
G. glandarius	P	0.7	1.2	0.4	0.7	F
S. aluco	P	0.7	0.6	0.4	0.4	
C. canorus	P	0.5	0.2			E

Species (1)	Years (2)					Trend
	1958– –1959	1970– –1973	1986– –1988	2000– –2002	2009– –2010	
O. oriolus	P	0.4	0.4	0.5	0.3	S
S. decaocto		0.4	0.6	0.2		D
S. curruca	P	0.4	1.0	0.9	0.6	S
P. palustris	C	0.3	0.4	0.1		D
C. carduelis	P	0.3		0.4		F
F. hypoleuca	C	0.3	1.0	8.6	5.7	I
F. albicollis (N)			0.2	6.0	3.2	I
H. icterina	P	0.07	1.2	3.0	0.3	F
S. borin	P	0.2	0.2			E
R. regulus	?	0.07	0.2	+		E?
R. ignicapilla (N)				0.8		
L. megarhynchos	C	0.15	0.6	+	0.15	DS
P. modularis	P	0.15				E
Ae. caudatus	P	0.15	0.1	+	+	D
Ph. trochilus	P	+				E
T. pilaris (N)					0.6	
D. minor	P	0.1	0.5	0.1		E
P. viridis	P	0.4	0.6	0.6	0.4	S
P. canus (N)				0.2	0.3	I
D. martius (N)			0.3	0.2	+	I
P. pica	P		0.2			F
A. platyrhynchos (N)			3.7	0.9	4.1	I
Mean N of species/ /season (3)	c. 45	37.7	38	37	28	D
Overall density (p/10 ha) (4)	c. 257[1]	230.2	144.8	178.9	149.3	D

[1] Density derived from a 4 ha sample plot, presumably overestimated

The 1970s – a year to year growth (from 92 pairs to 111–117), due to an increase of Tree Sparrows; other small hole-nesters were steadily at c. 48 pairs;

The 1980s – after a crash of Tree Sparrows only a half of small hole-nesters remained in spite of increased occupation of a few new nest boxes by tits and flycatchers (their rise from 43 to 52 pairs);

Early 2000s – small hole-nesters still less numerous than during 1970s and declining from 86 to 73 pairs, in spite of flycatcher's use of new nest boxes;

The years 2009–2010 – a sharp decline from 77 to 38.5 p in 2010 (only one-third of the 1970-numbers), probably resulting from co-action of three factors: long winter 2009/2010, low number of remaining nest-boxes and strong pressure of crows.

Disregarding fluctuations, the overall density of birds in p/10 ha was – unexpectedly (compare Photo 1 and 2) – always higher (mean 232±36.3) in Słowacki Park, which has a much simpler structure, than in high-stemmed and luxuriant part of Szczytnicki Park (mean 183 ±45.8). The difference calculated for nine overlapping years is statistically significant (test t–Student, two-sided, $P<0.05$). In the former park the earliest sign of declining trend

(Wood Pigeon, Rook and Jay, Table 2) was noticed during mid 1970s, when remaining groups continued to increase. Only since around 1985, and chiefly after 2000, the majority of species entered a declining phase. In Szczytnicki Park an overall density decreased during early 1980s and again during 2009–2010 (Table 4).

The abundance of three nesting guilds was changing in each park differently (Table 5). While the hole-nesters in Słowacki Park were steadily increasing for the first 15 years to decline much later, in Szczytnicki Park this group collapsed strongly before 1986. In contrast, the guild of open nesters of trees and high bushes, started to decline first in Słowacki Park (since the late 1970s – Table 5, decline marginally insignificant, regression slope –0.73; $P<0.06$), while in the other park only in the 2000s. Similar though less pronounced change has been found in a subgroup of small tree nesters (five finches, Spotted Flycatcher *Muscicapa striata,* Blackcap): their overall density in Słowacki Park was increasing until 1999, while in the other park remained on a low level to reach peak numbers during 2000–2003, which subsequently was followed by a clear drop in both parks (Table 6).

Changes in the numbers of common species

Strong decline of Jackdaws. A decline in the abundance of this species has been observed in Wrocław agglomeration mainly in built up districts. Therefore a complete disappearance of a big and old (lasting at least since 1920 – Merkel 1921, 1930) nesting colony of Jackdaws in Szczytnicki Park was surprising. It occurred before 1986 (Table 3), i.e. well preceded the removal of some old trees, and apparently followed an arrival of Pine Martens. The reason for a more recent decline in Słowacki Park (Table 1) was obviously a removal of old plane trees or their limbs with big holes, though fierce fights with increasing Hooded Crows might also contribute to this drop.

