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# Changes in the number of nesting pairs and breeding success of the White Stork *Ciconia ciconia* in a large city and a neighbouring rural area in South-West Poland

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**Abstract** During the years 1994–2009, the number of White Stork pairs breeding in the city of Wrocław (293 km$^2$) fluctuated between 5 pairs in 1999 and 19 pairs 2004. Most nests were clumped in two sites in the Odra river valley. Two nests were located only cca. 1 km from the city hall. The fluctuations in numbers can be linked to the availability of feeding grounds and weather. In years when grass was mowed in the Odra valley, the number of White Storks was higher than in years when the grass was left unattended. Overall, the mean number of fledglings per successful pair during the years 1995–2009 was slightly higher in the rural than in the urban area. Contrary to expectation, the mean number of fledglings per successful pair was the highest in the year of highest population density. In two rural counties adjacent to Wrocław, the number of breeding pairs was similar to that in the city in 1994/95 (15 vs. 13 pairs). However, in 2004 the number of breeding pairs in the city almost doubled compared to that in the neighboring counties (10 vs. 19 pairs). After a sharp decline between 2004 and 2008, populations in both areas were similar in 2009 (5 vs. 4 pairs), but much lower than in 1994–1995. Wrocław is probably the only large city (>100,000 people) in Poland, where the White Stork has developed a sizeable, although fluctuating, breeding population. One of the most powerful role the city-nesting White Storks may play is their ability to engage directly citizens with nature and facilitate in that way environmental education and awareness.

Keywords: *Ciconia ciconia*, Lower Silesia, census, reproductive success, urban ecology, nature conservation, citizen science, ubranization

**Összefoglalás** A Wrocławban (293 km$^2$) költő fehér gólyák száma 5 (1999) és 19 (2004) között ingadozott az 1994 és 2009 közötti időszakban. A legtöbb fészek két helyen csoportosult az Odera völgyében. Két fészek kb. 1 km-re helyezkedett el a városházától. A számbeli ingadozás a táplálkozó terület elérhetőségéhez és az időjáráshoz köthető. Azokban az években (1995–2009), amikor a füvet lekaszálták az Odera völgyében, a gólyák száma nagyobb volt ahhoz képest, amikor nem kaszálták. Összességében, a mezőgazdasági területen a sikeres fészekaljakkénti átlagos fiókaszám kicsivel nagyobb volt a városi területhez képest. A várakozásokkal ellentétben a legnagyobb populációsűrűségű évben volt a legnagyobb a sikeres fészekaljankkénti átlagos fiókaszám. Két Wrocław melletti, vidéki megyében a költő párok száma a városéhoz hasonlóan alakult 1994/95-ben (15 ill. 13 pár). Ezzel szemben 2004-ben, a költő párok száma majdnem megduplázódott (19 pár) a környező megyékhez képest (10 pár). A 2004 és 2008 közötti nagymértékű csökkenés után, a költő párok száma kiegyenlítődött 2009-ben, de sokkal kevesebb lett az 1994/95-ös időszakhoz képest. Valószínűleg Wrocław az egyetlen nagyváros (>100 000 lakos) Lengyelországban, ahol a fehér gólyának figyelemre méltó, bár ingadozó méretű költő állománya van. A városban költő fehér gólyák legnagyobb társadalmi szerepe abban lehet, hogy a városlakók természet iránti elkötelezettségét erősíthetik, és ezzel segíthetik a környezeti nevelést és tudatosságot.

Kulcsszavak: fehér gólya, Alsó-Szilézia, felmérés, szaporodási siker, városi ökológia, természetvédelem, civil tudomány, urbanizáció

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## Introduction

The urban ecosystem is a conflicting arena between human development and nature conservation. Urbanization affects animals and plants mainly by destruction (local extinctions) and fragmentation (demographic and genetic instabilities) of their habitats. A wide range of new habitats are created in such ecosystems, resulting in an increase of biodiversity. Ornithologists have, however, recorded that with the increase of urbanization the common species are in increase, while the rare and threatened species are often in decline (Magle *et al.* 2012).

Around some big cities, large open areas are created, such as allotment gardens, sport fields, airports, mowed grasslands along rivers and canals, polders, sewage dams, dumping sites etc. From the point of view of the city management, some of these areas can be regarded as sorts of wastelands. They may provide, however, good foraging grounds for numerous birds, including those which are endangered (Mazur & Kopij 2007, Kopij 2008), but the role of such peri-urban artificial habitats has been poorly investigated (Magle *et al.* 2012, McKinney 2002, Meffert & Dziock 2012).

