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Urban development from an avian perspective: causes of hooded crow (*Corvus corone cornix*) urbanisation in two Finnish cities

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Abstract

The hooded crow (*Corvus corone cornix*) colonised Turku and Helsinki, two cities in southern Finland, in the first half of the 20th century as a breeding species. Their urban population densities, however, remained low for decades, in spite of considerable changes in the urban environment. Since the 1960s, the breeding populations have increased very rapidly in both cities. The possible causes of the early colonisation of cities, the long period of low population density, and the recent rapid population increases are discussed based on environmental history data. The establishment of city parks in the 19th century was probably a prerequisite for initial colonisation, although it cannot alone explain the timing of colonisation. Hooded crow populations did not increase before the 1960s, although biological waste production increased considerably and large landfills were continuously available near both cities. In Turku, the rapid increase of the crow population took place after the availability of biological waste in the main landfill had decreased due to opening of a municipal waste incinerator. Suitable habitats created by urban expansion and a lack of predators in cities during the breeding season may have promoted urbanisation. The main factor promoting urban population growth has probably been decreased persecution in cities since the 1960s. Low levels of persecution in urban areas have facilitated the habituation of crows to humans and traffic, and probably explain the recent colonisation of city centres as breeding habitats.

Keywords: Hooded crow; Urbanisation; Environmental history and change; Finland

1. Introduction

Considering the wide interest in bird urbanisation (e.g. Diamond, 1986; Stephan, 1987; Marzluff et al., 2001a), it is surprising that there are no published stud-
on changes in urban conditions may be lacking. Environmental history is such a young discipline that historical data on the environment in cities has, at least in Finland, only very recently become available. Finally, there is the problem of scale. Most studies have so far focused on documenting urbanisation processes on a large scale, for instance for entire countries or even sub-continents (Luniak, 1990; Marzluff et al., 2001b). Such studies often have a tendency to generalise about the possible causes of urbanisation. From an ecological perspective, it is, however, more likely that the causes and consequences of urbanisation vary geographically.

Detailed ecological analyses of urbanisation processes are needed both for scientific reasons and for successful management of urban bird populations. The purpose of our study was to investigate the urbanisation of the hooded crow (Corvus cornix L.) in two Finnish cities by using both historical and ecological data. In large areas of Europe, from Russia (Konstantinov et al., 1982; Ilyichev et al., 1990) to northern Italy (Milan; Londei and Maffioli, 1989), urban hooded crow populations have increased in recent decades (also Glutz von Blotzheim and Bauer, 1993). Although no detailed studies have been performed, this widespread urbanisation has been attributed to the crows’ omnivory and behavioural plasticity (Konstantinov et al., 1982), or to the increasingly favourable conditions in European cities. These supposedly include low levels of predation and persecution (Londei and Maffioli, 1989; Ilyichev et al., 1990), and increased availability of anthropogenic food sources (i.e. biological waste), especially since the Second World War (Glutz von Blotzheim and Bauer, 1993). Ilyichev et al. (1990) suggested that in addition to constant availability of anthropogenic food sources, the ability of the hooded crow to winter in cities and the creation of a large number of new nesting habitats by urban expansion also may have promoted crow urbanisation. Similar explanations have been put forward to explain the urbanisation of a related corvid species, the American crow (C. brachyrhynchos) (Marzluff et al., 2001b).

The hooded crow is considered an urban pest in Finland (Hugg et al., 1997; Vuorisalo et al., 1997). Before urbanisation, the species was classified as a pest for two reasons: it causes damage to agriculture by occasionally feeding on grain and sprouts; and it harms “useful” bird species by nest predation (Anonymous, 1890; Parker, 1985). The pest status of the hooded crow was established in Sweden and Finland by the Royal Decree of 16 October 1741, which set a bounty of 20 silver pennies for the killing of ten adult birds (Kongl. Förordning, 1741). More recently, the aggressive nest/fledgling defence behaviour of urban hooded crows has developed into a considerable problem in Finland (Vuorisalo et al., 1997). Roosting in urban areas has also created problems resulting from faecal droppings and noise (Raatikainen, 1989); these problems parallel related species, such as the American crow (Gorenczel and Salmon, 1995) or the jackdaw (C. monedula; Antikainen, 1968). In the 1960s and early 1970s (when the last statistics were collected) about 110,000 to 160,000 corvids (mostly hooded crows) were killed annually in Finland (Raatikainen, 1989).

The specific objectives of our study were: (i) to document the urbanisation processes of the hooded crow in two cities (Turku and Helsinki) chosen for study areas, (ii) to analyse the importance of several behavioural and urban environmental factors for crow urbanisation, and (iii) to derive, if possible, practical conclusions for successful management of the hooded crow. Throughout the study, data on social, cultural and ecological factors were analysed together. Due to the close interaction between human activities and bird populations in urban ecosystems, such integration of multidisciplinary data is essential in any comprehensive analysis of long-term urbanisation processes (cf. Parlange, 1998; Hostetler, 1999).