Increase and decline of Tree Sparrows. Their abundance has eventually declined, even if during earlier decades the species was showing a strong increase (Tomiałojć & Profus 1977). Recent decline, and almost total disappearance from five parks of the city (Mazurek 2003 msc) has not been reversed even by erecting c. 30 nest boxes in Szczytnicki Park. Moreover, breeding Tree Sparrows changed their behaviour to a very secretive and shy. In spite of that retreat, however, these birds have recently continued to forage regularly in Szczytnicki Park during the breeding season, though mostly along the edges of a tree stand (Mazurek 2003 msc, own data). I also observed the whole families of Tree Sparrows coming to feed in the park from nests located amidst neighbouring housing districts. Only in down-town Słowacki Park Tree Sparrows breed still in good yet smaller numbers (Table 1). Their past abundance fluctuated there in parallel with the number of nest boxes and street lanterns which provided hollows suitable for nesting. After 2000 also in that park the species number declined four times, with a partial recovery during 2009–2010 (Table 1). The latter result is surprising in view of recent lack of nest boxes and snowy winter 2009/2010. In Słowacki Park their decrease may partly result from co-action of two factors: reduced number of nest sites and a shrinking size of a ruderal area in the park, once a weed-rich wintering site. Yet, Słowacki Park remains a fairly attractive breeding site while Szczytnicki Park turned into a marginal area. The reason for this local difference seems to be a different level of predation. A declining trend in urban Tree Sparrows must, however, have some geographically based reasons, as it has been observed in the neighbouring Wrocław Botanical Garden (Król 1977 cited after Dyrcz et al. 1991), in the predator-free and rich in tree holes parks of Legnica and Gliwice (Tomiałojć 2007, Grochowski & Szlama 2011), as well as in other central-European cities (Hagemeijer & Blair 1997, Abs & Bergen 1999, Biaduń 2004, 2009), except those from the northeastern cities of Warsaw and Kaliningrad (Luniak et al. 2007, Lykov 2007).

Table 5. Total densities of three nesting guilds: 1 – tree-cavity nesters, 2 – open nesters of trees and high bushes, 3 – ground and low-bush nesters

Tabela 5. *Zmiany łącznej liczebności (średnio p/10 ha) trzech grup (gildii) wg typów gniazd: (2) – dziuplaków, (3) – gniazd otwartych nadrzewnych i wysoko w krzewach, (4) – gniazd naziemnych i nisko w krzewach. (1) – lata*

Słowacki Park	Years (1)						
	1970– –1973	1975– –1979	1980– –1984	1985– –1989	1990– –1994	1995– –1999	2008– –2010
Hole-nesters (2)	123.0	166.5	180.7	143.8	148.9	132.8	92.9
Tree/high bush nesters (3)	127.7	85.4	96.7	81.9	98.1	93.4	63.4
Ground/low bush nesters (4)	1.9	4.4	4.6	4.7	5.7	6.0	3.2
Szczytnicki Park	1970–1973			1986–1988		2000–2002	2009–2010
Hole-nesters (2)	167.4			93.5		121.5	107.5
Tree/high bush nesters (3)	55.7			40.3		41.7	38.6
Ground/low bush nesters (4)	5.9			9.0		6.8	4.1

Increase and decline in abundance of columbids. Two park species, Wood Pigeon and Collared Dove, at first were strongly increasing in Polish towns owing to the absence of predators to reach astonishingly high densities (Tomiałojć 1980a, Górski 1989, Biaduń 2004, 2009, Grochowski & Szlama 2011, Table 2 and 4). In Słowacki Park during 1958–1960 there were merely a few pairs of Wood Pigeons and a single pair of Collared Doves (J. Okulewicz, pers. inf.), while later both species reached 10 times higher numbers (Table 1). However, by now the pressure of predators has gradually reduced columbid numbers as well as their breeding success to their past low level. In Słowacki Park in the predator-free period of early 1970s Wood Pigeons had very high first brood success of 60%. (Tomiałojć 1980). In contrast, in 1989–1999, at the presence of a few Hooded Crows, it lowered twenty times to the mere 3% (N=101, Tomiałojć 2005), while during 2008–2010 the breeding success in both parks was exactly 0% (N=43 nests, new data) at still higher crow numbers. Similarly, the Collared Doves during years 1990–2010 in Słowacki Park had a breeding success of only 5% (N=22 nests, own data). Since replenishment of crows only some of July and August broods of both these columbids happened to be successful (cf. Tomiałojć 1980a, 2005). Owing to their body size and conspicuousness of their nests columbids and their broods constitute a preferred prey to medium-size predators.

