

Larger broods in the Northern Goshawk *Accipiter gentilis* near urban areas in southern Finland

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I examined if the distance from densely-built (urban) areas is reflected in the brood size of the Northern Goshawk near the southern coast of Finland. The data were collected from 70 nesting territories in 1976–2007, including 270 fledged broods. Within an approximate distance of less than 2.5 km from the nearest urban area, the average brood size was significantly higher than that in more rural environments. In the most densely populated urban area, the brood size was significantly higher than in the least urban areas. In general, urban habitats seemed to provide more stable food and nesting conditions as compared to rural ones. This was suggested by the long-term stability of relatively many of the most urban nesting localities, and by the recent apparently increasing tendency of Goshawks in urban areas to re-occupy earlier abandoned territories and even to establish new ones. For the Northern Goshawk, the urban life habits may locally provide superior alternatives for the rural ones. From a conservation point of view, urban and near-urban territories of the Northern Goshawk might be particularly valuable due to the general scarcity of suitable nest-sites in urban environments.



1. Introduction

Birds inhabiting environments that are intensively used by man may be original inhabitants of the area, or colonists that have adapted to occupy such modified or new habitats. At present, natural habitats are rare in Europe where rural (agricultural and silvicultural) and urban environments predominate (Tucker & Evans 1997, Donald *et al.* 2000). From the point of view of breeding birds, man-made rural and urban environments may differ in many respects other than the direct effects of human activities (Bird *et al.* 1996, Marzluff *et al.* 2001). Such factors, including local food supply, wintering conditions, bird density (competition, prey supply) and predation, may considerably affect the occurrence and breeding of birds.

Various studies have shown that some bird species, in particular small passerines, produce fewer eggs and fledglings in urban habitats than they do in rural ones (Perrins 1965, Berressem *et al.* 1983, Cowie & Hinsley 1987, Schnack 1991, Hörak 1993, Solonen 2001). However, urban habitats may be superior for some other species such as birds of prey and corvids because they often are free from persecution there and have an abundant year-round food supply (Newton 1986, Jerzak 2001, Vuorisalo *et al.* 2003, Kelcey & Rheinwald 2005, Rutz *et al.* 2005, Chace & Walsh 2006, Solonen & af Ursin 2008). Unlike most passerines, birds of prey may have home ranges that extend beyond the urban boundary and therefore do not need to meet all their ecological requirements within urban areas.

Birds of prey are used to be considered as inhabitants of remote districts far away from human settlements. This is supposed to be due to avoiding persecution but also to deterioration of habitats by various human activities (e.g., Newton 1979). In more recent years, however, various species have become established even in the most heavily built-up areas (e.g., Bird *et al.* 1996, Marzluff *et al.* 2001, Kelcey & Rheinwald 2005, Chace & Walsh 2006, Rutz *et al.* 2006). Feeding and breeding conditions may have improved in urban areas due to increasing populations of suitable prey while they may have got worse in the surroundings (e.g., Marzluff *et al.* 2001, Rutz 2006, 2008). Besides the clear changes in clutch size and brood size, the food supply may have various (less easily visible) effects on the reproduction and offspring survival of birds (e.g., Newton 1998, Byholm & Kekkonen 2008). These include variations in the breeding investments (such as egg volume and egg quality) or in the condition and fitness of offspring.

The Northern Goshawk *Accipiter gentilis* is a common, widely but sparsely distributed year-round inhabitant of various forested areas of the temperate and boreal climatic zones (Cramp & Simmons 1980, Kenward 2006). In Finland, the main habitat of the species constitutes of old and large spruce forests far away from human settlements but due to the lack of alternative options it also accepts small fragments of suitable habitats even in the vicinity of built-up areas (e.g., Solonen 1993). A suitable nesting tree is an essential prerequisite for breeding that is otherwise largely governed by the adequate availability of food (e.g., Lindén & Wikman 1983, Bijlsma & Sulkava 1997, Kenward 2006, Rutz *et al.* 2006). The Finnish Northern Goshawk population has long shown a slow but steady decline (e.g., Bijlsma & Sulkava 1997). During recent decades, the living conditions of Fennoscandian Northern Goshawks have changed dramatically because nesting habitats and food supply in forests have remarkably deteriorated due to intensive forestry (Widén 1997, Solonen 2003, Selås *et al.* 2008).