2. Materials and methods
2.1. Study species

The hooded crow is a widespread subspecies of the carrion crow in northern and eastern Europe, western Asia and the Middle East (Cramp et al., 1994). As a conspicuous human commensal, it is a familiar bird to people at least in northern Europe (Olaus Magnus, 1555; Järvinen, 1991). Although the diet of hooded crows in Finnish cities has never been systematically studied, old observations of foraging behaviour confirm the importance of anthropogenic food sources. Palmgren (1914, p. 96) wrote in a study of the birds of the Helsinki region that “after having
arrived [from migration] the hooded crows search for food in compost piles in the fields, among waste materials around buildings as well as in the landfills and on sea ice in harbours around the city. The numerous crows that overwinter in the city depend on these same food sources." Slaughter wastes and large urban landfills seem especially to have attracted hooded crows. In the village of Hanko, an increase in the crow population was associated with the opening of a new slaughterhouse, and the birds were observed to feed on slaughter refuse (Kaikko, 1925). In the cities of Kemi and Joensuu slaughterhouses and their surroundings were the preferred foraging sites of wintering crows (Pynnönen, 1931; Grenquist, 1946).

Hildén and Mikkola (1967) noted that hundreds of wintering crows tended to gather in the new landfills of Iso-Huopalahti and Vuosaari in Helsinki (established in 1963 and 1964, respectively; Leminen et al., 1993). Finnish hooded crows now utilise landfills throughout the year as foraging sites (Kilpi, 1997).

The principal predators of the hooded crow in Finland are the eagle owl (Bubo bubo) and goshawk (Accipiter gentilis) (von Haartman et al., 1963–1972). Corvids are included in the diet of both species, but are relatively more important to the goshawk, especially during the breeding season (Sulkava, 2000). Neither predator breeds in built-up environments, although an increasing proportion of eagle owls in Finland depend on brown rat (Rattus norvegicus) populations of urban landfills (Mikkola, 1974; Rönkä, 1999), and may even breed in landfill areas (Rönkä, 1999). However, both the goshawk and eagle owl are regular winter visitors in Finnish cities (Vuorisalo and Tiainen, 1993).

2.2. Study areas

The city of Turku, the old capital of Finland, is located on the southwestern coast of Finland (60°27′N, 22°16′E). From 1890 to 1920, the population increased from 27,298 to 45,482 (Jutikkala, 1957a; Laakso, 1980), or to 62,000, if residential suburbs that did not belong to the administrative city are included (Jutikkala, 1985). At this time, Turku still bore a small-town appearance, with a large number of low wooden houses along long, unpaved streets. After 1900, the economy of the city, especially trade and industry, increased rapidly. From 1920 to 1980, the population of Turku increased 2.7-fold, being 163,680 in 1980 (Laakso, 1980; Statistical Yearbook of Finland, 1999). Several small-house areas were built around the grid-plan area starting from the 1920s, and apartment block suburbs since the mid-1950s (Andersson, 1983; Laakso, 1985). Since the Second World War, the urban structure has become more dispersed, largely resulting from the rapid population growth (Andersson, 1983).

Helsinki, the capital of Finland since 1812, is located on the northern coast of the Gulf of Finland (60°08′N, 25°00′E). Since 1860, the population has grown rapidly. This rapid growth has been promoted by its status as the capital city of the country. From 1920 to 1980, the population tripled from 160,921 to 483,036 (Åström, 1956; Statistical Yearbook of Finland, 1999). Industrial housing areas began to form around Helsinki in the late 19th century, and after the Second World War the first apartment block suburbs were built (Schulman, 2001). Nowadays, Helsinki is the centre of a metropolitan area with about 1.2 million inhabitants (Schulman, 2001).

2.3. Historical data sources

Historical data were gathered from scientific and popular journals published in Finland, including Luonnon Ystävä-Luonnon Tutkija, Ornis Fennica, Metsästys ja kalastus and Finlands Jakt- och Fisketidskrift. Data were also found in the Palmén Archive of the Zoological Museum of the University of Helsinki, and in the unpublished diaries of the Natural History Club 'Tähtimö' in Turku (1905–1920; referred to as 'Tähtimö, unpublished'), Professor H. Bruun (Turku, 1935–1949), and Professor R. Tenovuo (Turku, 1939–1992). In 1993, we also interviewed a leading ornithologist who lived in Turku during the 1930s, Dr. K.A. Fredrikson. Finally, all hooded crow observations were systematically collected from all issues of the leading local newspaper in Turku in 1890–1950. In 1890–1896, this leading newspaper was Aura, in 1897–1917, Uusi Aura ('New' Aura), and in 1918–1950, Turun Sanomat. In this paper, references to these local newspapers will be made within the text by mentioning the date and name of the newspaper only (e.g. Uusi Aura, 5 April 1899).

Environmental historical data on conditions of Turku and Helsinki were collected from the published Annual Reports of these cities, the local newspapers
of Turku (listed above), and from historical monographs and papers. These sources included data on the sanitary state of yards, waste management practices, numbers of domestic animals in urban areas, and control attempts on pest animals such as the hooded crow. Generally, our data is more complete for Turku than for Helsinki, for which we did not do a comprehensive newspaper survey.

2.4. Sanitary state of urban areas

The sanitary state of urban areas, which depends on the efficiency of waste collection and disposal, probably influences the foraging possibilities for hooded crows. Good sanitation may decrease, while dirtiness and lack of proper sanitation probably improve food availability for crows.

