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# Distribution of nests and breeding density of birds of prey, Black Stork and Common Raven in forests of Litovelské Pomoraví (Czech Republic)

*Distribuce hnízd a hnízdní hustota dravců, čápa černého a krkavce velkého v lesích Litovelského Pomoraví (Česká republika)*

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***Abstract.*** *The study is focused on breeding populations of birds of prey (*Pernis apivorus*,* Accipiter gentilis*,* Accipiter nisus*,* Buteo buteo*,* Falco subbuteo*), Black Stork (*Ciconia nigra*) and Common Raven (*Corvus corax*) in forest complexes of Litovelské Pomoraví (93,186 km², percentage of forest cover 57.9%). In the period 2000–2005, altogether 213 large tree nests of studied species were found. The English Oak (*Quercus robur*), European Ash (*Fraxinus excelsior*) and Common Alder (*Alnus glutinosa*) were used most frequently for nesting in the floodplain forest; the European Larch (*Larix decidua*), Sessile Oak (*Quercus petraea*) and Common Alder in the Doubrava and Třesín area. Majority (88.7%, n = 213) of the nests were found in forest stands at the age of 81–140 years. 24% of the nests were situated less than 100 m from the forest edge and 73% of the nests less than 500 m from the forest edge. In total, 249 cases of nesting attempts were recorded, 227 of them (91.2%) were related to the Common Buzzard, 5 to the Northern Goshawk, 2 to the European Honey Buzzard, 6 to the Black Stork, 7 to the Common Raven, 1 to the Eurasian Sparrowhawk and 1 to the Eurasian Hobby. The mean distance between two occupied nests of the Common Buzzard was 747 m (min. 91 m, median 623 m, max. 2225 m). In the Common Buzzard, breeding density calculated for the whole study area (D) ranged between 26.8 and 52.6 pairs/100 km², density calculated for the total area of forests ($D_{forest}$) ranged between 46.3 and 90.7 pairs/100 km². In the Northern Goshawk, the densities were D = 1.1–2.1 pairs/100 km² and $D_{forest}$ = 1.9–3.7 pairs/100 km², in the European Honey Buzzard they were D = 2.1 pairs/100 km² and $D_{forest}$ = 3.7 pairs/100 km², in the Black Stork D = 2.1 pairs/100 km² and $D_{forest}$ = 3.7 pairs/100 km², in the Common Raven D = 1.1–2.1 pairs/100 km² and $D_{forest}$ = 1.9–3.7 pairs/100 km². Nest occupancy ranged between 16.0 and 30.8%. Of the total number of 227 breeding attempts of the Common Buzzard, 86.3% were successful. The mean number of fledged juveniles in the Common Buzzard was 1.74 juveniles per successful breeding attempt and 1.44 juveniles per initiated breeding attempt. In the Common Buzzard, the distance to the nearest occupied nest, calculated for different numbers of fledglings per breeding pair, did not differ significantly, neither in individual years nor for all years pooled.*

***Key words:*** *bird population abundance, breeding success, Common Buzzard, SPA, floodplain forests, Morava*

## Introduction

Diversity of bird communities at a local scale is a frequent issue of a number of faunistic ornithological studies, since the local scale is important for nature conservation interests aimed at adaptive management of particular habitats (Comiskey et al. 2001). Orientation of these studies on certain focal species (Lambeck 1997) may provide support for the assessment of impact of anthropic projects on the environment (Machar 2010). The knowledge of distribution of focal bird species in particular types of forest ecosystems makes it possible to assess the ef-

fectiveness of ecosystem management (Larsson 2001). Orientation of regional ornithological studies on defined focal species is also used in monitoring of Special Protected Areas of the Natura 2000 network (Miko 2012).

This type of information may be important for the use of birds as bioindicators (Furness & Greenwood 1993), in conservation practice for the assessment of ecological quality of habitats (Underhill & Gibbons 2002, Sutherland & Green 2004) and for testing of some ecological concepts and theories (Holmes et al. 1986, Wesołowski & Tomiałojć 1997, Korňan 2013). The present paper concentrates on focal species representing large birds nesting on trees in forest ecosystems (European Honey Buzzard, Northern Goshawk, Eurasian Sparrowhawk, Common Buzzard, Eurasian Hobby, Black Stork and Common Raven). In the Czech Republic, relatively many studies focused on numbers of breeding birds of prey are available (e.g. Drozd 1977, Hlásek 1987, Orel 1987, Závalský 1987, Gahura 1979, Voříšek 2000), however, only few of them (Suchý 1989, Diviš 1990, Voříšek 1995, Horák 2000, 2004) are based on rather long-term data (at least six years of observation are necessary to include at least two gradations in the population cycles of small mammals) and were carried out at a representative area (at least ca. 50–100 km$^2$ to be able to calculate breeding density per 100 km$^2$). The aim of this paper is to assess the distribution of nests of birds of prey, Black Stork and Common Raven in forest ecosystems of Litovelské Pomoraví (Machar 2008), as well as breeding density and temporal variability with respect to the age of forest stands. This aspect has not yet been analysed in detail in the Czech Republic. Moreover, results of such assessment can be useful for forest management and conservation practice.

## Material and methods

*Study area*

Monitoring of nests of birds of prey was carried out in forest stands of the Litovelské Pomoraví Protected Landscape Area and Special Protection Area, which has an elongated shape reaching 28 km in length, its width is 1.06 km in the narrowest part and 7.33 km in the widest part. Its area is 9318.6 ha. Forests cover 5400 ha (57.95%), arable land 1436 ha (15.41%), gardens and orchards 233 ha (2.50%), meadows and pastures 870 ha (9.34%), water bodies 770 ha (8.26 %), built-up areas 98 ha (1.05%) and other areas 511.6 ha (5.49%). The lowest altitude is 212 m a.s.l. (south-eastern boundary at Olomouc-Hejčín), the highest point is the Jelení vrch hill at Doubrava – 345.4 m a.s.l. (Poprach & Machar 2012).

