Slovak Rapt J 2009, 3: 1–12

Estimating density, population size and dynamics of Common Buzzard (*Buteo buteo*) in the West Carpathian region by a new method

Odhad denzity, veľkosti populácie a dynamiky myšiaka hôrneho (*Buteo buteo*) vo vybranom regióne Západných Karpát novou metódou

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Abstract: In the Horné Ponitrie Region (central Slovakia) during 1991–2001 we conducted a regular survey of Common Buzzard nests. In 2002–2006 our sampling effort increased and within the selected areas we studied buzzard dispersion/distribution, density and population dynamics using a new method of large-scale thorough search for nests with multiple nest check. The method is designed to estimate the dispersion/distribution, density and population size of target species (particularly raptors) at an absolute scale of abundance in large tracts of heterogeneous landscapes for studies of population fluctuations, trophic dynamics, reproductive success, habitat selection and use. It consists of systematic search for nests with extent of several tens of km^2 and grain of *c*. 3000 m^2, identifying and positioning the nests, and subsequent 1–3 nest checks during the each of three or more consecutive breeding periods. Further essential features include correct record of nest positions and other variables, combination of nest checks with ringing and marking, proportional sampling in apparently suitable and less suitable areas and proper timing and spacing of nest visits. In 2007 the sampling focused on DSF (Databank of Slovak Fauna) grid square 7377 covering *c*. 135 km^2. We searched 71 km^2 in total and estimated the density at 129 pairs/100 km^2. Within the district of Prievidza (959 km^2) we found 150 active buzzard nests. In 2008 we sampled the grid square 7377 more extensively, including higher altitudes (800–1200 m a. s. l.). Sampling of 82 km^2 in total yielded the density estimate of 93 pairs/100 km^2. Within the district of Prievidza we found 110 active buzzard nests. The reproductive success over four year period averaged 1.2 fledgling per active nest (n = 310 nests). Our sample enabled us to estimate the minimum population size in the whole grid square 7377 at 130 breeding pairs, i.e. 96 pairs/100 km^2. Minimum population size for the whole district of Prievidza can be estimated approximately at 500 breeding pairs (52 pairs/100 km^2), *c*. 350 of which breed in mountain forests, *c*. 80 in agricultural woodlots, and *c*. 70 in riparian vegetation. Rough estimate of minimum breeding population in the whole Slovakia is *c*. 15 000 pairs, i.e. on average 31 pairs/100 km^2.

Abstrakt: V oblasti horného Ponitria sme v rokoch 1991–2001 vykonávali rámcový monitoring hniezd myšiaka hôrneho *Buteo buteo*. V rokoch 2002–2006 sa výskum zintenzívnil a na vybraných plochách sme zisťovali disperziu, denzitu a populačnú dynamiku novou metódou veľkoplošného podrobného vyhľadávania a kontroly hniezd. Metóda je určená na odhad disperzie/distribúcie, hustoty a veľkosti populácií cieľových druhov (najmä dravcov) vo veľkých výsekoch heterogénnej krajiny na absolútnej úrovni presnosti s cieľom poznať ich populačnú a potravnú dynamiku, úspešnosť rozmnožovania, výber a využívanie stanovíšť. Zahŕňa systematické vyhľadávanie hniezd v krajinných priestoroch s rozsahom niekoľkých desiatok km^2 a „zrnom" (rozlišovacou úrovňou) ca 3000 m^2, určenie druhu a polohy hniezd a ich následné 1–3 kontroly v 3 a viacerých po sebe idúcich hniezdnych obdobiach. Ďalšie dôležité črty sú správne určovanie polohy hniezd a iných premenných, kombinovanie kontroly hniezd s krúžkovaním a iným označovaním jedincov, proporciálne vzorkovanie vhodných i menej vhodných stanovíšť, správne načasovanie návštev a ich umiestnenie do priestoru hniezdisk. V roku 2007 sa výskum sústredil na kvadrát DFS 7377 s rozlohou ca 135 km^2. V tom roku sme prehľadali z tejto plochy 71 km^2 a zistili hustotu 129 párov na 100 km^2. Celkovo sme v okrese Prievidza (959 km^2) dohľadali 150 obsadených hniezd myšiaka. V roku 2008 sme prehľadávali plochu kvadrátu intenzívnejšie, vrátane vyšších polôh (800–1200 m n. m.). Celkovo sme prehľadali plochu 82 km^2, kde hustota činila 93 párov na 100 km^2. V okrese Prievidza sa zistilo 110 obsadených hniezd. Za štyri roky vyletelo z 310 hniezd priemerne iba 1,2 mláďaťa na 1 obsadené hniezdo. Zo získanej vzorky sme pre celý kvadrát DFS 7377 odhadli minimálne 130 párov myšiaka, t. j. 96 párov na 100 km^2. V celom okrese Prievidza odhadujeme veľkosť populácie na najmenej 500 hniezdiacich párov, t. j. 52 párov na 100 km^2, z toho v lese ca 350, v poľných lesíkoch 80 a v brehových porastoch 70 párov. Hrubý odhad pre Slovensko je minimálne 15 000 párov, čo v priemere vychádza 31 párov na 100 km^2.

