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# Detectability as an important factor influencing the knowledge of bird diversity in a floodplain forest ecosystem

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**ABSTRACT**: Knowledge of the structure and diversity of bird populations in forest ecosystems is important for the conservation of forest biodiversity. The results of bird population studies in forest ecosystems are influenced by the detectability of the subject birds. In spite of this fact, the detectability of birds in different forest habitats is often paid little attention. The aim of the present study is an assessment of the key factors which are important for the detectability of birds in floodplain forest ecosystems. The paper analyses the detectability of bird species in floodplain forests (Litovelské Pomoraví, Czech Republic) during the period 1998–2012. In this study the authors analysed data with relation to the date of the census, climatic factors (cloud cover, air temperature, wind and precipitation) and the main two habitat types (closed mature forest and ecotone). The results of the study show that the numbers of dominant bird species change significantly during the particular census dates within one season, mainly with respect to bird detectability.

**Keywords**: bird transect census; hardwood floodplain forest; regression model

Birds are an important component of forest ecosystems (Wiens 1989). Results of bird studies from forest ecosystems are influenced by detectability of birds (Janda, Řepa 1986). Despite of this, detectability of birds in different forest habitats is paid little attention (Fuller 1995). Detectability of birds in an ecosystem is based on the ecology of individual bird species and methods of census (Bibby et al. 2007).

This article presents the results from a point-count study of bird community in floodplain forests in the Litovelské Pomoraví Protected Landscape Area, Czech Republic (Machar 2008). The studied forest ecosystems represent habitats of forest interior and forest edges (Šálek et al. 2013). The aim of this paper is to assess some factors which influence detectability of bird species in a floodplain forest ecosystem.

## MATERIAL AND METHODS

Both the point-count transects (Vrapač and Litovelské Luhy) are situated in a hardwood floodplain forest of *Querco-Ulmetum* association in the Litovelské Pomoraví Protected Landscape Area (Fig. 1). The forest ecosystems at transects are large complexes of mature forest stands, which are classified as a hardwood floodplain forest of lowland rivers (habitat code L2.3) within the classification of Natura 2000 habitats (Chytrý et al. 2001). Research of birds was carried out at the Vrapač transect (coordinates 17°02'E, 49°42'N; length of transect is 6,900 m) in the years 1998–2003 and 2005–2010 and at the Litovelské Luhy transect (coordinates 49°38'N, 17°08'E; length of transect is 7,200 m) in

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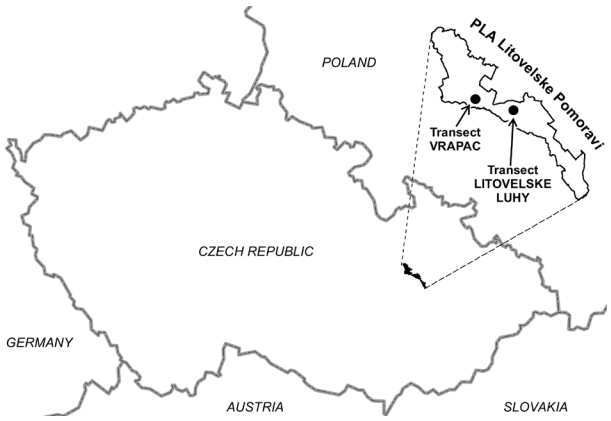


Fig. 1. Study area and location of research transects

the period 2005–2012. For specific natural conditions and tree species composition of the Vrapač transect see Simon, Machar (2014) and for the Litovelské Luhy transect see Simon et al. (2014).

At each transect, 20 monitoring points were established, spaced at 300 m intervals as a minimum. The counts were carried out three times during the breeding season at both transects: in mid-April – 1st census, in mid-May – 2nd census and in mid-June – 3rd census (in 2005, both transects were censused only in mid-May and mid-June). Three census dates per year were chosen because of the fact that some bird species (resident or arriving early in spring) start breeding earlier and their singing activity during territory defence may be rather intensive already during April. The birds were recorded for five minutes at each point. At both transects, the census started at 6 a.m. Central European Time. The points at a given transect were always censused in the same order, from the first to the 20th.