From the geomorphological point of view, three units can be identified in the area: 1) floodplain forests between the municipality of Chomoutov and the Mladeč – Nové Zámky – Nový Dvůr road, including floodplain forests on the right-bank side of the Morava river below Nové Mlýny (2420.3 ha), 2) Doubrava (2826.3 ha) – a rather hilly and morphologically diverse large forest complex in the northern part, and 3) Třesín (153.4 ha) – a morphologically diverse karst formation with the lowest point at 344.9 m a.s.l. (Machar 2008). The river Morava runs through the area from north to south, in the floodplain forests it is free of channelization, with numerous meanders and side arms (Bureš & Machar 1999). The bioregion is found in a warm area, well supplied with precipitation. From the phytogeographical point of view, it belongs to thermophyticum (phytogeographical subdistrict of Hornomoravský úval) and marginally to mesophyticum (phytogeographical districts of Zábřežsko-uničovský úval and Bouzovská pahorkatina). The surface consists mainly of quaternary sediments covered with soil and loess deposits. Soils include mainly gley fluvisols changing into typical gley soils. Potential vegetation consists mainly of different types of floodplain forests (mostly Ficario-Ulmetum campestris, at some places Carici elongatae-Alnetum) with enclaves of primary forest-free areas (pools, oxbow lakes, and also fens in the surroundings of Olomouc). In hills above the floodplain, oak-hornbeam forests (Melampyro nemorosi-Carpinetum, less often Tilio-Carpinetum) with fragments of thermo-

philous oak forests in south-oriented places (Sorbo torminalis-Quercetum) can be found.

The proportion of woody plants in species composition of the forest is not even. The English Oak (*Quercus robur*) is the most represented woody plant, occurring throughout the study area (proportion between the English Oak and the Sessile Oak, *Quercus petraea,* was not distinguished). In the floodplain forest, the most represented species include the European Ash (*Fraxinus excelsior*), English Oak and Small-leaved Lime (*Tilia cordata*), which usually make a basis of the forest stand. The admixture of the Norway Maple (*Acer platanoides*), Sycamore (*Acer pseudoplatanus*) and Common Alder (*Alnus glutinosa*) is frequent there. In the Doubrava area, the Sessile Oak prevails (the English Oak usually occurs only at places influenced by water). The admixture of the European Beech (*Fagus sylvatica*, which at the same time is the main woody plant in the most elevated parts), European Hornbeam (*Carpinus betulus*), Small-leaved Lime and Silver Birch (*Betula pendula*, forming homogeneous stands in some parts), is frequent there. Among conifers, the most represented species include the Norway Spruce (*Picea abies,* its proportion has been reduced purposefully by logging) and the European Larch (*Larix decidua,* commonly occurring as an admixture or forming the upper storey of two-storey stands). Its proportion has not been reduced significantly, the allowed percentage is used during forest regeneration (Online Appendix 1a). The proportion of age categories is uneven. In general, the area of the 1st and 5th age categories is relatively small and that of the 9th and 10th age categories is slightly above average. However, the situation varies among particular forest management units, particularly between the floodplain forest and Doubrava – oak forest. The proportion of old stands is not high. Stands older than 130 years occur only scarcely, most often as the upper storey in multi-storey stands, the highest age is 175 years (Online Appendix 1b) (Anonymus 2008). The precipitation amount recorded at the Litovel meteorological station (situated approximately in the centre of the study area) is 350–400 mm in the growing season, and 200–300 mm in winter. The lowest amount of precipitation occurs in February, the highest one in July. The mean annual relative air humidity is around 76%, being the highest in December (86%) and the lowest in May (68%). The mean annual temperature is 8–9 °C, with the lowest mean in January (–2 °C) (Vysoudil 2003).

*Data collection and analysis*

The nests were searched for by slow walking through the forest stands during the winter period and intensively in early spring before leaves started growing. The found nests were entered into 1:10,000 scale forest maps. Tree species was recorded in each nest. Localities where courtship or circling was observed in early spring and the nest was not found, were visited repeatedly with the aim to find the nest. The first large-scale monitoring was started in the winter of 1999/2000 and in the early spring of 2000, however, the whole area was monitored incompletely also in previous years (since 1994). Thanks to long-term monitoring, it was possible to identify the bird species which built the nest. During each breeding season of the monitoring period, present nests were checked, their occupancy was recorded, physical check was carried out in accessible nests in the nestling period and the young were ringed. Observations of territorial behaviour of the birds or single observations when no nest was found were not included in this study. Nests with at least one fledgling were considered as successful breeding attempts. All breeding attempts, both successful and unsuccessful (with no fledged juveniles) were considered initiated breeding attempts.

For data analysis, locations of nests recorded in forest maps were digitized into the WGS 84 system and subsequently, data on the age of the given forest stand and its vertical structure (presence of storeys) were detected from the particular data layers. Age of the stands and storeys was determined in 2000 (the first year of monitoring), when the new forest management plan for the period January 1, 2000–December 31, 2009 came into practice. The multi-storey

stand is here defined as an area of a forest stand subunit demarcated in a forest map of the given forest management unit, where several tree generations are present. Primary data were processed in the TYTO database (Poprach 2011). Based on the number of breeding pairs, breeding density per 100 km$^2$ was computed in each focal species: the D density – covering the whole study area (9318.6 ha) including non-forest habitats neighbouring the forest complex, and the $D_{forest}$ density – covering only forest habitats (5400 ha) where monitoring was carried out. Mean density, minimum and maximum range (where the total number of breeding attempts was higher than 3), standard deviation (SD) and coefficient of variance (CV) are given in the results. Distance to the nearest nest occupied by the same species was computed for individual years and breeding species in MS Access using the SQL query – computation of distances between nests based on the nearest-neighbor analysis method. Distance between points was computed using the Pythagorean theorem in the Cartesian coordinate system. If only one pair of the given species nested in the given year, the distance was not computed. Moreover, distance of the nest from the outer edge of the forest complex was measured in GIS (a meadow inside the forest was thus not taken into account as a forest edge). Locations of all nests found in the period 2000–2005 and nest occupancy in the particular years are shown in map annexes with age classification of the stands.