Due to the presence of numerous rivers, canals, and extensive polders, the city of Wrocław in South-West Poland is abundant of such peri-urban ”wastelands”. A species often associated with such modified habitats is the White Stork *(Cicocia ciconia)*. Since it is in decline in many European countries, it has been included as strictly protected in all member states of the European Union (Bird Directive, 79/409/EWG) and is regarded as so called charismatic species.

The White Stork began to nest in human settlements probably in the Neolithic period (Jakubiec 1991). At present it is strictly associated with human settlements, for example, in Poland more than 99% nests are located in settlements (Jakubiec 1991, Guziak & Jakubiec 2006). However, it nests typically only in villages and in small towns, and avoids larger towns and cities. In most Polish cities (more than 100,000 people) only 1–3 nests have been recorded (Guziak & Jakubiec 2006). However, the city of Wrocław, appears to be an exception to the rule. Because it is situated in the big valley of the Odra river, where four other smaller rivers join it, the area is suitable for both feeding and nesting of the White Stork.

The aim of this study was to examine the numbers and productivity of the White Stork in order to determine the population trend and to address the appearance of the species in the city of Wrocław. These ecological parameters are compared with those in White Storks nesting in the neighbouring rural area.

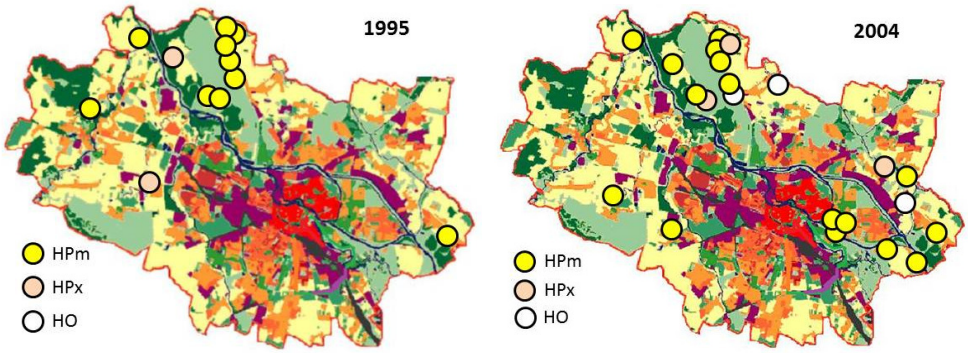


*Figure 1.* Distribution of White Stork nests in the city of Wrocław in 1995. Explanations: HPm – nests with fledglings; HPx – nests with unknown breeding success, HO – nests without breeding success. Light green – meadows, pastures, polders and other grassy areas; green – allotment gardens, parks and other timbered urban areas; dark green – forests, yellow – arable grounds; orange – loosely built-up areas, red – densely built-up areas; purple – industry areas; black – larger railway areas; blue – rivers and water bodies

*1. ábra* A fehér gólya fészkek elhelyezkedése Wrocławban 1995-ben. Jelmagyarázat: HPm – fiókás fészek; HPx – fészek ismeretlen költési sikerrel; HO – fészkek sikeres költés nélkül. Világoszöld – rét, legelő, belvizes vagy egyéb füves terület; zöld – veteményes kertek, parkok és egyéb fás városi terület; sötétzöld – erdő; sárga – szántó; narancssárga – ritkán beépített terület; vörös – sűrűn beépített terület; lila – ipari terület; fekete – nagyobb vasúti terület; kék – folyók és vizes terület

## Materials and Methods

### Study area

The study area is the city of Wrocław (South-West Poland) within its administrative boundaries *(Figure 1)*. The surface area of this city is 293 km$^2$ and the human population is cca. 640,000 inhabitants (2004). The city is situated in the large Odra Valley, where four other smaller rivers (Oława, Ślężea, Bystrzyca and Widawa) join the Odra river. There are lots of grasslands along these rivers. In 2004, arable land comprised 44.8% of the total surface area, whereas 5.6% were covered by forests and wooded areas, 3.4% by water, 9.8% by roads, 18.7% by built-up areas, 3.7% by gardens, 6.1% by recreational areas, and 1.3% by wastelands (data from the city government). There was a huge flood in 1999 which affected all river valleys. In 2002–2004, large parts of the grasslands were mowed, but later on, these were left unattended. Czernica (84.2 km$^2$) and Siechnice (98.6 km$^2$) counties border the city from the south-east. In the former county, farmlands occupied 64.3% of the total surface area, whereas 20.9% were covered by forests, 3.5% by water, 4.5% by settlements, 7% by other land use; the human population density was 147 ind./km$^2$. In Siechnice county farmland comprised 63.1% (including 9.3% meadows and pastures), whereas forests made up 12%, water 3.3%, settlements 11%, and population density was 170 ind./km$^2$ (data for 2015 from the county governments).