The census was carried out under suitable climatic conditions, or during slight weather changes (e.g. a mild short-term rain or drizzle). In the case of heavy rain, the census was stopped and continued only after the rain was over. The year 2010 was extreme, it started raining on 1 May and the rain persisted almost continuously till the end of the first ten-day period of June. Under such circumstances, it was difficult to finish the census, therefore e.g. the last point at the Vrapač transect was censused in mid-May as late as at 00:30 p.m. The birds recorded at the monitoring points were determined both visually and acoustically (song, different types of contact calls, alarm calls, attraction calls etc.). During the census in mid-April, the determination of species and individuals was 70–80% acoustic, while in mid-May when most of the trees had already come into leaf, the share of acoustic registrations increased to 90–100%. In mid-June, when the trees are already covered by leaves and the canopy is closed, the share of acoustic registrations at the particular points was up to 100%.

All observed or otherwise registered individuals were recorded, without distinguishing the distance from the monitoring point. Individuals which were obviously recorded twice at the neighbouring points (their voice activity clearly continued during the movement of the observer between two points) were excluded from the records (e.g. *Buteo buteo*). Individuals recorded when crossing the area without any direct breeding relationship to the studied habitat were also excluded from the data set, based on the results of previous surveys in the area (summary see Poprach, Machar 2012). In case that a fledged brood was observed, only the adult birds were included into the results.

The analyses were carried out in the R software (www.r-project.org). The Poisson regression was used for further analyses. For the purpose of this study, the floodplain forest complex was considered as a closed forest. The floodplain forest adjacent to a larger open area (meadow, field, larger clearing, Morava River etc.) was considered an ecotone. The effect of the following factors on the number of recorded bird species and their total abundance (number of registrations) was tested: transect (A – Vrapač transect, B – Litovelské Luhy transect), year of census, order of the particular census in the given year (1st census – mid-April, 2nd census – mid-May, 3rd census – mid-June), habitat type (closed forest, ecotone), time of the record (testing was carried out in 30 minute intervals from 6:00 to 12:00 a.m. – analysed separately, not as a factor in the Poisson regression model), and climatic characteristics: precipitation (no rain, mild rain, sporadically also heavy rain), wind (windless conditions, gentle breeze, fresh breeze, strong breeze), cloud amount (clear sky, partly cloudy sky, cloudy sky), air temperature. Incidence rates in Table 1 mean the exponents of coefficients (and their confidence intervals). The p-value in Table 1 corresponds to the results for type I tests.

## RESULTS

At the Vrapač transect, 43 breeding bird species were found during the first year of monitoring; 11 out of the 14 years of monitoring were needed to be able to detect all 63 recorded species. At the Litovelské Luhy transect, 39 breeding bird species were found during the first year; all 8 years of monitoring were needed to be able to detect the total of 67 breeding species.

Table 1. Results of a multivariate analysis – Poisson regression model for the number of species at the Vrapač and Litovelské luhy transects

| Factor (basic category) | Incidence rate (95% CI) | *P* |
|---|---|---|
| Transect: B (A) | 0.985 (0.952, 1.019) | 0.477412 |
| Census order: 2 (1) | 0.911 (0.873, 0.950) | 0.000319 |
| Census order: 3 (1) | 0.778 (0.739, 0.819) | 1.96e-15 |
| Habitat: closed forest (ecotone) | 0.918 (0.890, 0.948) | 2.43e-05 |
| Precipitation: TRUE (FALSE) | 0.845 (0.771, 0.926) | 0.000874 |
| Wind: gentle breeze (windless conditions) | 0.941 (0.905, 0.979) | 0.010945 |
| Wind: fresh breeze (windless conditions) | 0.889 (0.836, 0.945) | 0.001594 |
| Wind: strong breeze (windless conditions) | 0.748 (0.682, 0.820) | 0.015288 |
| Cloud amount: partly cloudy sky (clear sky) | 0.9998 (0.960, 1.041) | 0.992140 |
| Cloud amount: cloudy sky (clear sky) | 1.098 (1.037, 1.162) | 0.008353 |
| Air temperature: > 20 (≤ 20) | 1.078 (1.037, 1.120) | 0.001460 |

Using the Poisson regression, the date of census was found to be a statistically significant factor, both for the regression model of the number of species (Wald test of significance of the regression coefficient for the 2nd vs. 1st census and 3rd versus 1st census, respectively, $P < 0.001$) and for the regression model of the total number of registrations (Wald test of significance of the regression coefficient for the 2nd vs. 1st census and 3rd versus 1st census, respectively, $P < 0.001$). The chance to detect another species during the 2nd census (in the same habitat and at the same transect) was 0.808 times lower than in the 1st census, and that in the 3rd census was 0.68 times lower compared to the 1st census. Similar results can be found in analogical models of the total number of registrations, where any other registration can be expected with much lower probability during the 2nd census (incidence rate = 0.81) as well as during the 3rd census (incidence rate = 0.68) compared to the 1st census in the given year.