Two parts of the study area were subjected to testing: the floodplain forest and the Doubrava area (including Třesín). The following parameters were tested: 1) difference in the distance to the nearest occupied nest between the floodplain forest and Doubrava – oak forest (exact Wilcoxon two-sample test); 2) using descriptive statistics, we assessed the distribution of occupied nests in relation to the distance from the forest complex margin in individual years and sites; 3) difference in the number of fledged juveniles of the Common Buzzard between the floodplain forest and Doubrava – oak forest (chi-square goodness of fit test for the probabilities $P_{oak\ forest} = 0.55$, $P_{floodplain\ forests} = 0.45$, Bonferroni correction P-value); 4) difference in the number of nests in particular years between the floodplain forest and Doubrava (chi-square goodness of fit test for the probabilities $P_{oak\ forest} = 0.55$, $P_{floodplain\ forests} = 0.45$, Bonferroni correction p-value); 5) distance to the nearest nest in relation to different numbers of Common Buzzard juveniles in the nest (Kruskal-Wallis test, Bonferroni correction); 6) distance of the nest from the margin of the forest complex in relation to the number of juveniles in the nest (Kruskal-Wallis test, Fisher's exact test of independence of the number of fledglings raised by one pair in relation to the categorised distance of the nest from the margin – nests „inside" and „on the margin" of the forest complex) – nests situated less than 500 m from the margin were classified as „on the margin" of the forest complex, while nests situated more than 500 m from the margin were included in the „inside" category. All statistical analyses were carried out using the R software (R Core Team 2014). Significance level was 5% in each of the tests.

## Results

*Distribution of nests*

In the years 2000–2005, altogether 213 large tree nests were localised in the forests of Litovelské Pomoraví – 198 nests of the Common Buzzard (*Buteo buteo*), 3 nests of the Northern Goshawk (*Accipiter gentilis*), 1 nest of the Eurasian Sparrowhawk (*Accipiter nisus*), 2 nests of the European Honey Buzzard (*Pernis apivorus*), 3 nests of the Black Stork (*Ciconia nigra*) and 6 nests of the Common Raven (*Corvus corax*). Distribution of the localised nests is shown in Fig. 1. Moreover, distribution of occupied nests in particular years is provided in Online Appendix 2. The English Oak (*Quercus robur*), European Ash (*Fraxinus excelsior*) and Common Alder (*Alnus glutinosa*) were used most frequently for nesting in the floodplain forest; the European Larch (*Larix decidua*), Sessile Oak (*Quercus petraea*) and Common Alder in the Doubrava and Třesín area (Table 1). The lowest number of nests was

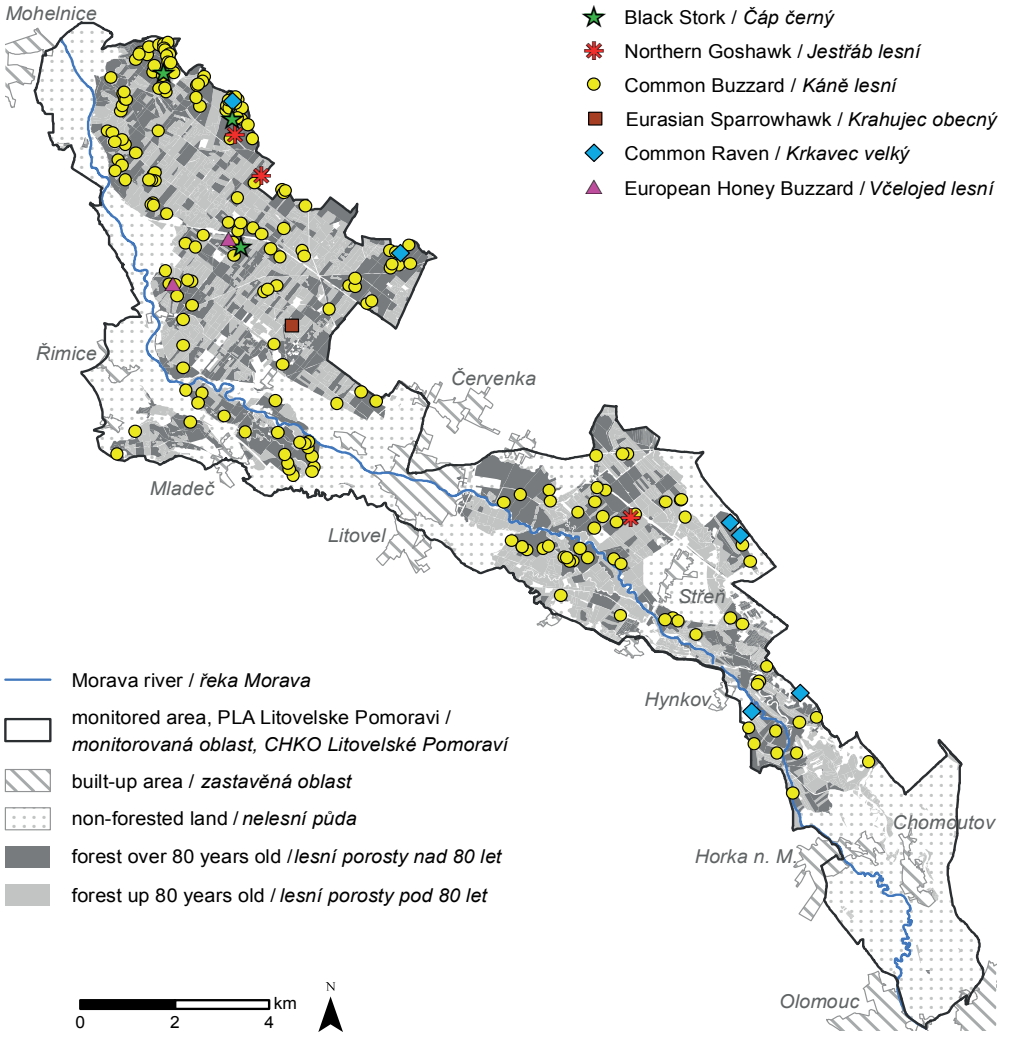


**Fig. 1.** Distribution of localised nests of birds of prey, Black Stork (*Ciconia nigra*) and Common Raven (*Corvus corax*) in Litovelské Pomoraví in the period 2000–2005 (n = 213).
***Obr. 1.*** *Rozmístění lokalizovaných hnízd dravců, čápa černého (*Ciconia nigra*) a krkavce velkého (*Corvus corax*) v Litovelském Pomoraví v období let 2000–2005 (n = 213).*

found in the European Hornbeam (*Carpinus betulus*), Norway Spruce (*Picea abies*) and Poplar (*Populus* x *canadensis*), in spite of the fact that e.g. the proportion of the Norway Spruce is 10.78% and in Doubrava – oak forest it is the most common conifer species. On the other hand, proportion of the European Larch is 4.13% and it was the most frequently occupied woody plant in Doubrava – oak forest. The studied bird species used those species of woody plants in which trunk and branch arrangement enables construction of a safe nest and easy access to the nest. The nests were situated at the altitudes of 220–242 m a.s.l. in the floodplain forest (n = 78) and at 230–328 m a.s.l. in the Doubrava and Třesín areas (n = 135). In the studied period, altogether 42 nests (19.7%) were destroyed by a spontaneous fall (because of high age of the nest, strong wing etc.) or due to felling.