We studied changes in sanitary conditions directly by collecting data on sanitary inspections made in both cities since the late 19th century, and indirectly by collecting data on animal husbandry in urban areas. We assumed that the keeping of livestock increased food availability for crows. The first Decree on Public Health in Finland of 1879 granted local health officials the right to perform sanitary inspections of houses and public areas (Public Health Decree, 1879, Sections 4 and 5). Both in Helsinki and Turku such inspections were probably done regularly, although data from all years are not available. The results of sanitary inspections probably reflect both the environmental quality of cities and the goals of each city's sanitary policy, which may vary temporally. We assumed that although data from a particular year may vary according to short-term changes in sanitary policies, long-term trends in inspection data probably reflect real changes in sanitary conditions.

2.5. Estimation of food waste production

The two main anthropogenic sources of food for urban crows in the past were food waste and slaughter waste. Unfortunately, accurate data on the history of waste production in these Finnish cities are not available. However, it is known that municipal waste production in Helsinki increased after the Second World War more rapidly than the human population (Nygård, 2001), and that before the 1950s most waste transported to Helsinki landfills was of organic origin, and consisted of food wastes, human excreta and animal dung (Leminen et al., 1993). Landfills have been the main treatment practice for municipal solid wastes in Finland. In 1989, about 80% of all municipal wastes in Finland were dumped in landfills (Lahti, 1991).

Increases in waste production in recent decades have mainly been in areas other than biological components, most notably paper, metals, glass, and plastics (Lahti, 1983). We estimated food waste production in Turku and Helsinki by assuming that the amount of food waste produced per person is fairly constant at 50 kg per person per year. This estimate is currently used in the Finnish environmental administration (e.g. Turku Environment Office, 1998). Although this estimate does not include faecal and urine production or garden waste, it is probably a reliable indicator of the quantity of biological waste produced.

3. Results

3.1. Urban nesting

The hooded crow probably started to breed in Finnish cities some years before the First World War. The earliest known case is from 1908, when a pair built their nest in a large birch tree in a city park in Lappeenranta, SE Finland (Uusi Aura, 16 June 1908). Four years later, in 1912, a nest was found in Turku in the recently built Samppalimina park close to a popular restaurant (Tähtimö, unpublished). The same source mentioned that crows had become more common in the surroundings of the city of Turku (Tähtimö, unpublished). According to several newspaper reports, a small breeding population was established in the city parks and peaceful peripheral gardens of Turku in the 1910s (Table 1). The urban crow population of Turku remained small (probably less than five pairs) at least until the mid-1960s (Table 1; Tenovuo, 1967). Since then the breeding density in the grid-plan area has increased at least 9-fold (Table 1).

Although our data from Helsinki are less complete than from Turku, the evidence shows that at least since the early 1930s the hooded crow has been breeding in some parks close to the city centre. Palmgren (1914) did not mention any urban nesting in Helsinki. The first known nesting attempt, in Kaivopuisto park
in 1930, was terminated for the safety of the ‘little birds’ breeding in the same park (Anonymous, 1930). Kajoste (1961) listed Vanhankirkonpuisto park and the Hietaniemi cemetery as the traditional nesting sites of crows in Helsinki. The oldest known nesting from Vanhankirkonpuisto park is from 1932 (Anonymous, 1932) and from Hietaniemi in 1933 (Rauhala, 1946). The third old nesting site was Kaisaniemi park, where hooded crows had by 1943 been breeding for many years (Erkamo, 1944). The later development of the breeding population in Helsinki parks is summarised in Table 2. There are no accurate data available from other habitats besides parks. It seems that the number of breeding crows started to increase before 1965.

3.2. Factors affecting urbanisation

3.2.1. Predation in urban areas

Winter predation in cities by the eagle owl has probably increased since the early 20th century, when avian predators observed in urban areas were commonly persecuted (Vuorisalo et al., 2001). Although there are some old observations of eagle owls in urban areas (e.g. a bird in Turku in October 1876; Åbo Underrättelser, 28 October 1876), regular visits to urban areas are probably a recent phenomenon. In 1890–1920, the local newspapers in Turku published only one report of a visiting eagle owl near Turku (a dead bird in January 1919; Vuorisalo et al., 2001), and in the 1930s eagle owls were almost never seen within the
city (K.A. Fredrikson, personal communication; see, however, Turun Sanomat, 12 December 1938, for a report on a visiting bird attacked by crows). The lack of urban visits earlier was probably caused by intense persecution. Söyrinki (1954) explicitly mentions that eagle owls that visited the landfills near Helsinki to forage on rats and crows were usually shot. Both in Turku (Vuorisalo and Tiainen, 1993) and in Helsinki (Halkka, 1992) urban visits of eagle owls have apparently become more common recently.