Precipitation, wind force, cloud amount and air temperature showed to be important climatic factors both in the model of the number of species and in the model of the number of registrations. Statistically significant differences ($P < 0.05$) in the number of recorded species in relation to the following climatic characteristics were found: negatively mainly in relation to precipitation (incidence rate = 0.850, $P < 0.001$) and wind force, in the case of cloud amount slightly positively (incidence rate = 1.098, $P = 0.008$) only for "cloudy sky" versus "clear sky" (for "partly cloudy sky" the result is not significant). The results of statistical tests suggest that the most marked decline in the number of recorded species was in the case of strong wind (0.748 times) compared to windless conditions, and during the 3rd census (0.779 times) compared to the 1st census. Similarly, the most marked decline in the number of registered individuals was found during the 3rd census compared to the 1st census, and in the case of strong wind compared to windless conditions (0.644 times). Higher cloud amount and higher air temperature slightly increased the number of registrations. The results are summarised in Tables 1 and 2 (incidence rate = chance of incidence of the particular phenomenon, i.e. registration of a species or an individual, under a given value of the fac-

Table 2. Results of a multivariate analysis – Poisson regression model for the number of registrations at the Vrapač and Litovelské luhy transects

| Factor (basic category) | Incidence rate (95% CI) | *P* |
|---|---|---|
| Transect: B (A) | 0.890 (0.856, 0.924) | 2.00e-10 |
| Census order: 2 (1) | 0.808 (0.768, 0.850) | < 2e-16 |
| Census order: 3 (1) | 0.680 (0.640,0.723) | < 2e-16 |
| Habitat: closed forest (ecotone) | 0.934 (0.900, 0.969) | 8.19e-05 |
| Precipitation: TRUE (FALSE) | 0.825 (0.740, 0.921) | 7.76e-06 |
| Wind: gentle breeze (windless conditions) | 0.908 (0.867, 0.951) | 2.29e-06 |
| Wind: fresh breeze (windless conditions) | 0.837 (0.784, 0.893) | 6.52e-08 |
| Wind: strong breeze (windless conditions) | 0.644 (0.581, 0.713) | 3.42e-05 |
| Cloud amount: partly cloudy sky (clear sky) | 1.070 (1.015, 1.126) | 0.00224 |
| Cloud amount: cloudy sky (clear sky) | 1.173 (1.102, 1.248) | 2.00e-07 |
| Air temperature: > 20 ( ≤ 20) | 1.064 (1.019, 1.111) | 0.00232 |

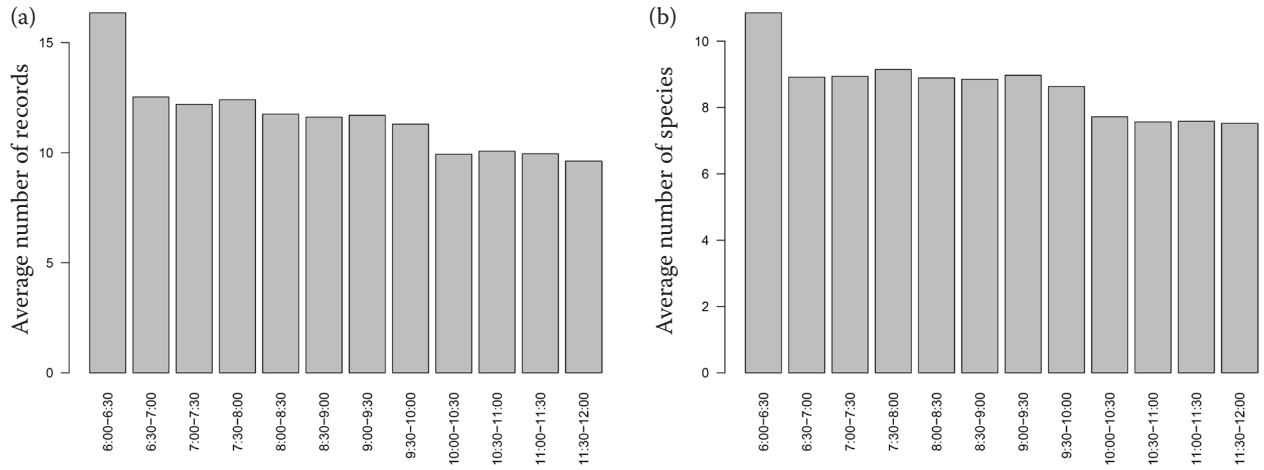


Fig. 2. Results of detectability of bird individuals (a), bird species (b) in relation to time of research Vrapač transect

tor versus the basic value of the factor under constant values of other factors in the model).