Table 6. Total mean density (p/10 ha) of a guild of six small open-nesting species breeding high in trees and bushes (finches, Spotted Flycatcher, Blackcap)

Tabela 6. *Zmiany łącznego średniego zagęszczenia (p/10 ha) sześciu drobnych gatunków wijących otwarte gniazda nadrzewne i w wysokich krzewach (łuszczaki, muchołówka szara i kapturka). (1) – lata*

Years (1)	1970– –1973	1975– –1979	1980– –1984	1985– –1989	1990– –1994	1995– –1999	2000– –2002	2009– –2010
Słowacki Park	20.5	18.8	37.1	36.9	49.4	49.6	?	27.4
Szczytnicki Park	17.2	?	?	19.0	?	?	30.7	18.0

Changes in Blackbird numbers. The dynamics of Wrocław park populations of this species appears complex. In spite of lack of substantial changes in park structure, a steady and statistically significant decline in the number of breeding pairs has been observed during recent twenty years in both parks (Tables 1 and 3). In Słowacki Park their numbers at first increased up to 13 pairs, but since mid 1980s have fallen down to just one pair. In 300 m distant Botanical Garden the situation was not very different: at first the density was close to 20 p/10 ha (Josse 1964 msc, after its recalculation for 5.5 ha), during 1967 and 1976–1978 declined to 9–10 p/10 ha (which coincided with the occurrence of a crow pair, Sułkowski 1996 msc), and eventually dropped a few times at the presence of 4–6 pairs of Hooded Crows. A responsibility of predation pressure for this change is supported by a strong increase in Blackbird nesting losses, at first very low: only 20% in 1967 (Dyrcz 1969) or 16.7% (N=12 broods) in 1976 in Słowacki Park (own data) and fairly low (37%) in the Botanical Garden during the period of co-occurrence of Blackbirds with single pairs of Hooded Crows and Jay. Before and later in the same part of the city Blackbirds suffered very high breeding losses: 66–88.8% (Josse 1964 msc, Kuć 1978 msc, Sułkowski 1996 msc). A lack of coincidence between population dynamics in two neighboring study areas might result from the differences in vegetation structure: plenty of evergreen bushes in the Botanical Garden and their scarcity in Słowacki Park. It remains unclear, however, why Blackbird numbers were unstable in "optimal" Botanical Garden, and so stable in "suboptimal" Słowacki Park. This might have resulted from an inaccessibility of Botanical Garden to humans during early morning hours, leaving more time for the activity of predators, when present in some years there.

In Szczytnicki Park Blackbirds have also declined 3.5 times (statistical significance at regression slope –0.97; $P<0.0001$), mostly quite recently, and apparently in opposition to increasing crow numbers. Similar situation has been found in the neighbouring housing district of Sępolno, where between 1988 and 2003 Blackbirds declined four times (Kopij 2004a), despite a steady number of breeding crows and penetration of this area by a flock of c. 50 non-breeders (Udolf 2005). Thus, after decades of high abundance, recently Blackbird has become a scarce breeding species in all four study areas located in the eastern half of Wrocław.

Changes in numbers of important predators

In the course of this study Wrocław parks have been occupied and then faced an increase in the number of important predators of birds or their broods. The most important predator is Hooded Crow, for which the process of colonization has been fully documented. Crows arrived at Słowacki Park in 1972. Currently 8–9 pairs breed there (Table 1), and a dozen or so non-breeders is regularly observed; the change is highly statistically significant (regression slope 0.93; $P<0.0001$). Within the census plot in Szczytnicki Park single pairs of crows bred (irregularly?) since at least 1958 (Dyrcz 1963), then numbers increased from about 2 pairs during the 1970s to 10 pairs recently (Table 3) plus c. 50 non-breeders (a clear increase though not statistically significant). Also the numbers of Red Squirrel *Sciurus vulgaris* fluctuated considerably in the latter park (c. 27 ind. during the early 1970s, only 7 ind. during 2000–2001, and again c. 20 during 2009–2010). Less important avian nest predators remained on a steady level (Table 3), while domestic cats in both parks were encountered fewer than once per season. Sporadic nesting attempts of raptors (Common Buzzard, Sparrowhawk) had no clear impact on bird numbers.