Key words: *Buteo buteo*, direct search for nests with multiple nest check, dispersion, number of breeding pairs, Horné Ponitrie Region, Slovakia

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Introduction

From the region of Horné Ponitrie (central Slovakia) first information on the breeding densities of Common Buzzard was published by Harvančík (1977) who recorded the density of 20 pairs/100 km^2. Later attempts to estimate the buzzard densities were made in 1999 as a result of atlas and census work in the DSF (Databank of Slovak Fauna) grid square 7377, situated in southeastern part of the Prievidza District (Fig. 1). For its area of size *c*. 135 km^2 (*c*. 12.2 × 11.1 km) the estimates varied from 10 to 18 breeding pairs. More recent data from the Horné Ponitrie Region can be found in papers by Šotnár (2003, 2007, 2008, 2009).

Danko et al. (1994) summarized the knowledge on breeding numbers of raptors and owls in the whole Slovakia. Using Common Buzzard as an example, they pointed out the serious biases (underestimation) due to striking differences between observers, sampling methods and sampling plot sizes. Particularly the first author (Š. Danko) documented higher densities when employing the method of direct search for nests. Similar method was used in neighbouring countries, e.g. by Król (1985), Jagoš (1998), Voříšek (2000), Pikunas (2001) and others.

The aim of this paper is twofold. First, to introduce the new modification of large-scale and thorough direct search for nests with multiple nest check using Common Buzzard as model species. Second, to estimate the buzzard density, dispersion, population size and dynamics within the region of Horné Ponitrie.

Material and methods

The territory of the Horné Ponitrie Region is situated in the southwestern part of central Slovakia near the border of administrative regions Žilina and Nitra with the district of Prievidza (959 km^2) at the core. Altitude ranges from 180 m a. s. l. (the confluence of Nitrica and Nitra Rivers) to 1 351 m a. s. l. (Mt. Kľak). Forests cover 54 %, agricultural land 38 % and urban environments 8 % of the total district area. Forests are dominated by deciduous trees, mostly beech (*Fagus sylvatica*) and also oaks (*Quercus sp. div.*) in lower altitudes. Considerable part of native forests has been replaced by allochthonous stands of conifers such as Norway Spruce (*Picea abies*), Scotch Pine (*Pinus sylvestris*) and, to a lesser extent, Larch (*Larix decidua*). Silver Fir (*Abies alba*) still occurs in remnants of native fir-beech forests (Brtek 1990).

During 1991–2001 we conducted a regular survey of Common Buzzard nests in that area so as to examine the reproductive success, collect prey remnants and ring the young. In 2002–2006 we increased our sampling effort and aimed it at study of buzzard dispersion/distribution, density, and population dynamics within the selected areas. In 2007 the sampling focused on the DSF (Databank of Slovak Fauna) mapping grid square No. 7377 (Fig. 2) whose size is 10 minutes of longitude × 6 minutes of latitude, i.e. approximately 12.2 × 11.1 km (*c*. 135 km^2). Three observers thoroughly searched 71 km^2 of the grid square area, whereas in 2008 the same area was sampled by two observers who then continued to search for nests in higher altitudes of the grid square (800–1200 m a. s. l.) and reached the sample total of 82 km^2. During last two years (2007–2008) we studied buzzard dispersion/distribution, density, population size and dynamics using a new, large-scale and thorough modification of direct search for nests with multiple nest check. Here we provide the first description of the method.

Method of large-scale thorough search for nests with multiple nest check

Scope and objectives

The method is designed to estimate the dispersion/distribution, density and population size (i.e. number of breeding pairs) of target species, particularly raptors, at an absolute scale of abundance (Verner 1985) in large areas (plot sizes extending to many tens of km^2) and heterogeneous landscapes for the purpose of studying the population fluctuations, trophic dynamics (energy flow in ecosystems), reproductive success, habitat selection and use.