In this paper, I examine if the distance to urban areas relates the brood size of Finnish Northern Goshawks (cf. Rutz 2008, Selås *et al.* 2008). I predicted that due to abundant anthropogenic food supply the brood size is higher near human settlements (Diermen 1996, Rosenfield *et al.* 1996,

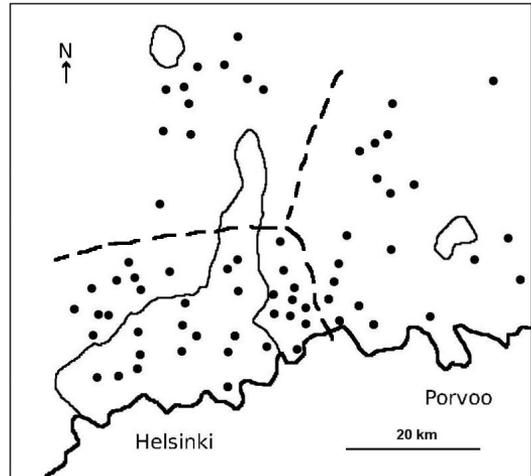


Fig. 1. Schematic map of the distribution of main urban habitats (thin lines) and the nesting territories of the Northern Goshawk from where the data were derived (black dots) in the study area of the Helsinki district and its surroundings, near the southern coast (heavy line) of Finland. The sub-areas (south-western & western, eastern, and northern) are broadly indicated by the clusters of data points delimited by a dashed line.

Boal & Mannan 1999, Millsap & Bear 2000, Rutz *et al.* 2006). In addition, I expected a negative relationship between the distance from urban habitats and the frequency of territory occupancy, and a positive relationship between the brood size and the number of successful nesting attempts, suggesting that the most suitable localities were urban and that they also were occupied most frequently (cf. Sergio & Newton 2003).

2. Material and methods

2.1. Study area

The study was conducted in 1976–2007 in Uusimaa, southern Finland (60°N, 25°E). The main study area was situated in the municipalities of Helsinki, Espoo, Vantaa, and Sipoo, but some data from the surrounding Nurmijärvi, Tuusula, Hyvinkää, Mäntsälä, Pornainen, Askola, and Porvoo were also included (cf. Solonen 1993). On the basis of the geographical situation and general habitat characteristics, the study area was broadly subdivided into four sub-areas (Fig. 1): a) the urban south-western part, b) the rural western part (sur-

rounding the sub-area a), c) the mainly rural eastern part, and d) the largely rural northern part.

The south-western main study area of more than 500 km² consisted of the capital district of about one million inhabitants, the most urban area in the country (sub-area a), and the nearby rural habitats of mixed fields and forests (sub-area b). Even in the sub-area a the built-up areas were, however, quite fragmented because urban sprawl is relatively recent, and still largely surrounded by more or less rural habitats. Really urban, densely built-up city environments covered relatively restricted areas near the southern coast. Pressed by various urban areas there were several small city parks and some larger forest tracts mainly used for recreation (e.g., Solonen 2001). The sub-area b was characterized by relatively productive fields and forests in the vicinity of the most urban sub-area a. In the eastern sub-area c, the proportion and density of built-up areas were low, while they were relatively high in the northern sub-area d, where the rural habitats were relatively barren.

2.2. Hawk monitoring

Territories and nests of Northern Goshawks were localized mainly by listening for calling birds, checking the known potential nest-sites, and searching for new ones in suitable habitats (Forsman & Solonen 1984). Nest-sites found were monitored annually, but the monitoring often lasted only short periods of years due to the common destruction of nest-sites, usually by intensive forestry. Alternative and new replaced nest-sites were sought, but often there were no suitable habitats available in the vicinity of the lost ones or they seemed to be too close to the nest-sites occupied by neighbouring pairs (see Solonen 1993). So, the annually monitored locations as well as the monitoring periods of single nest-sites varied considerably. In general, however, Northern Goshawks occupied the study area relatively evenly (Solonen 1993), the main gaps in the distribution map (Fig. 1) being due to gaps in the data available for the present study.