**Table 1.** Proportion of particular species of woody plants with tree nests of studied birds in Litovelské Pomoraví in the period 2000–2005 (n = 213).
***Tab. 1.*** *Zastoupení druhů dřevin se stromovými hnízdy studovaných druhů v Litovelském Pomoraví v období let 2000–2005 (n = 213).*

| | pine / *borovice* | larch / *modřín* | spruce / *smrk* | birch / *bříza* | oak / *dub* | hornbeam / *habr* | ash / *jasan* | lime / *lípa* | alder / *olše* | poplar / *topol* | not identified / *neurčeno* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Floodplain forest / *Lužní les* | 1 | 3 | 0 | 3 | 22 | 1 | 18 | 5 | 12 | 2 | 11 |
| Doubrava & Třesín – oak forest / *Doubrava & Třesín – dubový les* | 3 | 59 | 2 | 4 | 28 | 0 | 1 | 2 | 7 | 1 | 28 |

**Table 2.** Age of forest stands with tree nests of studied birds in Litovelské Pomoraví in the period 2000–2005 (n = 213).
***Tab. 2.*** *Stáří porostů se stromovými hnízdy studovaných druhů v Litovelském Pomoraví v období let 2000–2005 (n = 213).*

| Age of the stand / *Věk porostu* | 31–40 | 41–50 | 51–60 | 61–70 | 71–80 | 81–90 | 91–100 | 101–110 | 111–120 | 121–130 | 131–140 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of cases (n) / *Počet případů (n)* | 1 | 0 | 4 | 9 | 10 | 40 | 42 | 35 | 39 | 21 | 12 |

**Table 3.** Distance of nests of birds of studied birds from forest edge in Litovelské Pomoraví in the period 2000–2005 (n = 213).
***Tab. 3.*** *Vzdálenost hnízd studovaných druhů od okraje lesa v Litovelském Pomoraví v období let 2000–2005 (n = 213).*

| Species / *Druh* | Distance to forest edge (m) / *Vzdialenosť od okraja lesa (m)* | | | Distance to the nearest nest (m) / *Vzdálenost k nejbližšímu hnízdu (m)* | |
|---|---|---|---|---|---|
| | n | mean (SD) / *ar. průměr (SD)* | median (1st–3rd quartile) / *medián (1.–3. kvartil)* | mean (SD) / *ar. průměr (SD)* | median (1st–3rd quartile) / *medián (1.–3. kvartil)* |
| *Pernis apivorus* | 2 | 735 (516.19) | 735 (552.5–917.5) | 1534.3 (0) | 1534.3 (1534.32–1534.32) |
| *Accipiter gentilis* | 5 | 345 (347.42) | 355 (75–355) | 2205.7 (2088.17) | 1071.8 (1071.79–4442.35) |
| *Accipiter nisus* | 1 | 852 (–) | 852 (852–852) | 0 (–) | – |
| *Buteo buteo* | 227 | 399.4 (352.66) | 340 (100–536) | 746.6 (456.88) | 623.1 (426.33–964.68) |
| *Falco subbuteo* | 1 | 124 (–) | 124 (124–124) | 0 (–) | – |
| *Ciconia nigra* | 6 | 774 (465.26) | 726 (352–1208) | 2761.4 (86.42) | 2817.2 (2691.67–2817.19) |
| *Corvus corax* | 7 | 58.9 (38.18) | 33 (29–91) | 2613.6 (4463.56) | 0 (0–4573.79) |

In the years 2000–2005, 177 nests (83.1%) were situated in stands at the age of 81–130 years. Only 24 nests (11.3%) were found in stands younger than 80 years. At least 12 nests (5.6%) were found in stands which were 130–140 years old, considering the absence of overaged stands due to felling age. One nest in the stand which was 31–40 years old belonged to the Eurasian Sparrowhawk. Further 23 nests built in stands at the age of 56–80 years belonged to the Common Buzzard (Table 2). Of the total number of 213 localised nests, 139 (65%) were situated in stands without understorey, 74 nests (35%) were found in stands with differentiated understorey (16–93 years old). Except for the European Honey Buzzard, Eurasian Sparrowhawk and Black Stork, the studied species built their nests rather close to the margin of the forest complex than in its interior (see Table 3). Among 213 localised nests, 24% were situated less than 100 m from the forest margin and 73% less than 500 m from the forest margin.

In the study period, we recorded altogether 249 cases of nesting, 227 of them (91.2%) were related to the Common Buzzard (222 in own nests, 5 in nests built by the European Honey Buzzard), 5 (2.0%) to the Northern Goshawk (one of them in a nest built by the Common Buzzard), 2 (0.8%) to the European Honey Buzzard, 6 (2.4%) to the Black Stork (one of them in a nest built by the European Honey Buzzard), 7 (2.8%) to the Common Raven, 1 (0.4%) to the Eurasian Sparrowhawk and 1 (0.4 %) to the Eurasian Hobby (in a nest built by the Common Raven). The numbers of occupied nests in particular years were as follows: year 2000 – 32 nests (20.3%, n = 158), year 2001 – 43 nests (25.7%, n = 167), year 2002 – 53 nests (30.8%, n = 172), year 2003 – 44 nests (25.9%, n = 170), year 2004 – 26 nests (16.0%, n = 163), year 2005 – 51 nests (30.0%, n = 170).