On the contrary, the goshawk seems to have been a regular urban visitor for more than 150 years in spite of intense persecution (Wikström, 1950). von Wright (1848) was probably the first to mention the urban visits of goshawks in Finland. He wrote that goshawks arrived in Helsinki in late autumn and winter, and were often seen hunting pigeons. In Turku, the local newspapers reported five visits of goshawks in or near the city in 1890–1920 (Vuorisalo et al., 2001), and since the mid-1950s, the species has certainly been regular (R. Tenovuo, personal communication; Vuorisalo and Tiainen, 1993). In Helsinki, goshawks were frequent winter visitors both in the early 20th century (Palmgren, 1940) and later (Hildén, 1968).

Predation by conspecifics may have increased simultaneously with the increase of the urban crow population. Hooded crows are known to forage on eggs and nestlings of their own species (Cramp et al., 1994). Due to lack of other predators, this may be the most important form of predation during the breeding season. Accurate data on intraspecific predation in Finnish cities are not available.

3.2.2. Availability of food

Fig. 1 shows the estimated growth of food waste production for the Turku and Helsinki households, respectively.

In addition to quantities of food produced, the spatial distribution of food sources also may be important for the birds. Fig. 2 presents the temporal changes in numbers of major municipal landfills for biological waste within a 10 km radius of the Turku and Helsinki city centres.

A tendency (not apparent in Fig. 2) in both Helsinki and Turku in the 20th century was the concentration of municipal solid waste in large landfills. In Helsinki, the first such attempt was the opening of the Malmi landfill in 1904, and organisation of waste
transport to Malmi by railroad connections (Åström, 1956; Nygård, 1999). The main landfill operated there until 1944 (Lerninen et al., 1993). Since 1987, most collected waste from the Helsinki region has been concentrated in the Ammässuo landfill. In the early 1990s, Ammässuo received more than 600,000 t of waste per year (Nygård, 1999).

There was also a tendency to concentrate waste management in Turku. A landfill was opened in Pet-tola, south of the city, in 1943 (Turun Sanomat, 14 January 1943), and at least since the early 1950s, it was considered the main landfill of the city (Uusitalo, 1982). The main landfill operated there until the end of 1970, when it was replaced by a new one in Topinoja, east of the city. A remarkable change in the treatment of biological waste in Turku was the opening of a municipal waste incinerator in 1975. Since then most biological waste has been incinerated (Turku Environment Office, 1988, 1992), which must have decreased the availability of biological waste for crows.

3.2.3. Urban expansion and establishment of parks
The two major changes in urban structure and land-use from the crow’s perspective may have been urban expansion, a by-product of the rapid population growth of cities, and the establishment of city parks. In both Turku and Helsinki, small-house areas, apartment blocks and industrial sites have been built around the old grid-plan areas since the 19th century (Andersson, 1983; Schulman, 2001). Consequently, the boundary between countryside and city, which in Turku was still sharp in the early 1900s (Jutikkala, 1985), developed into an urban–rural continuum with no sharp boundaries in land-use (Andersson, 1983; Fig. 3). The same happened (although earlier) in Helsinki (Schulman, 2001). Population growth and urban development have in recent decades concentrated in these areas surrounding old city centres (Schulman, 2001), and large new areas surrounding the old grid-plan area have thus come under a strong urban influence, although patches of forest have survived between the suburbs (Andersson, 1983; Lehto, 1989).
Fig. 3. The expansion of the Turku urban area: (a) the built-up area of Turku in 1920, (b) the joint built-up areas of Turku and the adjacent municipalities of Raisio and Kaarina in 1975, and (c) the population density distribution of Turku in 1975. In (c), each dot represents 10 inhabitants (cf. Andersson, 1983).
Table 3
The age of city parks at the time of first recorded hooded crow nesting attempt

<table>
<thead>
<tr>
<th>City/park</th>
<th>Established</th>
<th>First nesting</th>
<th>Age of park at first nesting (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsinki</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaivopuisto</td>
<td>1835^</td>
<td>1930^</td>
<td>95</td>
</tr>
<tr>
<td>Vanhankirkonpuisto</td>
<td>1790^</td>
<td>1932^</td>
<td>&gt;130</td>
</tr>
<tr>
<td>Kaisaniemi</td>
<td>1833^</td>
<td>1943^</td>
<td>110</td>
</tr>
<tr>
<td>Turku</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porhan’s park</td>
<td>1835–1837^</td>
<td>1916^</td>
<td>79–81</td>
</tr>
<tr>
<td>Sanappalinnna</td>
<td>1895^</td>
<td>1912^</td>
<td>17</td>
</tr>
<tr>
<td>Puolala</td>
<td>1898^</td>
<td>1937^</td>
<td>39</td>
</tr>
</tbody>
</table>

^Anonymous (1930).  
^Lindberg and Rein (1950).  
^Anonymous (1932).  
^Erkamo (1944).  
^Dahlström (1960).  
^Uusi Aura, 3 June 1916.  
^Tähimä (unpublished).  
^Uusi Aura, 11 March 1898.  
^H. Bruun (unpublished).  