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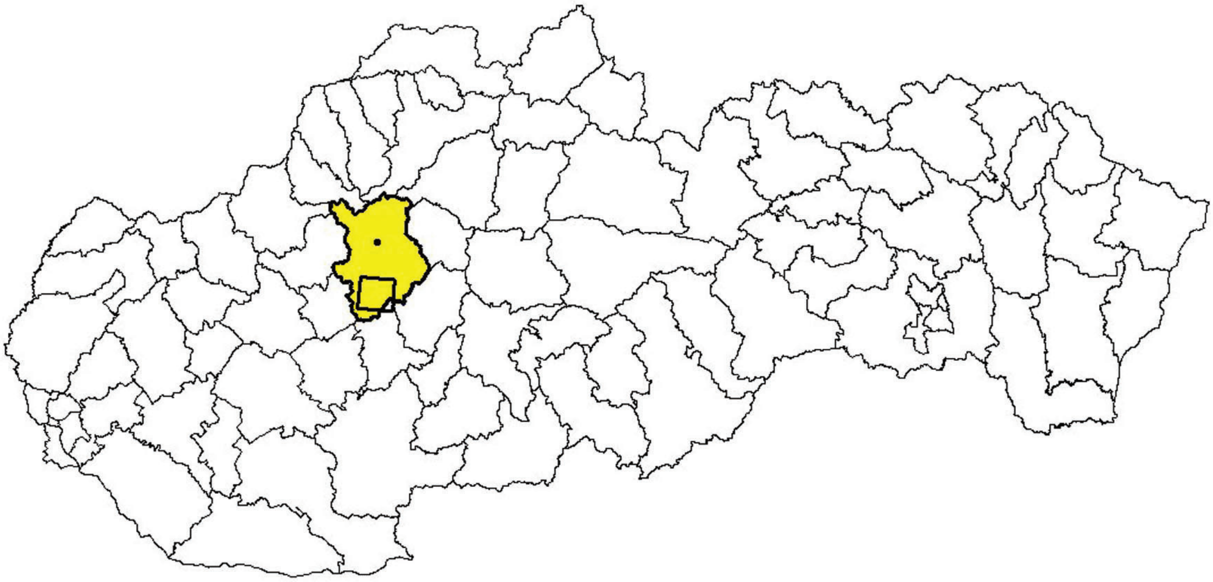

Fig. 1. Situation of the study area in Slovakia. Yellow – Prievidza district, black point – Prievidza town, square – DFS 7377.
Obr. 1. Poloha skúmaného územia v rámci Slovenska. Žltá – okres Prievidza, čierny bod – mesto Prievidza, kvadrát – DFS 7377.

Assumptions of validity

1. All target species and their nests are correctly identified.
2. Position of each nest of the target species is correctly determined and recorded (always and everywhere, but most carefully near the boundaries of study plot).
3. Populations of target species during one sampling period (i.e. breeding period) remain stable and each nest is used by only one breeding pair (i.e. by mated female and male).
4. If a nest is used by a different number of individuals (e.g. cases of polygyny, polyandry, helpers etc.), an accurate estimate is made of the mean number of individuals using that nest.

Brief summary and perspective

The method involves systematic search for nests of target species over the entire study plot, recording the exact position of each nest and subsequent multiple check of each nest attendance and productivity in each of three or more successive breeding periods.

Ideally, the method would eventually track the whole „life cycle“ of as many nests of target species as possible, i.e. record the entire history of each nest's use from its construction to its destruction. After obtaining a sufficiently large sample of such complete nest histories (say, for 40–50 nests) one would analyze it – together with additional incomplete nest histories – by means of appropriate statistical methods (e.g. survival analysis) and thus substantially advance our current knowledge of target species. This could be true particularly when also the fates of individual birds would be analyzed simultaneously (if known e.g. from ringing or marking).

Essential features

1. Thorough and systematic search for nests in as large study plot as possible during the non-breeding period (November to February) while meeting the following criteria for sampling extent and grain:
   a. study plot is a continuous, geographically and ecologically well-defined unit that embraces at least 50 active nests of target species and/or an area of at least 50 km^2
   b. within that study plot, no patch larger than 2000–3000 m^2 (variation due to habitat complexity, e.g. in coniferous forests smaller, in deciduous larger) will be left unvisited.
2. Proportional sampling effort in apparently suitable and less suitable habitats.