Because of practical difficulties and probably higher risks of harming nesting success when checking the clutch size, the investment to reproduction was measured by the brood size. In vari-

ous species of birds, the brood size largely follows similar patterns of variation than the clutch size (e.g., Solonen 2005, but see Byholm 2005).

The nests found were usually climbed to establish brood size when ringing the nearly fledged young. In a few cases also a reliable record of the number of fledged young was accepted. The data included 270 successful broods (at least one young fledged). The mean size of successful broods from 70 nesting territories (*sensu* Newton 1979) was included in the analyses.

2.3. Explaining variation

The habitats of Northern Goshawks were broadly divided into densely built-up urban areas and less intensively used rural ones. Densely built-up habitats were characterized by urban-type land use, and included traffic routes, industrial areas, commercial houses, and groups of buildings of at least 200 inhabitants not allowing any gaps of typically more than 200 meters, as defined by Statistics Finland. The gaps were usually parks, recreational forests, and small plots of more or less natural open habitats. Other, larger agricultural, silvicultural and wilderness areas were defined as rural. The approximate distance (to the nearest km) of nest-sites from the nearest densely built-up area served as an indicator of the urban effect on the brood size. Based on this distance, the territories were divided into two categories separated by a value of 2.5 km, approximating the general nearest-neighbour distance of the species in the district (Solonen 1993). In addition, the mean data for the most urban capital district were compared with those of other, less urban parts of the study area (Fig. 1). As the real habitat use of the foraging hawks was not known, the above broad classification of habitats seemed justified and adequate for the present purpose.

Groups were compared by *t*-test, Mann-Whitney rank sum test, or by one way analysis of variance. When the data compared did not meet the requirement of normality, ln-transformation was used. Relationships between variables were examined by Pearson product moment correlation. *P* values higher than 0.05 were considered non-significant. Calculations were performed by Sigma-Stat 3.1 statistical software.

Table 1. Mean brood size of the Northern Goshawk (averages for means of nesting territories) in the four sub-areas of the present study (Fig. 1). The differences are not significant (one-way analysis of variance, $F = 1.305$, $P = 0.280$).

Sub-area	Habitat	Number of territories	Mean brood size (SD)
South-western (a)	Urban	18	2.94 (0.50)
Western (b)	Near urban	18	2.73 (0.44)
Eastern (c)	Mainly rural	22	2.68 (0.68)
Northern (d)	Largely rural	11	2.57 (0.50)

3. Results

On average, the 270 successful broods of the Northern Goshawk produced $2.71 (\pm 0.86$ SD, range 1–4) fledglings. The territorial means ($n = 70$) averaged $2.75 (\pm 0.55$ SD). The mean brood size of the nesting territories in the vicinity (< 2.5 km) of urban environments (2.95 ± 0.48 SD, $n = 19$) was significantly higher than that further away from the densely built-up areas (2.67 ± 0.56 SD, $n = 51$) ($t_{68} = 2.06$, $P = 0.043$, ln-transformed data).

The mean brood size differed significantly between the most urban capital district and the least urban study areas eastwards (Mann-Whitney test, $T_{27,31} = 973.5$, $P = 0.006$; medians 3.0 and 2.5, respectively). There were expected kinds of differences also between the four minor sub-areas (a–d) but they were not significant (Table 1).

The number of successful broods in the nesting territories showed pronounced variation (Fig. 2). Relatively many of the most frequently occupied nesting territories were situated near to urban areas but the relationship, in general, was not significant ($r = -0.168$, $P = 0.164$, $df = 68$). There were no significant relationship either between the brood size and the distance from urban habitats ($r = 0.042$, $P = 0.731$, $df = 68$) or between the brood size and the frequency of territory occupancy ($r = -0.077$, $P = 0.529$, $df = 68$).