The effect of habitat type was also statistically significant ($P < 0.001$). According to the regression model, the chance to register a species in the closed forest was 0.918 times lower than in the ecotone (Table 1). At the same time, an increase in the number of registrations was 0.934 times lower in the closed forest compared to the ecotone (Table 2).

Fig. 2 shows that there is a marked decline in the number of recorded individuals and species after the time interval of 6:30 a.m. This decline is apparent on all census dates, however, it is most pronounced (at both transects) during the 3rd census (in mid-June), when some bird species do not sing any more and use only contact calls.

Mean abundance of the particular bird species in relation to observation time as pooled results from the Vrapač and Litovelské Luhy point-count transects are presented in Fig. 3. Standardisation of the mean abundance of bird species in relation to observation time shows detectability of the given species in time (the larger the difference in colours, the more time-dependent detectability of the given species). Values in each line have normal distribution, the dark colour shows when the given species is most active, the light colour shows when it is least active.

The absolute mean number of registrations of the particular species in particular time intervals without standardisation as pooled results from the Vrapač and Litovelské Luhy point-count transects are presented in Fig. 4. The absolute mean number of registrations of the particular species in particular time intervals without standardisation is given. This figure shows dominant species in the bird community.

The decline in the number of recorded individuals and species is also suggested by the results of statistical tests. Similarly during the 2nd census (in mid-May), a decrease in the singing activity of some species was recorded and only their contact calls were registered.

## DISCUSSION

In this study from floodplain forests of Litovelske Pomoravi, detectability of birds and the dominance values vary among particular census dates. Shifts in dominance values are caused mainly by changes in the singing activity of birds. The *Coccothraustes coccothraustes* was a dominant species at both transects on the 1st census date, however, its proportion declined below 2% during the subsequent two census dates. Likewise, *Sturnus vulgaris* was a dominant species at both transects during the 1st and 2nd census dates, but on the 3rd census date the values of its dominance declined below 2 percent. A similar trend of the decline of dominance values at the Vrapač and Litovelský luh transects was apparent in *Parus major* and *Parus caeruleus*. An interesting development of dominance values was observed in *Sitta europaea*, being similar at both transects. During the 1st census date, an average value of its dominance was found, followed by a strong decline on the 2nd census date and a strong increase on the 3rd census date. This fluctuation is caused by the course of breeding in this species: during the 1st census date the nuthatches are active and defend their breeding territories, during the 2nd census date their singing activity declines due to the care of the young, and during the 3rd cen-