Before the 19th century, there were no centrally located parks in Turku or Helsinki, and even planted trees were scarce. In both cities, several urban parks were established in the 19th century, largely for fire control purposes. In the 19th century, many cities experienced large fires, some of them repeatedly. The great fires in Helsinki in November 1808 (1/3 of houses burnt) and in Turku in September 1827 (3/4 of houses burnt) were the immediate cause for the total restructuring of the central areas of these two cities (Dahlström, 1960; Klinge, 2000). In both cities, reconstruction resulted in an increased openness of the city structure, the widening of streets, the establishment of urban parks, and the planting of trees between houses and along streets. The availability of city parks seems to have been especially important for the initial colonisation of urban areas by hooded crows (Tenovuo, 1967). For instance, in Helsinki, all identified nesting sites until the 1950s (Hietaniemi cemetery, Kaivopuisto, Kaisaniemi and Vanhankirkonpuisto parks) were urban parks (Anonymous, 1930; Kajoste, 1961; Table 2). Kajoste (1961) classified the hooded crow as a park-nesting, urban bird species. The age of the park probably did not affect initial colonisation. In Turku, hooded crows settled in the 1910s in parks ranging from 17 to ca. 80 years in age (Table 3).

3.2.4. Changes in sanitary conditions
The data collected from annual sanitary inspections in Turku are summarised in Fig. 4a, and those from Helsinki in Fig. 4b. During and after the Second World War, there appears to have been a peak in Turku’s sanitary problems (Anonymous, 1946). In Helsinki, the conditions seem to have consistently improved since the 1960s.

Horses, cattle, pigs, goats, sheep and poultry were still abundant in urban areas in the early 1900s. In Turku, their numbers were, however, declining at the time of hooded crow colonisation (Table 4). Animals and their dung attracted swarms of insects (Jutikkala, 1957a), on which the crows probably foraged. Crows may have also succeeded in killing some chickens (cf. Kivirikko, 1926). Fig. 5 shows the change in numbers of animal shelters (stables, cowhouses and piggeries) in the administrative area of the city of Turku. Within the city itself, the keeping of animals decreased rapidly especially after 1952, when the city prohibited animal
Fig. 4. The sanitary state of yards in Turku (a, 1910–1979) and Helsinki (b, 1960–1979). The data are based on sanitary inspections performed by the health officers of these cities (Annual Reports of the City of Turku, 1900–1981; Annual Reports of the Health Board of the City of Helsinki, 1960–1979).
Table 4
Numbers of domestic animals inside the city of Turku in 1890 and 1909 (Jatikkala, 1957a,b)

<table>
<thead>
<tr>
<th></th>
<th>1890</th>
<th>1909</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horses</td>
<td>655</td>
<td>758</td>
</tr>
<tr>
<td>Cows</td>
<td>344</td>
<td>57</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>158</td>
<td>66</td>
</tr>
<tr>
<td>Pigs and piglets</td>
<td>308</td>
<td>120</td>
</tr>
<tr>
<td>Rabbits</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>Poultry</td>
<td>2289</td>
<td>331</td>
</tr>
</tbody>
</table>

husbandry in urban areas, although the city veterinary surgeon was granted a right to give special permits for keeping animals (Anonymous, 1955).

A notable exception was the war years 1939–1945. In 1940, the Health Commission of Turku allowed, due to war conditions, establishment of piggeries in built-up areas (cf. Fig. 5). As a result the number of piggeries in the city rose from 4 (1940) to 87 (1945). In 1943, there were about 1400 pigs, thousands of rabbits, and dozens of goats and sheep in Turku (Turun Sanomat, 30 October 1943). The keeping of animals in the city caused hygiene problems (Turun Sanomat, 30 October 1943). Helsinki also allowed the keeping of pigs in 1942 due to war conditions (Anonymous, 1945). Sheep, goats and cattle were also kept by Helsinki inhabitants during the war (Lehto, 1989). The numbers of animal shelters and domestic animals declined gradually after the war (for Turku, see Fig. 5).

3.2.5. Human attitudes and persecution

The Hunting Decree of 1898 compelled each municipality, cities included, to pay bounties for killed birds. The municipality had to pay a price of 15 pennies for a killed adult crow and 10 pennies for a killed young bird or nestling (Hunting Decree, 1898). The impact of this decree in Finnish cities is not known. However, the local newspaper reported in January 1899 that the city of Turku, strictly enforcing the new decree, had paid one mark and 95 pennies for 13 crows that had been killed inside the city area (Uusi Aura, 24 January 1899).

The first nesting attempts were published in newspapers as unusual events, usually without any reference to persecution. One of the first nesting attempts in Turku was, however, terminated by destroying the nest in 1914 (Uusi Aura, 20 April 1915). The Annual Reports of the city of Turku in 1909–1981, and the local newspapers, mentioned municipal persecution of crows only in three periods: 1936–1937, 1938–1940 and 1975–1980 (which does not mean that crows were
killed only in these years). In the autumn of 1936, the city decided to invest 5000 Finnish marks for persecution of hooded crows, feral pigeons and gulls inside the city (Turun Sanomat, 2 October 1936). In 1938, the city invested 1907 Finnish marks in killing of crows (with phosphorus), in 1939, 2027 marks and 10 pennies, and in 1940, 407 marks and 10 pennies. It is not known how many birds were killed. For the last period the numbers of killed birds are known: 1975, 91 birds; 1976, 56 birds; 1977, 66 birds; 1979, 120 birds; and 1980, 130 birds (data from 1978 are missing). Crows were thus, at least periodically, killed within the city, probably in places where the birds caused some threat to hygiene (Annual Reports of the City of Turku, 1900–1981). In 1992–1996, 530 to 780 crows were killed in Turku per hunting season (J. Laine, personal communication). This organised killing of crows has taken place after the breeding season and outside the built-up areas.