**Table 4.** Abundance and density of studied breeding species in Litovelské Pomoraví (whole study area = 93.19 ha; area of forests = 54.00 ha) in the period 2000–2005 (n = 249). *SD = standard deviation, VC = coefficient of variance, PV = population variability.*
***Tab. 4.*** *Abundance a denzita studovaných hnízdících druhů v Litovelském Pomoraví (celková plocha oblasti = 93,19 ha; rozloha lesů = 54,00 ha) v období let 2000–2005 (n = 249). SD = směrodatná odchylka, VC = variační koeficient, PV = populační variabilita.*

| Year / *Rok*<br>Species / *Druh* | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | average / *ar. průměr* | SD | PV |
|---|---|---|---|---|---|---|---|---|---|
| *Pernis apivorus* | 2 | | | | | | 0.33 | 0.82 | – |
| *Accipiter gentilis* | | | 1 | 2 | | 2 | 1.83 | 0.98 | – |
| *Accipiter nisus* | | 1 | | | | | 0.17 | 0.41 | – |
| *Buteo buteo* | 27 | 39 | 49 | 41 | 25 | 46 | 38.83 | 9.85 | 0.27 |
| *Falco subbuteo* | | | | | | 1 | 0.17 | 0.41 | – |
| *Ciconia nigra* | 2 | 2 | 2 | | | | 1.00 | 1.10 | – |
| *Corvus corax* | 1 | 1 | 1 | 1 | 1 | 2 | 1.15 | 0.41 | 0.17 |
| ∑ | 32 | 43 | 53 | 44 | 26 | 51 | 41.50 | 10.60 | 0.27 |

*Breeding density*

In the period 2000–2005, the number of breeding pairs of the Common Buzzard ranged between 25 and 49 pairs (D = 26.8–52.6 pairs/100 km$^2$, $D_{forest}$ = 46.3–90.7 pairs/100 km$^2$). The Northern Goshawk was recorded in the number of 1–2 breeding pairs in the years 2002–2003 and 2005 (D = 1.1–2.1 pairs/100 km$^2$, $D_{forest}$ = 1.9–3.7 pairs/100 km$^2$), the European Honey Buzzard in the number of 2 pairs in the year 2000 (D = 2.1 pairs/100 km$^2$, $D_{forest}$ = 3.7 pairs/100 km$^2$), the Black Stork in the number of 2 pairs in the years 2000–2002 (D = 2.1 pairs/100 km$^2$, $D_{forest}$ = 3.7 pairs/100 km$^2$), the Common Raven nested annually in the number of 1–2 pairs (D = 1.1–2.1 pairs/100 km$^2$, $D_{forest}$ = 1.9–3.7 pairs/100 km$^2$) (Table 4). The mean distance between two occupied nests of the Common Buzzard was 747 m (min. 91 m, median 623 m, max. 2225 m). The shortest distance between two occupied nests of the Common Buzzard was 91 m (years 2002 and 2003). Short distances between two occupied nests of the Common Buzzard were recorded in the Doubrava – oak forest area with high concentration of nests (years 2000–2004) and less often in the floodplain forest (years 2001, 2005). In the European Honey Buzzard, the distance between two occupied nests was 1534 m in the year 2000, in the Northern Goshawk it was 4442 m in the year 2003 and in the Black Stork it was 2817 m in the period 2000-2001 and 2650 m in the year 2002.

At the same time, we found no statistically significant difference between the floodplain forest and Doubrava – oak forest in the distance to the nearest occupied nest; neither when data for all species were pooled (exact Wilcoxon two-sample test, W = 7331, P = 0.866), nor when data for the Common Buzzard were analysed separately (W = 5441, P = 0.105) (Fig. 2); neither in individual years nor for all years pooled.

Some nests were occupied repeatedly during the study period 2000–2005, some were not occupied at all (n = 213 nests): 104 nests (48.8%) were unoccupied, 41 nests (19.2%) were occupied once, 29 nests (13.6%) twice, 16 nests (7.6%) three times, 16 nests (7.6%) four times, 5 nests (2.3%) five times and 2 nests (0.9%) six times. We did not find a statistically significant difference in the proportion of nests occupied by the Common Buzzard between the floodplain forest and Doubrava – oak forest (chi-square test).

As shown by summary characteristics for individual years (Fig. 3) and for the whole study period, at least a half of the occupied nests of the Common Buzzard as well as of other species were situated less than 500 metres from the margin of the forest complex. In the floodplain forest, over 80% of occupied nests were found less than 500 m from the forest margin (except for the year 2002, when data for all species were pooled, 3$^{rd}$ quartile = 501.5 m).

*Breeding success*

Numbers of fledglings (or full-grown nestlings) are given in Table 5. In the years 2000–2005, we recorded 196 (86.3%) successful and 31 (13.7%) unsuccessful nesting attempts in the Common Buzzard. Altogether 9 unfertilized eggs (six nesting attempts) were found in the Common Buzzard, seven juveniles (in seven

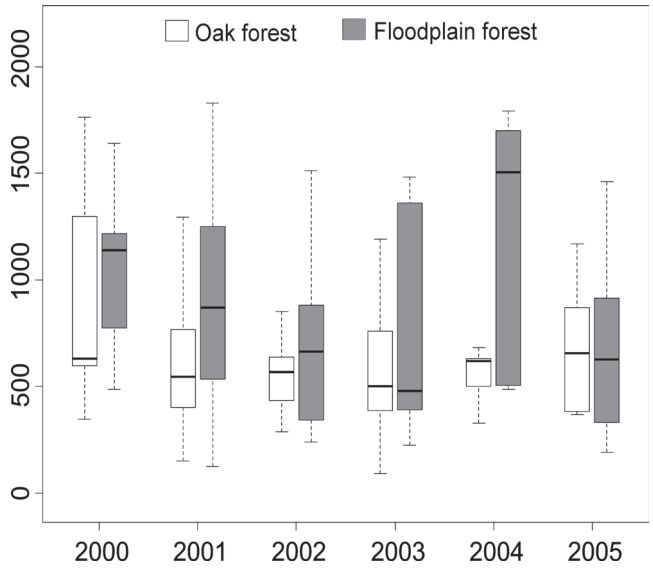


**Fig. 2.** Distance (m) between two nearest occupied nests of the Common Buzzard (in Litovelské Pomoraví in the period 2000–2005 (n = 227). Boxplot – quartiles with non-outliers range.
***Obr. 2.*** *Vzdálenosti (m) mezi dvěma nejblíže obsazenými hnízdy káně lesní v Litovelském Pomoraví v období let 2000–2005 (n = 227). Kvartilový boxplot bez vyznačení odlehlých hodnot a extrémů.*