Data on the occurrence of Pine Marten are less complete, yet unequivocal. The presence of this mammal within the census plot in Szczytnicki Park was revealed around 1978 (J. Hrynkiewicz, pers. com.), yet it could arrive earlier, as during 1972–1973 in five Wood

Pigeon and Collared Dove nests the nestlings or adults were killed by an arboreal mammal (Tomiałojć & Profus 1977). This loss could hardly be due to activity of Stone Marten *Martes foina,* also present there, because the last species is known as mostly vegetarian and human commensal (Tomiałojć 1980a, 2005). Single Pine Martens were again recorded in 1986–1988 (R. Cisakowski – pers. com.), while during 2000–2001 their family with two young occupied a hole within our census plot. During that last period martens returning at daytime to their hole were seen 5–6 times per season, chiefly in late May and June, usually being noisily mobbed by birds. On this background, the lack of Pine Marten records during 2002 and 2009–2010 (considering the same frequency of visits, as well as additional searches across the whole park in other years), strongly indicates their disappearance. A family of Stone Martens has also been occurring next to Słowacki Park at least since the 1970s, yet without any recognizable influence on breeding birds (Tomiałojć & Profus 1977, Tomiałojć 1980a).

Discussion

The aim of this study was: a) to evaluate how the breeding bird community composition changed during forty years in a stable environment, and b) to reveal main reasons for these changes, chiefly those not resulting from plant succession or direct human impact.

In spite of different size, age, location within an urban area and intensity of human visits in both Wrocław parks, the changes in their breeding avifauna were basically similar and mostly negative (declining species richness and/or abundance). Only two positive changes were recorded in both parks: the arrival of breeding Mallards and an increase in abundance of two expansive insectivores, Blackcap and Collared Flycatcher (the last one in Słowacki Park has been recorded as a non-breeder). This trend agrees well with the increase of these species elsewhere, in other towns and in natural habitats (Tomiałojć & Stawarczyk 2003, Tomiałojć 2007).

Long-term changes in bird community composition of distant urban parks

Parallel observations in 65 km distant town of Legnica (Tomiałojć 2007), 140 km distant Gliwice (Grochowski & Szlama 2011) and Wrocław in-between them (Tomiałojć & Profus 1977, new data) have revealed two directions of changes. Main trends of increasing species richness and bird abundance were similar in Legnica and Gliwice, while the opposite was in the city of Wrocław. This suggests that similar geographical and climatic conditions were of no importance. Likewise, a common tendency to increasing synurbization could not be the strongest factor, because colonisation pattern of expansive species (e.g. Wood Pigeon, Blackbird or Fieldfare *T. pilaris)* was quite different in the three towns: strong increase in Legnica and Gliwice, and slight one or a decline in Wrocław. Theoretically, owing to high similarity of mostly deciduous vegetation of all three towns (in contrast to some urban parks elsewhere) this should bring a similarity in composition of their bird communities. However, the avifauna of only two towns was developing in parallel: in the Central Park of Legnica and in park of Gliwice, where mostly an arrival of new bird species and huge increases in abundance of common species were noticed, while in most luxuriant Szczytnicki Park strong prevalence of negative tendencies has occurred. In Słowacki Park the situation was intermediate – at first increases prevailed, but were then followed by declines. Consequently, the similarity in the community composition between each of Wrocław parks and that of Legnica have changed differentially: bird community of Słowacki Park after decline of common species became less similar to that of Legnica Park (index Re dropped from 54% in the 1970s to 45% now), while bird community of Szczytnicki Park now recalls that of Legnica park more

(Re increased from 33.8 to 38.8%). Also the share of birds foraging outside Słowacki Park declined from 67% during the 1970s (once similar value to that found in Legnica – Tomiałojć 1970) to 34% recently, while the share of this group in Szczytnicki Park remained on the same level (c. 52%) as in the 1970s, with a temporary drop in the 1980s.

Results from Wrocław parks are very different not only from those obtained in Central Park of Legnica, in 10.75 ha urban park in Gliwice censused after 30 years (Grochowski & Szlama 2011), but also from those of 10 ha Dortmund urban park studied for 43 years (Abs & Bergen 1999). Bird communities from those truly urban parks were evolving for a long time without important nest predators, which resulted in an arrival of new species and strong increases in the densities of dominants. Old parks, including those of Wrocław, recently show relatively low species turnover in their avifauna composition (T=21%, see Results) when compared to parks of Lublin (Biaduń 2004) or chiefly of Dortmund, where T=42% (Abs & Bergen 1999). Exceptionally high turnover rate in the Dortmund park community, indicating almost half of species replaced by new ones, probably reflects a successional change in the vegetation structure of that fairly young tree stand, or/and its increasing coverage by luxuriant bushes.

Historical background of prevailing bird declines in Wrocław parks

Other than anthropogenic causes of declines in bird communities are poorly understood. Most frequently they were only suggested after a stepwise exclusion of other explanations. For example, bird declines in Wrocław parks suggest their independence from a marked local climate warming of the last forty years (Dyrcz & Hałupka 2009), which theoretically could improve breeding performance or winter survival. The impact of weather fluctuations was also negligible: warm winters 1972/1973 and 1974/1975 failed to cause any increase in abundance of residents, while rather cold winters 1978/1979, 1985/1986 and 1986/1987 were followed by only small drops in the overall abundance (in Słowacki Park by 13, 10 and 0%, respectively), restored after one breeding season (Tables 1 and 3). Only prolonged winter of 2009/10 could make an exception, but heavy crow predation could also influence the last decline.