Crows were also persecuted actively in the Helsinki area. In Viikki, northeast of the city, more than a thousand crows were shot each year in the 1920s (G. Wassenius; Päälä, 2001). The shooting of birds inside the city had been prohibited in 1908 (Haapanen, 2001). Also, Lethonen (1945, p. 76) mentioned regular shooting of crows in the Viikki area. The first known nesting attempt in a Helsinki park (Kairopuisto) was terminated to protect the nests of the little birds breeding in the same park (Anonymous, 1930). Some of the early nesting attempts in Vanhankirppouluisto park were terminated by the Animal Conservation Office of Helsinki, probably to protect songbirds breeding in the same park (Anonymous, 1949). In 1993–1996, 282–640 crows were killed in the city of Helsinki annually (V. Koskikallio, personal communication).

As hunting was not allowed in the cities, other forms of persecution were more important. Egg-collecting and the destruction of nests by schoolboys, or even the killing of adult birds, probably affected urban crow populations. Egg-collecting was a popular hobby among Helsinki schoolboys in the late 1800s (Paavolainen, 1977, p. 75), and was in the early 1900s, even encouraged by some natural history teachers, who wanted to increase their pupils' interest in natural phenomena (e.g. Mela, 1900). In Turku, schoolboys also collected birds' eggs (Saarento, 2001), even in city parks (Turun Sanomat, 5 May 1938). According to a sociological study, some members of boys' gangs in Turku in 1944–1951 mentioned killing of birds and egg-collecting as their hobbies (Helanko, 1953). Söyrinki (1954, pp. 96–97) wrote that "in many places the search for birds' nests and egg-collecting is a serious sin of e.g. boys of elementary schools. They spend all their free-time in the evenings during the birds' nesting period and often the mornings as well on this activity, so that they hardly get to school on time." As even song bird nest-boxes in backyards were emptied by young egg-collectors (Söyrinki, 1954), it is very likely that urban crows also suffered from such persecution. There also is direct evidence for persecution of crows. Leppänen (1964) mentioned that schoolboys of 8–15 years of age tended to shoot nearly all animals they saw, including hooded crows. Crow nestlings were sometimes taken as pets in Turku (Saarento, 2001).

Although municipal management of crow populations still continues, these "unofficial" forms of persecution have almost ceased in urban areas. Palmu (1964) still discussed the habit of Finnish schoolboys to destroy birds’ nests, and emphasised the importance of appropriate environmental education in its prevention. Only a decade later, Leinonen (1976) complained that the interest of schoolchildren in natural phenomena had rapidly decreased, and that their species identification skills could hardly be poorer. In Turku, we recorded no persecution of urban nests in the years 1992 and 1993 (Hugg, 1994).

3.2.6. Hooded crow behaviour

The fact that until the mid-1960s, nearly all known urban nests were located in city parks (Teno, 1967: Table 1) suggests that birds avoided humans and traffic inside cities. In Turku, the few breeding hooded crows in the 1930s probably avoided the built-up central areas, as they were never seen there (K.A. Fredriksson, personal communication). R. Teno (personal communication) first observed crows near the Turku marketplace in 1957. On 22 February 1977, he observed a crow in Turku with a flight distance of only three meters. This was Teno's first observation of reduced flight distances in urban areas of Turku. Nowadays, flight distances of 2–5 m are typical in central Turku (T. Vuorisalo, personal observation).

A similar trend can be traced in Helsinki, although the birds which attempted to breed in Kairopuisto park in 1930 had a flight distance of "only a few
steps” (Anonymous, 1930). Both nesting attempts were, however, terminated (Anonymous, 1930). According to Kajoste (1961), the birds breeding in the Vanhankirkonpuisto park near the centre of Helsinki were so timid and traffic so abundant “that the crow could not land on the streets or in the parks during the day closer than nearly 1 km from its nesting tree. One does not usually see crows feeding in the streets or parks of the city centre” (Kajoste, 1961, p. 54). The timidity of birds breeding in Vanhankirkonpuisto park is not a surprise, as several crow nests in that park had been destroyed by the Helsinki Animal Conservation Office (Anonymous, 1949). Since then crows have clearly habituated to humans. Erkamo (1987) wrote that in Helsinki the “flight distance, which earlier used to be at least 20–30 m, has now often decreased to 5–15 m,” and in some instances to 3 m.

The habitat use of hooded crows has also changed. According to Tenovuo (1967), nearly all known nesting before the mid-1960s in Finnish cities took place in peaceful city parks or gardens. The pattern of habitat use is now very different (Table 5). Hooded crows breed in all urban habitats in Turku, including the sparsely vegetated central areas, that were probably colonised in the late 1970s (Tenovuo, 1977).