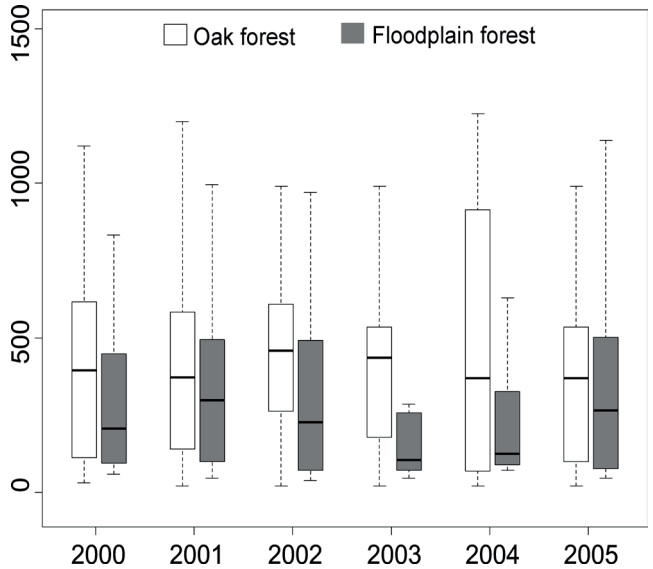


**Fig. 3.** Distances (m) of occupied nests of the Common Buzzard to the edge of the floodplain forest and of the Doubrava – oak forest in Litovelské Pomoraví in the period 2000–2005 (n = 227). Boxplot – quartiles with non-outliers range.
***Obr. 3.*** *Vzdálenosti (m) obsazených hnízd kání lesní k okraji lesních komplexů lužního lesa a Doubravy v období let 2000–2005 v Litovelském Pomoraví (n = 227). Kvartilový boxplot bez vyznačení odlehlých hodnot a extrémů.*

nests) died for unknown reason, and three juveniles (in three nests) were killed by their older sibling. Common Buzzards raised on average 1.75 juveniles (SD = 0.664) per successful nesting attempt and 1.44 juveniles (SD = 0.899) per initiated nesting attempt. Breeding success per initiated nesting attempt fluctuated between 0.84 juveniles (SD = 0.847) in 2003 and 1.84 juveniles (SD = 0.834) in 2000. Altogether 238 juveniles of the following species were ringed

**Table 5.** Number of fledged juveniles (or full-grown juveniles in the nest) recorded in studied bird species in Litovelské Pomoraví in the period 2000–2005 (n = 249). *Note: ? = breeding attempt was successful, the number of fledglings is not known though.*
***Tab. 5.** Počet vyvedených mláďat (případně vzrostlých mláďat na hnízdě) hnízdících sledovaných druhů v Litovelském Pomoraví v období let 2000–2005 (n = 249). Pozn.: ? = hnízdění bylo úspěšné, avšak počet mláďat není znám.*

| Number of fledged juveniles / *Počet vyvedených mláďat* Species / *Druh* | 0 | 1 | 2 | 3 | 4 | ? | ∑ | mean (SD) / *ar. průměr (SD)* |
|---|---|---|---|---|---|---|---|---|
| *Pernis apivorus* | | 2 | | | | | 2 | 1 (0) |
| *Accipiter gentilis* | 1 | | 1 | | 1 | 2 | 5 | 2 (2) |
| *Accipiter nisus* | 1 | | | | | | 1 | 0 (–) |
| *Buteo buteo* | 31 | 55 | 72 | 18 | | 51 | 227 | 1.4 (0.9) |
| *Falco subbuteo* | | | | 1 | | | 1 | 3 (–) |
| *Ciconia nigra* | 1 | | 2 | 2 | 1 | | 6 | 2.3 (1.37) |
| *Corvus corax* | | 1 | 1 | 1 | 1 | 3 | 7 | 2.5 (1.29) |

in the nests: European Honey Buzzard – 2 pulli, Northern Goshawk – 1 pullus, Common Buzzard – 215 pulli, Black Stork – 14 pulli and Common Raven – 6 pulli.

Neither the number of juveniles fledged by one pair of the Common Buzzard differed significantly between the sites (floodplain forest, Doubrava – oak forest) (Fisher's exact test, P < .392). At the significance level of 5%, after Bonferroni correction, a statistically significant difference was found in the absolute number of fledged juveniles of the Common Buzzard between the floodplain forest and Doubrava – oak forest in the year 2003 (3 vs. 24; $\chi^2 = 12.529$, $P_{adj} = 0.002$). In that year, there was also a difference in the number of breeding pairs of the Common Buzzard (12 pairs – floodplain forests, 29 pairs – Doubrava – oak forest), however, this difference was only of marginal significance ($\chi^2 = 4.0998$, P = 0.0429, Bonferroni correction – corrected P = 0.257). Distance to the nearest occupied nest of the Common Buzzard did not differ significantly between nests with a different number of fledged juveniles, neither in individual years nor for all years pooled (Kruskal-Wallis test, W = 2.827, P = 0.419).

## Discussion

*Distribution of nests*

The most abundant and species-rich breeding populations of birds of prey in the Czech Republic, and presumably also in the whole Central Europe, are found in floodplain forests of southern Moravia (Horák 2004). Gahura (1979) mentioned breeding of 10 species in the year 1978; Horák (2000) registered nesting of 12 species of birds of prey in the period 1981–2000. In our study, we recorded breeding of 5 species of birds of prey in the forests of Litovelské Pomoraví in the years 2000–2005. Over the period 1994–2013, nesting of altogether 8 species was evidenced: European Honey Buzzard (*Pernis apivorus*), Red Kite (*Milvus milvus*), White-tailed Eagle (*Haliaeetus albicilla*), Northern Goshawk (*Accipiter gentilis*), Eurasian Sparrowhawk (*Accipiter nisus*), Common Buzzard (*Buteo buteo*), Common Kestrel (*Falco tinnunculus*), Eurasian Hobby (*Falco subbuteo*); nesting of the Black Kite (*Milvus migrans*) was probable. Horák (2004) pointed out a marked decline in the number of breeding pairs of the Common Kestrel (*Falco tinnunculus*) in floodplain forests, which has been confirmed by our findings from Litovelské Pomoraví, as we did not record any breeding Common Kestrels in the forests in the years 2000–2005.