### Methods

Nests were surveyed in July, at the time when the chicks were well-visible in the nests. All nests in the city were surveyed in 1994, 1995, 1999, 2004 and 2009. I classified nests into one of the following categories (i) unoccupied (international symbol (Schulz 1999) HO), (ii) occupied by a non-breeding pair for shorter than one month (HB), (iii) occupied by a breeding pair for longer than one month, with known breeding success, (iv) occupied by a breeding pair for longer than one month, with breeding success unknown (HPx), and (v) occupied by a successfully breeding pair, with number of fledglings known (HPm1-5, where the number indicates the number of fledglings). I then calculated the total number of fledglings from HPm nests (HPm), the total number of fledglings in HP nests (HP), and the total number of nests (H).

## Results and Discussion

During the years 1994–2009, the number of White Stork pairs breeding in the city of Wrocław varied markedly. While there were 11–13 pairs in 1994–1995, only 5 pairs were recorded in 1999 *(Table 1, Figure 1)*. The population reached its minimum in 1999 and its maximum in 2004 (19 breeding pairs). Wrocław is probably the only city (>100,000 people) in Poland, where the White Stork has a sizeable and relatively stable breeding population.

Nests were clumped in two areas – in the eastern part of the city, where natural wet grasslands are abundant in the Odra and Oława river valleys and in the north-western part, where sewage dams and polders, reeds and meadows were abundant in the Odra and Widawa river valleys *(Figure 1)*. Most nests in the former area were initiated in 2004.

These marked fluctuations between 1994–2009 can be linked to the availability of foraging grounds and weather (Kopij 2006, 2013). For example, in the years when grass was mowed in the Odra and Oława river valleys (2002–2004), the number of birds were higher than in years when the grasslands were left unattended. In wet years, there were more food available for the White Stork to raise chicks, while in dry ones, there were less food.

Two nests were located very close (cca. 1 km) to the city centre (one in the Zoological Garden, and the other near the Redemptorists' Church in Wittiga Street). Both nests were also close to the Odra river *(Figure 1)*.

In the two counties (Czernica and Siechnice) bordering Wrocław in the south-east, the number of breeding pairs in 1995 was similar to that in Wrocław (15 vs. 13 pairs) *(Table 2)*. However, in 2004, the number of breeding pairs in Wrocław city almost doubled compared to that in the neighbouring counties (19 vs. 10 pairs). After a sharp decline between 2004 and 2009 (sharper in Wrocław than in the counties), both populations reached a similar level again (5 vs. 4 pairs). The decline from 1994/95 to 2009 was remarkable both for Wrocław (13 vs. 5 pairs), and for Czernica and Siechnice counties (15 vs. 4 pairs).

*Table 1.* Results of the White Stork nests inventory in Wrocław (293 km$^2$) during the years 1994–2009 (see text for abbreviations)

*1. táblázat* A wrocławi (293 km$^2$) 1994 és 2009 között végzett fehér gólya fészekalj felmérés eredményei. HO – üres fészek; HB – egy madár, vagy egy pár által kevesebb mint egy hónapra foglalt fészek (nem költő pár); HP – egy pár által több mint egy hónapra (költő pár) elfoglalt fészek; HPx – egy pár által több mint egy hónapra elfoglalt fészek ismeretlen költési sikerrel; HPm1-5 – ismert fiókaszámú fészek (HPm1 – egy fiókás, HPm2 – két fiókás stb.) HPm – HPm1-5 fészkek össz fiókaszáma; HP – HP fészkek össz fiókaszáma; HP – össz fiókaszám

| Parameter | 1994 | 1995 | 1999 | 2004 | 2009 | Total |
|---|---|---|---|---|---|---|
| HO | | | | 2 | 4 | 6 |
| HB | | | | 1 | 1 | 2 |
| HPx | 2 | | 1 | 2 | 1 | 6 |
| HPmx | 8 | 3 | 2 | 1 | | 14 |
| HPm1 | | 1 | | 1 | | 2 |
| HPm2 | | 2 | 1 | 8 | 4 | 15 |
| HPm3 | 1 | 3 | 1 | 4 | 1 | 10 |
| HPm4 | | 4 | | 3 | | 7 |
| HPm | **9** | **13** | **4** | **17** | **5** | **48** |
| HP | 11 | 13 | 5 | 19 | 5 | 53 |
| H | 11 | 13 | 5 | 22 | 10 | 61 |

*Table 2.* Results of the White Stork nests inventory in Czernica and Siechnice counties, Wrocław district (182.8 km$^2$) during the years 1994–2009 (see text for abbreviations)