Other two reasons for urban bird decline have been well documented elsewhere (Aldrich & Coffin 1980, Abs & Bergen 1999, Biaduń 2004, 2009, Luniak et al. 2007): a) long-term (historical) changes in character, age and structure of park vegetation under processes of ageing or intrusions of urban development; and b) decline of remnant bird populations due to random reasons, according to an island biogeography theory. The first of them could be important in Wrocław during post-war transformations, but not during last 40 years of a stable park structure. Disturbances should also be more conspicuous in an isolated, more changing and smaller Słowacki Park. This artificially established green "island" has never harboured a species-rich forest avifauna. Only during 1955–1960, after regrowth of wild young trees and bushes, it served as a sporadic nesting site to a few "true" forest species, the Wood Warbler *Phylloscopus sibilatrix* and Robin *Erithacus rubecula* (J. Okulewicz, pers. inf.). Recent changes in its avifauna (Table 1) constituted at first a steady increase in the overall density, as in other down-town parks (Biaduń 2004, Tomiałojć 1998, 2007) with a moderate (sometimes high – Biaduń 2009) species turnover in species composition. The theoretically expected loss of rare species could be due to "insularity effect", yet real data do not confirm a decline in the number of breeding species in Słowacki Park. In contrast to oceanic islands, this area is easily reached by birds; it is regularly visited by forest species (Woodcock *Scolopax rusticola,* Black Woodpecker, Green Woodpecker *Picus viridis,* Great Spotted Woodpecker *Dendrocopos major,* Middle Spotted Woodpecker *D. medius,* Lesser Spotted

Woodpecker, Wryneck *Jynx torquilla,* Song Thrush, Collared Flycatcher, Garden Warbler, two *Phylloscopus* sp., etc.), chiefly during spring migration, though without breeding attempts. Also a continuous – lasting for four decades – nesting of 1–2 pairs of Nuthatches *Sitta europaea* in this park, shows that a surplus of individuals able to reach such a down-town patch of greenery occurs even in truly resident species. A declining trend in the abundance of many common species, lasting for last 25 years, was a truly new and not expected event in this park.

The history of bird community in Szczytnicki Park was entirely different. It originated from an avifauna of riparian forest with meadow clearings. The original list of breeding species had to contain c. 60 species, judging from an account registered in 1890 in a structurally similar and situated only 3 km apart the Strachocin Wood (C. Floericke, cit. after Dyrcz 1964). Transformation of the suburban forest-like park into surrounded by urban development Szczytnicki Park, i.e. between the late 19th century and the years 1958–1959, has shortened the breeding list to c. 52 species (Dyrcz 1963), and by now to c. 46 species in the whole park. Within the 24-ha census plot (embracing present 17 ha plot), 9 breeding species were still present during 1958–1959 (Dyrcz 1960, Table 4), including a singing male of River Warbler *Locustella fluviatilis* recorded there till 1961. At that time this plot had secondarily a forest character owing to a post-war development of bush layer and a low human penetration, which allowed for a very high breeding density of the Song Thrush and Blackbird (Dyrcz 1963, Table 4). Since 1970, when a typical park character was restored, the old tree stand and scarce bush layer have remained almost unchanged (photos in the paper by Tomiałojć & Profus 1977, and the recent one – photo 2). Yet, bird community composition continued to change, chiefly during the 1980s (Cisakowski 1992, Tables 3 and 4) and during 2009–2010. To learn more about the present bird community composition in the whole park area, in 2010 additional three quick counts of scarce species were carried out outside my census plot. They have confirmed that 8 species (Cuckoo, Lesser Spotted Woodpecker, Dunnock, Treecreeper, Marsh Tit, Wood Warbler, Willow Warbler, Goldfinch) no longer breed there. Other 9 species (Feral Pigeon, Collared Dove, Magpie, Song Thrush, Black Redstart, Spotted Flycatcher, Goldcrest, Serin and Hawfinch) are represented by merely one or two breeding pairs within the whole park. Single pairs of Moorhen *Gallinula chloropus* and Reed Warbler *A. scirpaceus* still breed along an old river bed while a new addition to local avifauna may constitute Long-eared Owl *Asio otus*, encountered in the eastern part of the Park in July 2010 and known to breed for a few years in its close neighborhood, as well as to colonize other Wrocław and Legnica urban parks (Kopij 2004, own data).