The distribution of breeding birds of prey in forest ecosystems is affected by the age and spatial structure of the forest (Trzcinski et al. 1999), including forest management (Petty & Avery 1990). In Litovelské Pomoraví, 88.7% of all nests localised in the period 2000–2005 were found in stands at the age of 81–140 years. Similarly, in floodplain forests of southern Moravia, birds of prey prefer high stands at felling age. Large-scale cutting of these forests may cause significant decline in numbers of the particular species (e.g. in the Black Kite) or their complete disappearance (e.g. Saker Falcon) (Horák 2004). Long-term presence of nests in stands with the possibility of their

repeated use is considered to be an important factor affecting the choice of breeding territories in the Common Buzzard (Jimenez-Franco et al. 2014), because the Common Buzzard reuses old nests more often than other species of birds of prey (Hirai & Yanagawa 2013). In our study, however, we recorded mostly a single use of the nests. Conservation of old forest complexes with nests of birds of prey is of high importance (Beaudry et al. 2013). Presence of understorey does not seem to play role in the location of nests of birds of prey, of the total of 213 nests found in Litovelské Pomoraví, 139 nests (65%) were situated in stands without understorey and 74 nests (35%) in stands with understorey (age of understorey: 16–93 years).

*Breeding density*

The Common Buzzard is the commonest breeding bird of prey in floodplain forests of southern Moravia as well as in Litovelské Pomoraví. In 1978, Gahura (1979) recorded the breeding density of 18.7 pairs/10 km$^2$ (area between Veselí nad Moravou and Tvrdonice, 31 km$^2$ of forests). In the years 1991–1998, the mean breeding density of the Common Buzzard in the Tvrdonice forest district (33 km$^2$) was 17.7 pairs/10 km$^2$, in the Lanžhot forest district (40 km$^2$) it was 13.5 pairs/10 km$^2$ and in the Horní les forest district (15,35 km$^2$, Mráz in litt. 2014) was 27.5 pairs/10 km$^2$ (Horák 2000, 2004). The high breeding density of the Common Buzzard in the Horní les forest district was probably due to higher diversification of the forest, where open areas with fenced forest patches were created inside the forest complex as a result of large-scale management (Horák 2004). Similarly high values of breeding density of the Common Buzzard (14.4–22.9 pairs/10 km$^2$) were given by Voříšek (2000) from the years 1993–1995 from the enclave of the Milovický les forest (22.21 km$^2$ of woodland in agricultural landscape of the Břeclav region), with a similar structure of forest habitats (including larger areas of meadows and fields inside the forest). In Litovelské Pomoraví, the density of the Common Buzzard (D2 – calculated for the total area of forests) fluctuated between 4.6 and 9.1 pairs/10 km$^2$. In the intensively used farmland of the Ostrava-Opava region (50 km$^2$, 30% forests, 60% fields and meadows, 10% built-up areas, altitude 211–371 m a.s.l.), Závalský (1987) recorded the breeding density of the Common Buzzard of 3.2–3.8 pairs/10 km$^2$ in the years 1983–1985, i.e. lower than in floodplain forests of southern and central Moravia, probably due to low proportion of forest habitats. Similarly, in the hills of Nízký Jeseník (100 km$^2$, 52% forests, 40% farmland, 8% built-up areas, 290–778 m a.s.l.), Suchý (1989) mentioned the density of the Common Buzzard of 1.4–2.9 pairs/10 km$^2$ (mean 2.1 pairs/10 km$^2$) from the period 1970–1985. In the Náchod region (200 km$^2$, percentage of forest cover 10–20%), Diviš (1990) recorded the density of 2.0–3.5 pairs/10 km$^2$. In the Choceň area (study area of 41–117 km$^2$, percentage of forest cover max. 20%), Voříšek (1995) gives the density of 2.0–2.8 pairs/10 km$^2$ for the period 1984–1992. In areas with higher density of the Common Buzzard, the population becomes concentrated and nesting of two pairs some 50–60 m from each other is not exceptional (Horák 2004). In Litovelské Pomoraví, the shortest distance between two occupied nests of the Common Buzzard was 91 m (in the years 2002–2003). In the Milovický les forest near Břeclav, the shortest distance between two occupied nests of the Common Buzzard was 100 m (Voříšek 2000).

The high breeding densities of the Common Buzzard in the forests of southern Moravia and Litovelské Pomoraví seem to be a result of the presence of suitable foraging grounds with sufficient food availability and abundant breeding opportunities in the otherwise forest-free agricultural landscape. Concentration of nests of the Common Buzzard in forest „islands" inside agrocoenoses is affected by population cycles of the Common Vole (e.g. Mebs 1958, 1964, Hartung & Pessner 1985, Newton 1991, Kostrzewa & Kostrzewa 1994, Voříšek 1995). This confirms the importance of these „island habitats" as refuges of forest species (Suchomel et al. 2012) and at the same time, stresses their value for conservation of populations of birds of prey in agricultural landscape (Tucker &

Evans 1997). We suppose that the statistically significant higher number of nesting pairs and fledged juveniles in the year 2003 was a result of gradation of small mammals in the study area. This association of birds of prey and the Common Raven with farmland is also supported by the fact that 73% of the localised nests were situated less than 500 m from the forest margin.

Density of the Northern Goshawk in Litovelské Pomoraví was relatively low, both that calculated for the whole study area (D = 1.1–2.1 pairs/100 km$^2$) and for forest complexes only ($D_{forest}$ = 1.9–3.7 pairs/100 km$^2$). In the Czech Republic, several authors assessed breeding density of this species. Závalský (1987) mentions the density of 0.8–1 pairs/10 km$^2$ (study area of 50 km$^2$) from the period 1983–1985. Orel (1987) recorded 7–19 breeding pairs (density 0.7–2.0 pairs/100 km$^2$) in the Nový Jičín district (935 km$^2$, percentage of forest cover 22%, altitude 167–1129 m a.s.l.) in the years 1975–1985. Suchý (1989) recorded the mean density of 3.12 pairs/100 km$^2$. Diviš (2003) studied breeding density of the Northern Goshawk in the Náchod region (two mapping squares with the percentage of forest cover reaching 13 a 29%, respectively, altogether 266 km$^2$, altitude range 255–560 m a.s.l.). In the years 1979–1981, the density was 5–7 pairs/100 km$^2$ and in the years 1986–1988 it was 1.5–3.5 pairs/100 km$^2$. In northern Bohemia (study area of 300 km$^2$, forests 42%, farmland 48%, built-up areas 10%, altitude 315–1012 m a.s.l.), Hanel et al. (2013) recorded the mean density of the Northern Goshawk of 3.0 pairs/100 km$^2$ in the years 2010–2012. It is evident that the density of the Northern Goshawk significantly fluctuates in time (e.g. Diviš 2003), however, the causes of this phenomenon are not known sufficiently. Distance of suitable hunting grounds is an important factor affecting nest site occupancy in this species (Krüger 2002).