Habituation to human presence can result in increased aggressiveness of nest and offspring defence behaviour in urban areas. A questionnaire conducted in 1994 showed that in the late breeding season, hooded crows in urban areas of Finland often defend their nests and fledged young fiercely, even physically attacking approaching humans and dogs (Vuorisalo et al., 1997). The phenomenon was even known to some local hospitals due to the medical care needed by some victims of crow attacks. The first known cases of such attacks are from the late 1970s in Mikkeli and Turku. Nowadays, the attacks are a well-known annual problem, at least in the major urban centres in southern and central Finland (Vuorisalo et al., 1997).

4. Discussion

4.1. Urbanisation history: patterns and reliability of data

Our analysis and conclusions are based on the validity of the data presented on the urbanisation history of the hooded crow in two Finnish cities. It seems that in both cities hooded crows first colonised peaceful urban parks and gardens, and after the initial colonisation the breeding population remained very small (probably less than 10 pairs) for decades (Tables 1 and 2). Our data show that in Turku this period of low population density lasted for 50–60 years, and in Helsinki at least 30–40 years. This phase was followed by a period of rapid population growth that in Turku appears to have started in the late 1970s (Tenovuo, 1977) and in Helsinki perhaps a decade earlier (Tenovuo, 1967). Similar patterns have been observed elsewhere. For example, a small population of hooded crows had been breeding in Moscow for a long time, before the population increased 8-fold from 1965 to 1985 (Ilyichev et al., 1990).

Although our historical analysis of hooded crow urbanisation is partially based on reports published in local newspapers, the overall pattern of crow urbanisation is probably correct. Species identification mistakes in the case of hooded crow are highly unlikely. The urban nestings of crows in Turku in the 1910s were reported as a novel phenomenon by at least three sources (Tähtimö, unpublished; Uusi Aura, 2 April and 19 November 1915). One newspaper article even noted that at least in one respect Turku outcompetes Helsinki, i.e. in the number of crows breeding in the city (Uusi Aura, 3 June 1916). This
indirectly supports the assumption that initial colonisation took place in Helsinki later than in Turku, which is also indicated by the fact that Palmgren (1914) did not mention any urban nesting in the capital. The most uncertain detail is the exact timing of the initial colonisation of Helsinki. As we did not do a comprehensive newspaper analysis for Helsinki, it is possible that there were nestings in Helsinki earlier than the data in Table 2 indicate. This does not, however, change the overall pattern of urbanisation, with a long period of low population density (in both cities), and the well-documented rapid increase since the 1960s.

4.2. Factors affecting initial colonisation of cities

The availability of established city parks in both cities was clearly important for the early hooded crow colonists. However, in both cities parks apparently suitable as nesting habitats for crows had been available for decades before the urbanisation of birds actually started (Table 3). In Turku, the crows settled in the 1910s in parks which varied from 17 to ca. 80 years in age (Table 3). Thus, although parks were obviously necessary for urban colonisation, their existence alone can not explain the timing of urbanisation.

Our results show that early colonisation took place in a period characterised by intense persecution of bird predators in cities (Vuorisalo et al., 2001), which probably decreased winter predation pressure on crows. On the other hand, crows also were persecuted, although probably less actively than in rural areas. Food sources, provided by both domestic animals and increasing biological waste production, were almost certainly overabundant for the few breeding pairs of crows. This also explains the tendency of crows to overwinter in Finnish cities, first documented for Helsinki in 1826 (von Wright, 1996). This tendency itself may have contributed to urbanisation, as suggested by Ilyichev et al. (1990).

4.3. Why did crow populations not increase earlier?

The long periods of low population density in Turku and Helsinki are at first sight difficult to explain, as conditions from the crows’ perspective in both cities seem to have improved considerably during this period.

During the periods of low population density biological waste production in both cities increased (Fig. 1), and wastes were increasingly concentrated in large municipal landfills that provided a reliable source of food throughout the year. There is also direct evidence that at least wintering crows utilised these landfills as foraging sites (Hildén and Mikkola, 1967). In Turku, sanitary conditions deteriorated during the war years, which should have also benefited the crows. In both cities, an overabundance of food waste was therefore probably available for the few breeding crows. There is, however, no evidence for any population increase before the 1960s.

The winter predation pressure exerted on crows by eagle owls (rare) and goshawks (more common) probably remained at the same low level as in the period of early colonisation. The urban structure gradually changed during the period of low population density, as new residential suburbs were built around the old city centres, especially after the Second World War. However, habitat changes in central areas of both cities were small. The established city parks remained the main nesting habitats of crows in the central areas of Turku and Helsinki (Tables 1 and 2).

We suggest that continuing persecution in urban areas and the resulting timidity of birds (e.g. Kajoste, 1961) largely explain the long periods of low population density in Turku and Helsinki. According to several documents, nesting attempts of crows in city parks were frequently terminated, in Helsinki even by local animal conservationists. Egg-collecting and persecution by schoolboys were certainly often targeted at crows. The birds’ timidity in urban areas, sharply contrasting with the present situation, supports the assumption that continuous persecution may have slowed down the habituation of birds to human presence, and thus, prevented the colonisation of city centres.