Unexpectedly, quantitative structure of bird community in smaller Słowacki Park with less stable tree stand has changed less with time than that of more stable (after 1970) and larger Szczytnicki Park. The annual number of breeding species fluctuated strongly in the former one, yet did not decline, while within 17-ha census plot of the latter park the number of breeding species fell down from 42 (Dyrcz 1963) to 28–29 recently. The index of similarity composition (Re) calculated for Słowacki Park bird community between the early 1970s and the last period of census data shows 63% of similarity, while the same comparison within Szczytnicki Park – 61%. Presumably the first park had an urban character still before these studies started, while the increasing urbanization pressure on originally suburban Szczytnicki Park triggered a decline in its species richness. Though both figures are much higher than those revealed for even less stable avifauna of Lublin parks (Re=32–57%, Biaduń 2009), they are still fairly low – comparable to index values found between very distant deciduous parks or forests of Europe (Tomiałojć & Profus 1977).

To conclude, Wrocław data support a known regularity – decline in species richness with increasing area urbanization (Erz 1966, Tomiałojć 1970, Marzluf 2001, Ptaszyk 2003, Biaduń 2004, 2009). The opposite relation may be observed only exceptionally when habitat change goes from a fairly uniform patch of forest into an urban mosaic of different habitats, as it has been documented in the county Faifax, USA (Aldrich & Coffin 1980).

Predator pressure as the cause of changes in bird community composition

The avifauna of Słowacki Park during the 1970s was typical of an urban area, then for decades devoid of stronger impact of nest predators (Tomiałojć & Profus 1977). Even if a family of Stone Martens was occupying a neighbouring building, no remains of killed birds were regularly noticed (Tomiałojć 1980a). In Szczytnicki Park during the early1970s almost certainly there were no stationary Pine Martens, only Stone Martens, while single pairs of Hooded Crows (not necessarily each year) were penetrating mostly the edges of tree stands (Dyrcz 1963). At the absence or scarcity of dangerous predators several prey species, Jackdaw, Tree Sparrow, Wood Pigeon, Blackbird or Mallard, could built up their populations. In Szczytnicki Park this trend had stopped before 1986 (Cisakowski 1992) or perhaps c. 1973 (Tomiałojć & Profus 1977), after the arrival of stationary Pine Martens, while in Słowacki Park the main factor pressing bird populations down was gradually increasing nest predation of Hooded Crows. The restored nest predation in Wrocław parks, in contrast to the parks of Legnica or Gliwice (Tomiałojć 2007, Grochowski & Szlama 2011), resulted in a deep decline among abundant species, chiefly those of larger size (Wood Pigeon, Collared Dove, Jackdaw, Jay, Blackbird), as well as in some very numerous ones (Tree Sparrow), which constituted a very attractive prey.

The main result of this study is a finding that a decline of abundant bird populations in both parks coincided with restored nest predation and predation. Only for a few species could an additional reason, deterioration of nesting or foraging conditions, be suspected. For example, in Słowacki Park a neighbouring wasteland suitable for foraging to small granivores (Tree Sparrow, Serin) has been replaced by open lawns more suitable for other species (corvids, Starling *Sturnus vulgaris,* Wood Pigeon), though the birds of the latter group continue to forage away from the park and failed to respond with an increase. The early bird decline in Szczytnicki Park was noticed both among cavity nesters and species nesting openly in tree crowns (Table 5). This led Cisakowski (1992) to look for a possible cause in a deterioration of foraging conditions. New data falsify this possibility, because local climate during past 40 years has became milder (Dyrcz & Hałupka 2009, Szymanowski 2004), urban air pollution has declined (Szudnicki & Szykasiuk 2002), the condition of tree layer has improved, outbreaks of *Tortrix viridana* caterpillars have continued to occur. Likewise, grasslands and fields within a radius of 2 km from the park, used as foraging sites, have remained unchanged.

Mere coincidence in time between the moment of predator arrival and subsequent decline in prey numbers does not satisfy as an evidence of causal relation between these phenomena. Yet, in the case of Wrocław park bird communities there are additional symptoms indicating the causal tie. These are: a contemporary decline in the abundance of species characterized by a very different breeding biology, ways of nesting, entirely different diet, foraging outside or within the park, etc. Their common feature is the vulnerability to nest predation reflected in a dramatically lowered breeding success: recently well below 10% in some vulnerable species like Wood Pigeon, Collared Dove, Blackbird (see Results). This is a strong argument, because in the same part of the town the same species were reproducing 3–5 times more efficiently before the arrival of predators (Dyrcz 1963, 1969, Tomiałojć 1980a).