*2. táblázat* A Wrocław körzetbe eső Czreznica és Siechnice megyékben (182.8 km$^2$) 1994 és 2009 között végzett fehér gólya fészekalj felmérés eredményei (rövidítéseket lásd az *1. táblázatnál*)

| Parameter | 1995 | 2004 | 2009 | Total |
|---|---|---|---|---|
| HO | 1 | 11 | 1 | 13 |
| HB | | 1 | 1 | 2 |
| HPx | | 3 | | 3 |
| HPmx | 9 | | 1 | 10 |
| HPm1 | | | | 0 |
| HPm2 | | 5 | 1 | 6 |
| HPm3 | 3 | 4 | 2 | 9 |
| HPm4 | 3 | 1 | | 4 |
| HPm | **15** | **10** | **4** | **29** |
| HP | 15 | 13 | 4 | 32 |
| H | 16 | 24 | 5 | 45 |

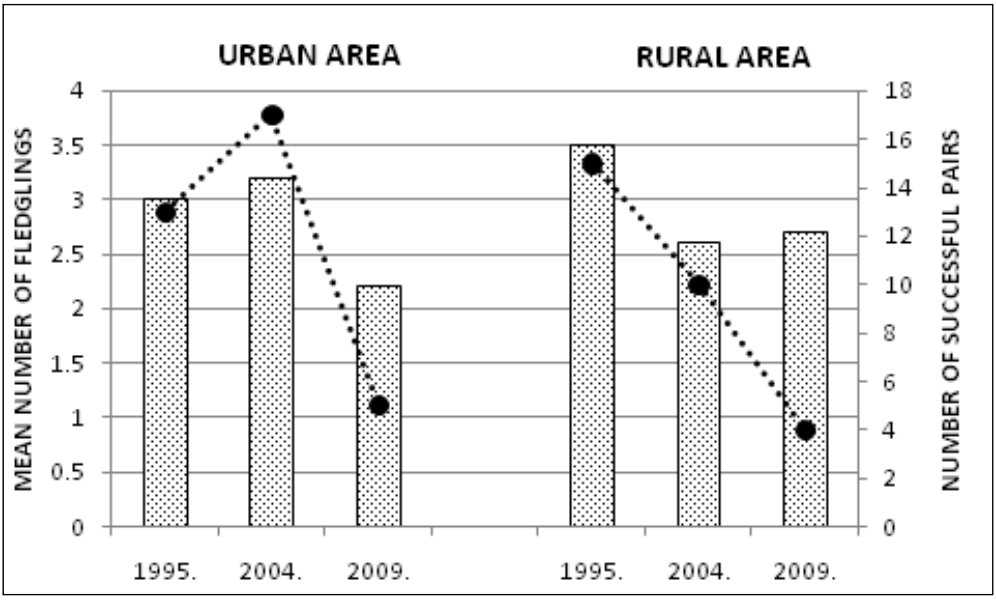


*Figure 2.* The number of successful pairs (dots) and the mean number of fledglings (bars) urban (Wrocław city) and rural (Czernica and Siechnica counties) areas

*2. ábra* A sikeres költőpárok száma (pontok) és a fiókák átlagos száma (oszlopok) a városi (Wrocław) és a mezőgazdasági területeken (Czernica and Siechnica megyék)

In overall, the mean number of fledglings per successful pair in 1995, 2004 and 2009 was slightly higher in the rural ($2.89; SD = 0.74; N = 19$) than in the urban area ($2.65, SD = 0.91; N = 31$). However, contrary to expectation, the mean number of fledglings per successful pair was the highest in the year when the White Stork reached the highest number of breeding pairs, both in Wrocław city and in Czernica/Siechnice counties *(Figure 2)*. This may indicate that neither groups reached saturation levels in that year. When birds reach such a level, their breeding success usually declines (Perrins & Birkhead 1983).

In a few nests, relatively high reproductive success was recorded, i.e. in Wrocław: Zajączkowska, Szachistów and Mikory streets. In most of the years, chicks were raised to fledging in these nests. There were some nests where chicks were reared only in 1–2 years out of the six surveyed, i.e. in Wrocław: Dłutowa, Opatowicka, Sułowska streets. This may indicate rich and poor feeding circumstances around those nesting sites. However, these differences can also be explained by other factors such as different sets of predators or different distance to the feeding areas.

In conclusion, my results suggest that Wrocław is probably the only larger city (>100,000 people) in Poland, where the White Stork has nested in relatively high density. Although the number of pairs breeding in the urban environment fluctuates widely, the White Stork has potentials for further expansion. This study shows a positive impact of urbanization on the number and breeding success of an endangered species and a possible role man can

play in this regard through adequate management of some peri-urban wastelands. As a charismatic species, the White Stork may attract attention of naturalists, ecologists and conservationists in urban environment, facilitate directly citizen engagement with nature, environmental education and awareness.

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