4. Discussion

The present study suggests that rural and urban habitats differed in some perceptible respects concerning the reproductive success of Northern Gos-

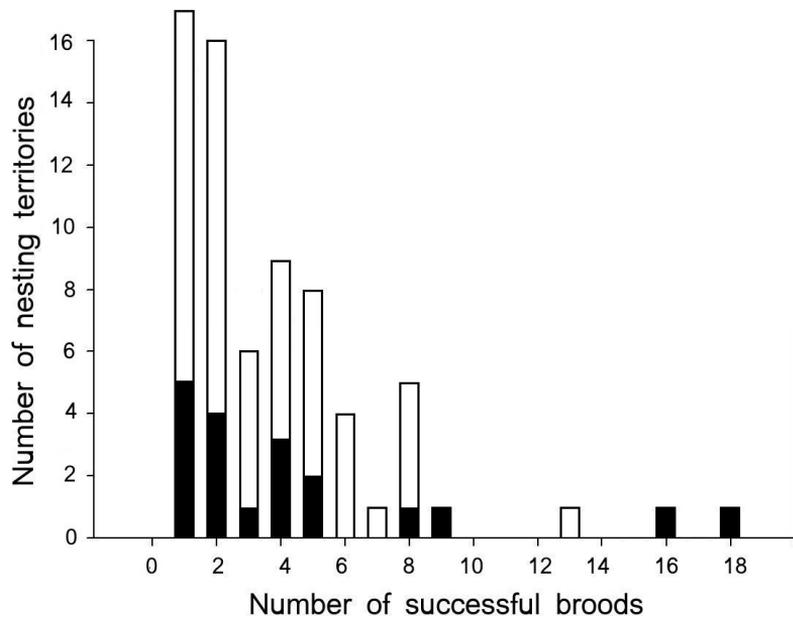


Fig. 2. The distribution of the number of successful broods in the urban (black) and rural (white) Northern Goshawk nesting territories.

hawks. As hypothesized, in the vicinity of urban areas, brood size seemed to be higher than elsewhere. It may have been difficult to prove convincingly, however, due to the considerable individual (territorial) variation in the brood size (range 1–4) and to obviously pronounced smaller-scale variation in the habitat quality within both urban and rural environments. So, the real effects of urbanization may have been poorly characterized by the broad habitat criteria used. In spatially and temporally heterogeneous data, slight differences will probably emerge clearly only in large data sets or within a long run. In these respects, the present data seemed to be somewhat too scanty.

4.1. Advantages of living in an urban environment

Some additional observations from the study area suggest that, at present, urban environments might provide particularly suitable breeding conditions for Northern Goshawks. In general, near-urban habitats seemed to offer nesting conditions and food supply that are stable as compared to those of the rural environments of the district for the following reasons. Firstly, the intensive harvesting of rural old forests has led to continuous or frequent re-establishment of territories (Solonen 1993) while the recreational forests near densely built-up areas have often been treated more moderately. Thus, some of the most urban nesting localities of the study area have been occupied, or at least remained in usable condition, throughout the study period. Secondly, concentrations of Feral Pigeons *Columba livia domestica*, corvids, and other bird species preferring urban areas seemed to be a tempting alternative to the nowadays generally scanty food supply of more rural and forested areas (cf. Lindén & Wikman 1983, Selås 1997, Rutz *et al.* 2005, Rutz 2006, Byholm *et al.* 2007, Byholm & Kekkonen 2008). This is also suggested by the recent and apparently increasing tendency of hawks to re-occupy old, long unused urban territories and even to establish new ones (T. Solonen, unpubl.). These observations coincide with those recently reported from various more urbanized areas (Bijlsma & Sulkava 1997, Chace & Walsh 2006, Rutz *et al.* 2006).

The production of young in birds is largely de-

termined by food-related factors (Newton 1980, 1998). It might be affected not only by the amount but also by the quality of available food. The local food supply in turn is largely determined by relatively predictable local habitat factors. The outcome of the habitat selection in birds seems to be a compromise between profits and disadvantages encountered. The primary habitats of most species can be found in rural, or rather in wilderness areas. Increased urbanization has led to local increases in avian density and biomass (e.g., Millsap & Bear 2000, Sorace 2002), and high densities of potential prey have attracted various birds of prey to hunt and consequently breed in urban environments (e.g., Bird *et al.* 1996, Marzluff *et al.* 2001, Kelcey & Rheinwald 2005, Chace & Walsh 2006, Rutz 2008). Also pairs nesting in rural habitats in the vicinity of urban areas may have benefited from using urban food resources (Solonen 1993).