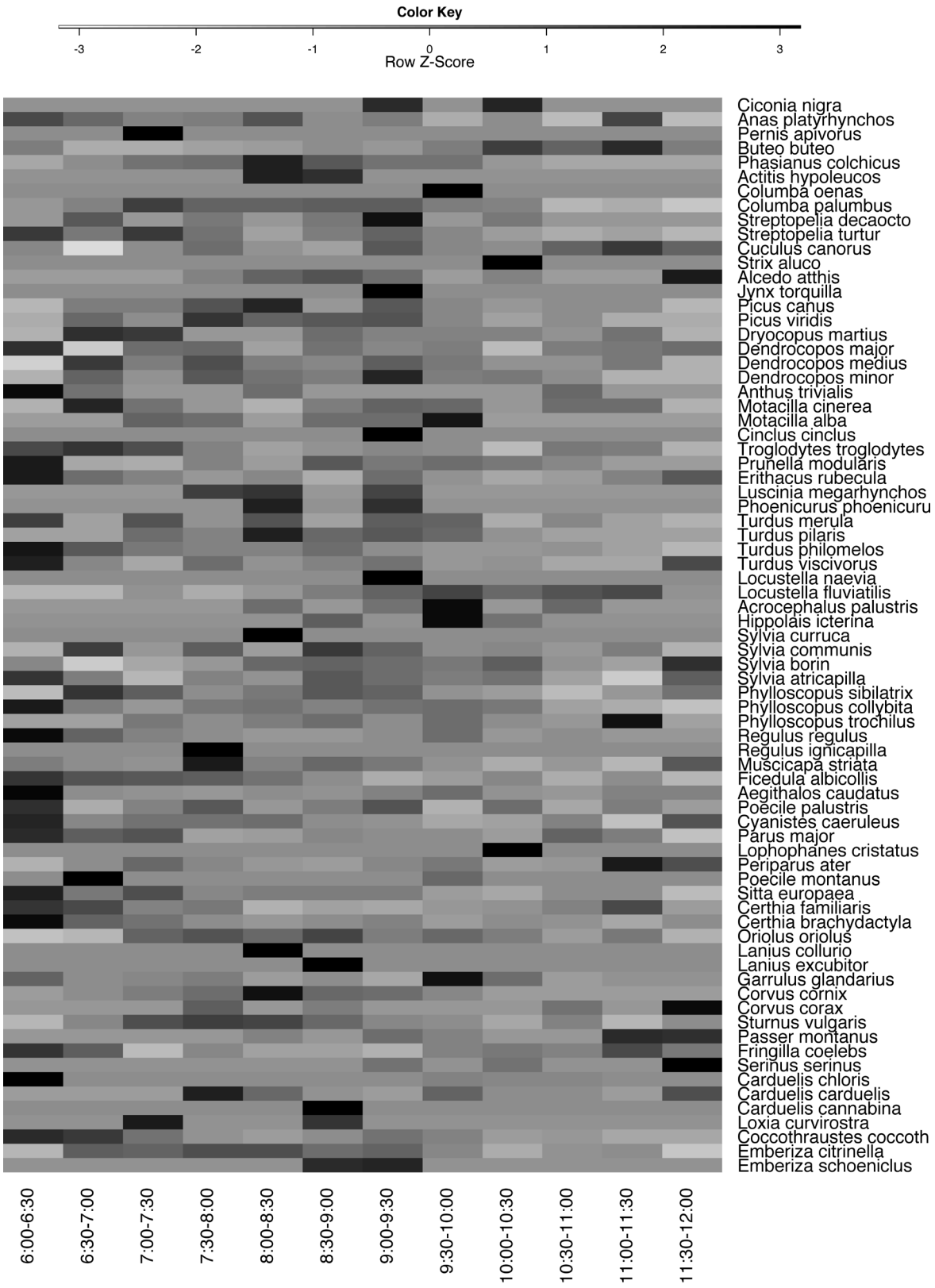


Fig. 4. Standardisation of the mean abundance of bird species in relation to observation time (transects Vrapač and Litovelské Luhy)

sus date the parents feed their fledged juveniles, which is accompanied by the increased call activity of both adults and fledglings. In the *Ficedula albicollis* (typical bird species of floodplain forests, which is an important in the framework of Natura 2000 system), the value of dominance at the Vrapač transect reached 9.24% on the 2nd census date, however, it was below 5% during


Fig. 5. Absolute mean number of bird registration without standardisation (transects Vrapač and Litovelské Luhy)

the 1st and 3rd census dates. At the Litovelské Luhy transect, the value of dominance in this species was comparable during the 1st and 2nd census date (5.72–8.00%), but declined to 3.82% during the 3rd census date. While in some dominant species the decline in dominance values occurs mainly on the 3rd census date, in *Sylvia atricapilla* the values of dominance reach their peak. This is not cer-

tainly due to the more intensive call activity of the latter species, but due to a decline of the call activity of other species in the bird community (especially other dominant species).

Comparison of the presented results with studies on bird communities of floodplain forests in a focal area in Central Moravia (nearby of the study site Litovelské Pomoraví) shows that the number of breeding bird species in floodplain forests varies significantly among the studies, which are affected by detectability in the framework of used methods (Machar 2012): Ginter (1964) listed 52 breeding species in Žebračka floodplain forest (from the period approximately 1949–1964, no specific method of data collection was used, only breeding species in the forest outside municipalities and surrounding meadows were included). Kavka (1967) reported 75 breeding species from the same locality and Chytil (1975) recorded regular breeding of 75 species (in the 1970s, no specific method of data collection was used) and breeding of 40 species in 1975 (territory-mapping method at 10 ha). Svoboda (1991) mentioned 68 breeding species (territory-mapping method in squares combined with nest searching). Koleček et al. (2010) recorded altogether 47 species (including species with no obvious association with the habitat, point-count method, less than 100 m from the monitoring point) and 51 species (distance from the monitoring point not limited), respectively, in the breeding seasons of 2007–2008.