Darwin already noted in the early 19th century that timidity of birds may increase as a result of persecution (Darwin, 1869, pp. 344–347). More recently, Knight (1984) observed that responses of nesting Ravens (Corvus corax) to approaching humans were most timid in farmland areas, and he considered this to be a response to persecution. He concluded that in areas where persecution lowers the reproductive success of ravens (as in the farmland), timid responses might be more beneficial than aggressive ones. Aggressive behaviour and short flight distances may alert human
intruders, and increase the chances of the birds being killed (Knight, 1984). Similarly, it seems likely that the decrease in flight distances of hooded crows in Finnish cities, as well as the increased aggressiveness of nest/fledgling defence since the late 1970s, can be best explained by the decrease in persecution level in urban areas.

4.4. Factors affecting the rapid population growth since the 1960s

As noted earlier, rapid urban population growth of hooded crows since the 1960s has been explained in other areas by the crows’ behavioural plasticity, improving food availability, lack of predation and persecution, and changes in the urban structure that have created suitable nesting habitats for crows (Konstantinov et al., 1982; Londci and Maffioli, 1989; Illyichev et al., 1990; Glutz von Blotzheim and Bauer, 1993). Our results enable a critical evaluation of these explanations.

The importance of food availability has probably been overestimated. Both in Turku and Helsinki, food sources were probably overabundant for decades before the onset of rapid population growth. In fact, in both cities, there are indications that rapid population growth occurred simultaneously with an absolute decrease in food availability. In Helsinki, the crow population increased simultaneously with an improvement of sanitary conditions (Fig. 4b), which may indicate reduced food availability in built-up areas. In Turku, the rapid increase of urban crow population started after 1975, when the operation of the municipal waste incinerator was launched. The resulting incineration of food waste must have decreased availability of biological waste for crows in landfills.

On the other hand, hooded crows have certainly benefited from the establishment of large and relatively peaceful landfills outside cities. For scavenging birds such as the hooded crow, landfills are a reliable source of food throughout the year. Although landfills may be located several kilometres away from urban nest sites, the local overabundance of food may decrease the total daily foraging time required, and can thus compensate for the loss of time spent in movement between the nest site and landfills (cf. Pyke, 1984). Still, the availability of large landfills cannot explain the recent rapid population growth of hooded crows, as such landfills had been available near both cities for decades before the rapid urbanisation (Fig. 2).

Changes in urban structure have in recent decades been considerable (Fig. 3), and it is possible, as Illyichev et al. (1990) suggested, that urban expansion has benefited hooded crows by creating new nesting habitats. Marzluff et al. (2001b) suggested that urban populations of the American crow are largely supported by immigrants from the suburban zone, where conditions for crow reproduction are particularly favourable. It is conceivable that such immigration occurs also in Turku and Helsinki. Historical evidence, however, suggests that centrally located, peaceful urban parks may have also sent crow colonists to built-up areas, at least during the rapid population growth phase of the 1960s and 1970s.

Cities are often considered as areas with low predation pressure (e.g. Tomialojc, 1979). The two main predators of the hooded crow in Finland, goshawk and eagle owl, are only present in winter, which means that during the breeding season Finnish cities have been almost enemy-free habitats for hooded crows. This is still so, although the population increases of corvids themselves in cities may have increased predation pressure. Of the two winter predators, the eagle owl has become more common since the 1960s, simultaneously with the rapid urban population growth of the hooded crow.

The behavioural changes of crows resulting from decreased persecution in urban areas may largely explain the colonisation of city centres as nesting habitats, and the resulting rapid increases in urban population densities. There is strong evidence that persecution in general has decreased in urban areas (cf. Vuorisalo et al., 2001), and that especially persecution by schoolboys has become rare. Probably, due to this change, very few crow nests in urban areas are now destroyed, which may explain the habituation of crows to human presence (perhaps) in the late 1970s. This, in turn, may explain colonisation of even most central areas as nesting habitats, and the increased aggressiveness of nest defence behaviour typical for crows in many Finnish cities.

4.5. Management implications

Management of undesirable species is one of the major biodiversity concerns related to urban
ecosystems (Savard et al., 2000). As the hooded crow clearly belongs to this category, it is important to consider the management implications of our study. The greatest problem caused by hooded crows in Finnish cities may nowadays be their aggressive nest/fledgling defence behaviour, which is considered frightening by local people and can even lead to physical injury (Vuorisalo et al., 1997). The cessation of persecution in built-up areas may explain the lack of timidity of crows towards humans, which in turn has probably increased the vigour of mobbing behaviour.

Theoretically, to tackle this problem we should find an acceptable form of persecution, which would minimise the risk of attacks in sensitive areas such as the surroundings of day-care centres and nursing homes. Active shooting or trapping of adult birds, however, are not ethically or socially acceptable in built-up areas (cf. Vuorisalo et al., 1997). Historical evidence shows that active population control measures performed outside urban areas also have little impact inside cities.

Currently the problem is solved by eliminating the most vigorously attacking birds upon request of victims. A possible preventive method could be to prevent nest-building in the vicinity of sensitive areas. Although ethically acceptable and probably effective, this method would require active monitoring of crow nesting attempts in certain urban areas, as well as removal of observed inhabited nests before the egg-laying period of crows. In combination with information on the crow problem targeted at local inhabitants this would probably be the most workable strategy to minimise the harm caused hooded crows in urban areas.

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