In the case of the Northern Goshawk, the urban life seemed to be locally a good, if not even a superior alternative to the rural one (Rutz *et al.* 2006, Rutz 2008, this study). Similar results have been reported also for some other species of birds of prey (Botelho & Arrowood 1996, Diermen 1996, Gehlbach 1996, Boal & Mannan 1999, Millsap & Bear 2000). However, there are pronounced differences in European and American Northern Goshawks and their use of urbanized areas (Kenward 1996, Bosakowski 1999, Morrison 2006). European hawks have been subject to intensive human presence and development for a very long time and apparently have adapted to use many urban areas. American Northern Goshawks, on the contrary, are not found to breed near urban settlements.

4.2. Variation in the number of successful nesting attempts

The expected relationship between the distance from urban habitats and the number of successful nesting attempts was not significant in the present data. Probably this resulted largely from the fact that the number of successful nesting attempts showed pronounced variation due to the differences in the long-term stability (frequency of occupation and preservation of habitats) of the nesting territories examined and in the length of the ob-

ervation period. Additional explanations can be derived from habitat alterations and the causes of unsuccessful breeding attempts (e.g., Byholm & Nikula 2007).

Besides forestry, the construction of buildings and traffic routes considerably diminished the amount of suitable habitats and potential nesting locations for the Northern Goshawk in the study area. The direct human interference was, however, only seldom proved to be the primary cause of nesting losses. Other predators such as the Pine Marten *Martes martes*, Eagle Owl *Bubo bubo*, and corvids probably were responsible for some nest losses (cf. Byholm & Nikula 2007). Nest-sites may also have been abandoned due to competition with other species such as Pine Marten and Common Buzzard *Buteo buteo* using similar nests for resting or nesting. Several nests had fallen down due to weak supporting branches of the nesting tree. Some territories were occupied most probably by non-breeding individuals. Finally, some alternative nests may have been missed, or nesting locations may have remained undetected due to insufficient field work.

4.3. Conclusions

The urban environments of the study area apparently provided better conditions for breeding Northern Goshawks than did the other compared habitats. The brood size in the urban habitats might be larger than in the rural ones due to a high and stable prey supply. From a conservation point of view, the urban and semi-urban Northern Goshawk territories seemed to be of particular value. Therefore, I suggest that urban planners take care of the even and continuous availability of parks growing mature trees and natural kinds of forests (see also Sergio & Bogliani 2000). Maintaining Northern Goshawks in urban habitats could yield the additional advantage of potentially lowering the populations of bird species considered by some as harmful; examples include gulls, pigeons and corvids.

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Kanahaukan poikuekoko kaupunki- ja maaseutuympäristöissä Etelä-Suomessa

Tutkin, vaikuttaako pesäpaikan etäisyys kaupunkimaisesta asutuksesta kanahaukan poikuekokoon. Vuosina 1976–2007 koottu aineisto on peräisin 70 pesimäpaikalta yhteensä 270 poikueesta. Korkeintaan n. 2.5 km:n päässä kaupunkiympäristöstä kanahaukan keskimääräinen poikuekoko oli merkitsevästi suurempi kuin maaseutumaisemmissa ympäristöissä. Pesyekoko oli kaikkein kaupunkimaisimmalla alueella merkitsevästi suurempi kuin vähiten kaupunkimaisella. Kaupunkiympäristöt näyttäisivät yleisesti olevan ravinto- ja pesintäolosuhteiltaan maaseutuympäristöjä vakaampia.

Tähän viittaavat myös monien kaupunkireviirien pitkäikäisyys, viime aikoina yleistynyt taipumus asuttaa uudelleen aikaisemmin ilmeisesti kaupungistumisen seurauksena hylättyjä pesimäpaikkoja, sekä asuttaa aivan uusiakin kaupunkiympäristöjä. Kaupunkiympäristö voi paikallisesti olla kanahaukalle maaseutuympäristöä edullisempi vaihtoehto. Tuotteliaat kaupunkilaisreviirit voivat myös elvyttää maalaisympäristöjen heikentynyttä kanahaukkakantaa. Sopivien pesäpaikkojen niukuus tekee kaupunkilaisreviireistä erityisen arvokkaita.

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