Chytil (1984) recorded in Filena floodplain forest 37 breeding species (in the years 1978–1979, territory-mapping method). In Zástudánčí floodplain forest Toman (1984) reported 34 breeding species (in 1982–1983, territory-mapping method at 5 ha). Bureš and Maton (1985) recorded from the Litovelské luhy Nature Reserve 39 breeding species (in 1982–1984, territory-mapping method at 3.4–7.5 ha). Machar (2010) found 38 breeding species at the Velký ostrov locality (in 1999–2000, territory-mapping method at 12.5 ha) and Machar (2011) 33 breeding species at the Šargoun locality (in 2006–2007, territory-mapping method at 12.1 ha). Svoboda (1993) mentioned from Království floodplain forest 67 breeding species (belt transect 6 km long in combination with nest searching). Koleček et al. (2010) recorded from this locality 62 species (but including species with no obvious association with the habitat, point-count method).

The study by Schlaghamerský and Hudec (2008) contains an overview of the fauna of temperate floodplain forests including avifauna. Studies dealing with the effects of bird detectability on the knowledge of bird communities of Central European floodplain forests are relatively scarce. The effects of forest habitat type on detectability of bird species of lowland (floodplain) forests with oak, manifested vicariously in different developmental stages of the forest, were studied in Poland by Tomialojć (1974) and Glowacinski and Weiner (1983), in Germany e.g. by Stein (1968) and in Hungary by Waliczky (1991). A relation between the structure and tree species composition of coppice woodlots and forest bird species in the Sarmassa River valley in the northwest of Italy was demonstrated in the study of Laiolo (2002).

The comparison of bird species detectability in habitats of mature floodplain forests from different sites shows that the species structure depends not only on the character and heterogeneity of forest habitats but also on the delimitation of the study plot within the studied forest segment. Nesting territories of birds typical of open alluvial landscape (e.g. *Locustella fluviatilis, Acrocephalus palustris, Sylvia borin, Emberiza citrinella*) do not usually extend more than 25–30 m into the interior of a mature continuous floodplain forest stand. Therefore the edge effect can increase the bird biodiversity in a floodplain forest (Hubálek 1997).

Many studies deal with the relationship between the fragmentation of forest environment and detectability of bird communities because this is an issue with many practical consequences for the forest management and nature conservation (e.g. Fuller 1990; Mortberg 2001). The fragmentation of forest habitat by clear felling launched changes in diversity and density of a relatively stable nesting bird community and further development can be expected depending on the applied forms of forest management. Changes in the species and quantitative composition of a bird community that depend on the forest stand development conditioned by forest management can be regarded as a model of man-controlled succession of the community (Lešo 2003). From this point of view, two models were created on a landscape scale based on the investigations of edges: "core area" model (Laurance, Yensen 1991) where the core area is not affected by edge effect, and "effective area" model (Sisk et al. 1997) in situations where the core area does not exist.

Detectability of birds during research is influenced inter alia by a census technique (Storch, Kotecký 1999). The territory-mapping method, due to its time-demanding character, is usually applied on smaller

plots of floodplain forests, while the point counts were performed in larger areas of floodplain forests with an increasing probability of detection of a larger number of species (Storch 1998; Hubálek 1999).

## CONCLUSION

The article deals with results of regression analysis of some factors influencing detectability of bird species in a floodplain forest ecosystem in the framework of transect long-term census (1998–2012). Altogether 63 breeding species were recorded at the Vrapač transect and 67 at the Litovelské Luhy transect, while the date of census and climatic conditions (precipitation, wind force, cloud amount and air temperature) were found to be statistically significant factors, both for the regression model of the number of species and for the regression model of the total number of registrations.

The effect of habitat type was also statistically significant. According to the regression model, the chance to register a species in the interior of the forest ecosystem was 0.918 times lower than in the ecotone. At the same time, an increase in the number of registrations was 0.934 times lower in the forest interior compared to the ecotone. Standardisation of the mean abundance of bird species in relation to observation time showed specific detectability of the given species in time.

Results of the present study confirmed detectability as an important factor influencing results of the bird census in a floodplain forest ecosystem. This fact can be taken into account in assessing the biodiversity of bird communities in forest ecosystems.

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