Of three nesting guilds recognizable after the type of nest accessibility (Table 5) each has declined according to its own pattern. In Słowacki Park bigger birds with open nests in trees started to decline first (Wood Pigeon, Rook, Jay) – soon after arrival of a pair of Hooded Crow. Smaller species of open nesting birds continued to increase until the number of crows grew up to a considerable level and these predators started to look for nests of even small birds. The absence of efficient predators of hole-nesting birds in this park (after disappearance of Red Squirrels) left this group of birds fairly safe, which resulted in their high abundance till mid 1980s, when they also started to suffer from both crow predation on fledglings and some shortage of nesting holes. Marginal in down-town parks group of ground and low-bush nesters was slowly increasing in Słowacki Park (contrarily to decline in Skaryszewski Park of Warsaw, Luniak et al. 2007), to decline during 2009–2010, possibly also under pressure of numerous crows.

In Szczytnicki Park the scenario of changes in guild abundance was quite different: the crash of both hole-nesting birds (with unclear exception of Mallard?) and open nesters occurred between 1975–1985, when Pine Martens settled there. Later occupation of this park by numerous crows (after retreat of Pine Martens) coincided well with the second sharp decline in all three guilds (Table 5). It may be surprising that in both parks an increase in abundance of small birds with open tree nests (Chaffinch *Fringilla coelebs,* Goldfinch, Greenfinch *C. chloris,* Serin, Spotted Flycatcher, Blackcap) lasted till the late 1990s or later (Table 6), i.e. until facing high numbers of crows. During 2008–2010 several attacks of crows on nests of these birds were observed first, or alarming of adults at a presence of a crow checking the tree crown was recorded, which supports the above explanation. For several years the fringillids, able to breed semicolonially, made use of ornamental spruces planted during the 1980s in Słowacki Park. However, later they also started to face stronger predation pressure for the two reasons: changing shape of spruces into an arboreal one made nests more conspicuous/accessible and an increased number of crows made them more frequently check the spruces. Similarly, a strong decline of the same species group in Szczytnicki Park occurred during 2009–2010 (Table 6), when crows became numerous.

Predator pressure on hole-nesters. Hole-nester numbers in Szczytnicki Park partly reflected changes in the availability of nest boxes. Yet, this factor alone is insufficient to explain a 40% decline of all hole-nesters during early 1980s, including the larger species independent of artificial nest boxes. A removal of some old trees occurred there only after and not before a crush in the number of breeding Jackdaws and Tree Sparrows. Small hole-nesters (titmice, sparrows, flycatchers, etc.) could not face any shortage of nest sites in so rich in natural cavities Szczytnicki Park. Yet, the overall number of small hole-nesters has been declining across 40 years, in spite of stable character of the habitat structure. Even the addition of c. 30 nest boxes during the late 1990s failed to trigger a return of Tree Sparrows. The reason is again a restored predation, because flycatcher broods in nest boxes left after Tree Sparrows soon started to be destroyed by martens, crows and sporadically humans. Destruction by martens (apparently Pine Martens) was easily recognizable. During 2000–2001 I found dozen of records when some nest material was pulled out of a nest box, entirely blocked the entrance or the entrance was enlarged with the mammalian teeth. A Pine Marten was seen twice to carry *Parus* sp. nestlings as a food. No such symptoms were noticed in years, when Pine Martens were not observed, which indirectly excludes also a responsibility by the permanently present Stone Martens.

It seems that bird decisions to settle to breed at a particular site or to avoid it, at the presence of a dangerous predator, depend on the moment of their nesting cavity occupation. Tree Sparrows, roosting in nest boxes during winter and early spring and Jackdaws early oc-

cupying bigger holes, could both be scared off or killed in cavities by martens well before breeding season. These two species may evaluate the safety of holes before the start of breeding, while flycatchers returning from wintering grounds around mid April have lesser possibilities for evaluating the nest site safety, and their breeding – once started – is continued.

Some – fairly low – proportion of brood losses were caused by crows, which sometimes learn to open nest boxes, by turning round the roof when attached with a single nail. Crows are more successful in catching young Starlings just about to fledge, when they are leaning out of tree holes, but still more frequently catch the fledglings. Generally Starling holes are safe from attacks by Hooded Crow and Pine Marten, owing to small entrance and a lack of suitable support (in contrast to nest boxes) for climbing mammals. Most likely, these factors were responsible for stable and high numbers of breeding Starlings in both parks, until their eventual drop in Słowacki Park after the year 2000, when old trees injured during the World War Two started to be replaced by the new ones devoid of holes.