In the years 1962–1991, altogether 325 Northern Goshawks were hunted (only registered shots) in the pheasantry of Střeň – Březová in Litovelské Pomoraví, the annual mean thus being 10.8 ind. (max. 41 ind.(!) in the year 1984). Until the year 1975, the annual bag was between 1–4 ind., later on the number increased to 7–32 ind. per year (Kučera & Rumler 1999). Note: the pheasantry of Střeň – Březová had the status of a reserved pheasantry of the Ministry of Agriculture and the forest had the status of a forest with a special function for hunting purposes. We suppose that the lower density of the Northern Goshawk may be a result of its long-term persecution in the period before the Litovelské Pomoraví was designated a Protected Landscape Area (Anonymus 1990), especially in the reserved pheasantry (Kučera & Rumler 1999, Poprach & Machar 2012). Similarly, e.g. Závalský (1987) mentions that at least 3 of 7 juveniles of one pair of the Northern Goshawk were shot during two years in a nest situated near the pheasantry.

*Breeding success*

In Litovelské Pomoraví, we recorded a high proportion of successful nests in the Common Buzzard – 86.3%, however, the mean number of fledglings per nest was relatively low – 1.74 fledglings per successful and 1.44 juveniles per initiated nesting attempt. In the years 1970–1985, Suchý (1989) recorded 72% successful breeding attempts in the Common Buzzard; the losses were due to picking of the eggs and destruction of the nests by people, logging, predation of the young by the Eurasian Eagle-owl (*Bubo bubo*) or by the Northern Goshawk and by climatic factors. Suchý (1989) recorded the mean number of 2.04 fledglings in the years 1970–1977 and 1.85 juveniles in the years 1978–1985. Based on the data of the Group for Conservation and Research of Birds of Prey and Owls, the long-term mean number of juveniles per initiated breeding attempt in the Czech Republic was 1.80 (n = 4298) in the years 1982–1998 (Hudec & Šťastný 2005). The low numbers of juveniles may be caused by temporal or local lack of food, as we found seven juveniles in seven nests which died for unknown causes and three juveniles in three nests which were cases of cainism. Breeding success of the Common Buzzard may be also affected by weather changes at the time of presence of non-fledged juveniles in the nest (Prytherch 2013).

Breeding success of the Common Buzzard is influenced by human activities, breeding density, nest tree crown cover and distance of the nest to the nearest forest margin (Krüger 2002).

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**Online Appendix** is available on the journal webpage.

***Elektronická příloha*** *je dostupná na webové stránce časopisu.*

**Online Appendix 1a.** Species composition of forests in the Litovelské Pomoraví PLA (Anonymus 2008).
**Online Appendix 1b.** Proportion of particular age classes of forest stands in the Litovelské Pomoraví PLA (Anonymus 2008).
***Elektronická příloha 1a.*** *Zastoupení dřevin v lesích chráněné krajinné oblasti Litovelském Pomoraví (Anonymus 2008).*
***Elektronická příloha 1b.*** *Zastoupení věkových kategorií lesních porostů v chráněné krajinné oblasti Litovelském Pomoraví – pouze porostní půda (Anonymus 2008).*

**Online Appendix 2.** Distribution of localised nests of studied birds in Litovelské Pomoraví in 2000 (n = 32), 2001 (n = 43), 2002 (n = 53), 2003 (n = 44), 2004 (n = 26), 2005 (n = 51).
***Elektronická příloha 2.*** *Obsazenost hnízd studovanými druhmi v Litovelském Pomoraví v roce 2000 (n = 32), ), 2001 (n = 43), 2002 (n = 53), 2003 (n = 44), 2004 (n = 26), 2005 (n = 51).*

## Súhrn

Práce se zabývá hnízdní populací dravců (*Pernis apivorus*, *Accipiter gentilis*, *Accipiter nisus*, *Buteo buteo*, *Falco subbuteo*), čápa černého (*Ciconia nigra*) a krkavce velkého (*Corvus corax*) v lesních komplexech Litovelského Pomoraví (93,186 km$^2$, lesnatost 57,9 %). V období let 2000–2005 bylo nalezeno 213 velkých stromových hnízd studovaných druhů. Pro stavbu hnízda byl v lužním lese nejčastěji využíván dub letní (*Quercus robur*), jasan ztepilý (*Fraxinus excelsior*) a olše lepkavá (*Alnus glutinosa*), v oblasti Doubravy a Třesína modřín opadavý (*Larix decidua*), dub zimní (*Quercus petraea*) a olše lepkavá. 88,7 % hnízd se nacházelo v porostech starých 81–140 let. Do 100 m od okraje lesa bylo situováno 24 % hnízd a do 500 m od okraje lesa 73 % hnízd. Zaznamenáno bylo 249 případů hnízdění, z toho 227× (91,2 %) káně lesní, 5× jestřába lesního, 2× včelojeda lesního, 6× čápa černého, 7× krkavce velkého, 1× krahujce obecného a 1× ostříže lesního. Vzdálenost mezi dvěma obsazenými hnízdy kání lesní byla v průměru 747 m (min. 91 m, median 623 m, max. 2225 m). Denzita v přepočtu na rozlohu celé oblasti (D) se u káně lesní pohybovala od 26,8 do 52,6 párů/100 km$^2$, v přepočtu na les ($D_{les}$) od 46,3 do 90,7 párů/100 km$^2$. U jestřába lesního byla denzita D 1,1–2,1 párů/100 km$^2$ a $D_{les}$ 1,9–3,7 párů/100 km$^2$, u včelojeda lesního D 2,1 párů/100 km$^2$ a $D_{les}$ 3,7 párů/100 km$^2$, u čápa černého D 2,1 párů/100 km$^2$ a $D_{les}$ 3,7 párů/100 km$^2$, u krkavce velkého D 1,1–2,1 párů/100 km$^2$ a $D_{les}$ 1,9–3,7 párů/100 km$^2$. Obsazenost hnízd se pohybovala od 16,0 do 30,8 %. Z celkového počtu 227 hnízdění káně lesní bylo 86,3 % hnízdění úspěšných. Káně lesní vyvedla v průměru 1,74 mláďě na úspěšné a 1,44 mláďě na započaté hnízdění. Vzdálenost k nejbližšímu obsazenému hnízdu káně lesní nebyla pro různé počty vyvedených mláďat jedním párem statisticky významně odlišná ani v jednotlivých letech a ani souhrnně pro všechny roky.

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