Interactions between predators. Pine Martens reduce activity or abundance of other nest predators – squirrels and crows – thus preventing some amount of brood destructions. E.g. during the presence of Pine Martens in Szczytnicki Park in 2001 the number of breeding Hooded Crows was clearly lower (Table 3), and during preceding season almost all crow nesting attempts failed. Higher numbers of Red Squirrels in this park were also found exclusively at the absence of martens. But also the presence of numerous Hooded Crows restricted nest predation of other corvids: the fights with Jackdaws and Rooks were frequently observed. Arrival of crows to Słowacki Park was soon followed by the disappearance of Jays (Table 1), while the destruction of Jay nests by crows in Szczytnicki Park forced the former species to hideits nests in tree holes (3 cases). Presumably crows forced six squirrels out of Słowacki Park or killed them (killing squirrels by Hooded Crows has been documented in Moscow – Karaseva et al. 1999). Such interactions between predators may make unrealistic some theoretical models, and fail to find strong relationships between the elements of the prey-predator system.

A time-lag between arrival of predators and changes in prey numbers. For decades or even centuries, most urban parks offered safe breeding sites, owing to the absence of efficient predators. Yet, during recent decades, when corvids, raptors and carnivorous mammals have also started to invade urban areas, some urban parks may turn into "ecological traps" to prey species. The strong decline of Blackbird population in Wrocław differs strikingly from the situation described in structurally similar urban parks of Szczecin (NW Poland), where an arrival of breeding Hooded Crows failed to reduce Blackbird population, in spite of causing high nesting losses (Wysocki 2005). The latter may be a transient situation, similar to that during the first 15-years of co-occurrence of numerous Blackbirds and a few Hooded Crows in Słowacki Park and Botanical Garden of Wrocław, also for a long time without a marked decline in prey population (Table 1). Hence, it would be wrong to expect a clear coincidence between a moment of arrival of a nest predator and an immediate behavioral or numerical response in its prey population. My observations show that a clear numerical response in prey species begins to be conspicuous (a clear decline in abundance) after 15–25 years of prey-predator co-occurrence, i.e. until the numbers of nest predators (here crows) reach the level when they are forced to a very intensive exploitation of available resources, including broods of small birds, like finches. Moreover, with increasing numbers of crows an intraspecific competition results in persistent and noisy fights between breeding individuals, as well as between breeding and non-breeding pairs. This overt behaviour makes predators very conspicuous to their prey, which might influence the decisions of prey individuals either to settle in the area or to move elsewhere. Pigeons, a very attractive prey, seem to be an exception, as their abundance may be reduced even by individual specialized predators.

Things are different when an arriving predator, like Pine Marten, threatens the adults of prey. In Wrocław a decline in prey species followed fairly soon the arrival of such a predator, though this has not been sufficiently documented, unfortunately not incessantly. In this case not only a physical interaction (killing individual prey items) may be involved , but also experienced prey individuals may desert dangerous site before breeding season or mob the sites with a predator. Labeled as "ecology of fear" (Brown et al. 1999), such a reaction could influence Jackdaw and Tree Sparrow numbers in Szczytnicki Park. Moreover, a memory of risk may be responsible for a lack of re-population of this park even 9 years after disappearance of Pine Martens, despite the abundance of cavities suitable for Jackdaws, each year excavated by large woodpeckers (Black Woodpecker, Green Woodpecker, Grey-headed Woodpecker). Fear as an ecological factor needs more attention in future bird research.

Conclusions

Transformation of suburban forest park into Szczytnicki Park surrounded by urban development resulted in shortening the breeding list of birds from c. 60 to c. 46 species after nearly half of a century. During the second half of a century within smaller census plot of the same park the species list has been reduced from 42 to 28–29 species. In the down-town Słowacki Park, contrarily, during last 40 years the species list has changed little.

During 40 years the overall density of birds and the numbers of most abundant species at first were increasing (in Słowacki Park), but later in both parks declined by c. 40% of the peak numbers (the same happened in the Botanical Garden).

In Szczytnicki Park ceasing of breeding or sharp declines have been revealed among species wintering in the city (Jackdaw, Tree Sparrow, Blackbird), chiefly hole-nesters, while in the down-town Słowacki Park largely among open-nesting birds (Wood Pigeon, Collared Dove, Rook, Blackbird, fringillids). This reflected an arrival of different predators: Pine Martens into the former park (with crows invading later), and Hooded Crows into the latter.

Main declines in abundance resulted from restored nest predation, which caused almost 100% nesting losses among monitored nests of Blackbirds, Wood Pigeons and Collared Doves. These results show that it would be wrong to expect an immediate (without time-lag) response of prey species to an arrival or disappearance of important predators.

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