Tab. 1. Time spent thorough searching for nests and nest checking on the study plot of 82 km^2 in the DSF grid square 7377 in 2007–2008 (one observer)
Tab. 1. Čas strávený podrobným vyhľadávaním a kontrolami hniezd na skúmanej ploche 82 km^2 v kvadráte DFS 7377 v rokoch 2007–2008 (jeden pozorovateľ)

month mesiac	XII	I	II	III	IV	V*	VI*	∑
days dni	2	6	8	10	20	18	11	75
hours hodiny	8	20	32	34	66	57	40	257

* of which 66 hours were spent ringing (two ringers)
* z toho krúžkovaním strávených 66 hodín (dvaja krúžkovatelia)

Tab. 2. Altitudinal breeding distribution of Common Buzzard on the study plot of 82 km^2 in the DSF grid square 7377 in 2008 [mhc – main hypsographic categories, after Danko et al. (2002), modified; ar – altitudinal range; bp – number of breeding pairs]
Tab. 2. Výšková hniezdna distribúcia myšiaka hôrneho na skúmanej ploche 82 km^2 v kvadráte DFS 7377 v roku 2008 [mhc – hlavné výškové kategórie, podľa Danka et al. (2002), upravené; ar – rozpätie nadmorských výšok; bp – počet hniezdnych párov]

mhc	ar [m a. s. l.]	bp
colline belt (hills)[1]	301 – 500	27
submontane belt[2]	501 – 700	23
lower montane belt (lower mountains)[3]	701 – 1000	24
upper montane belt (higher mountains)[4]	1001 – 1200	2

[1] kolínny stupeň (pahorkatina), [2] submontánny stupeň, [3] nižší montánny stupeň (vrchovina), [4] vyšší montánny stupeň (hornatina)

3. Correct and exact record of each nest's position (plotting on map, positioning by GPS) and other nest variables (tree species, height of nest, slope inclination, orientation etc.).
4. Multiple (1–3) checks of nest attendance and reproductive success in each breeding period (March to July).
5. Continuity in checking nests within the same study plot over several (3 or more) years.
6. Combination of multiple nest checks over several years with ringing and individual marking of young birds (or adults as well).

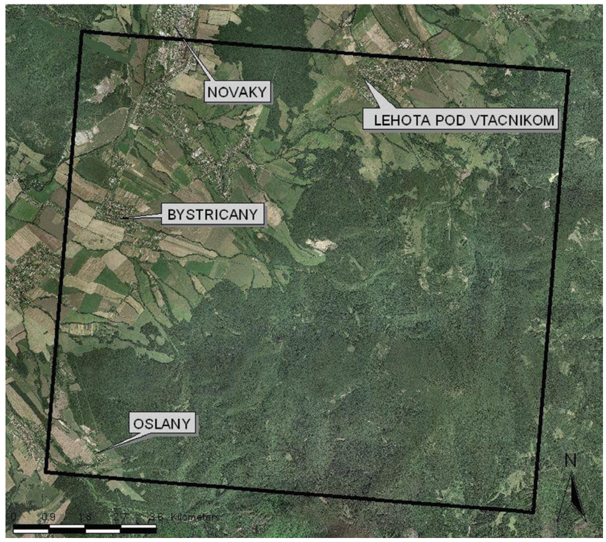

Fig. 2. Sampled DSF (Databank of Slovak Fauna) mapping grid square No. 7377 (total area *c.* 135 km^2, of which forests cover 86 km^2, agricultural land 43 km^2 and settlements 6 km^2).
Obr. 2. Skúmaný kvadrát DFS 7377 (celková rozloha ca 135 km^2, z toho lesy zaberajú 86 km^2, polia 43 km^2 a sídla 6 km^2).

7. Proper timing of nest visits (advisable peak in March–April) that ensures minimum bias in estimates of numbers of non-breeding pairs, unmated individuals and so on.
8. In cases of last-year or older nests that are not active in the current year a concentration of searching effort to their close surroundings (radius *c.* 100 m around an old nest) where pairs are most likely to build a new nest.
9. In cases of two new nests less than 100 m apart a conclusive check as to whether or not the nests are used by the same breeding pair.

Strengths

- when carefully executed, it deliver the most accurate estimates of density and dispersion/distribution of target species with minimum bias and maximum consistency in comparison with other methods
- it allows the adequate sampling and analysis of numbers of breeding failures and other parameters of reproductive success/productivity
- it allows also the adequate sampling and analysis of numbers of unmated individuals and other non-breeders
- these properties make the method eligible for the most difficult research tasks in population biology such as population fluctuations and trophic dynamics.

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Fig. 3. Study area in the DSF grid square 7377 in 2007 (**A** – well-sampled area of 59 km^2, **B** – acceptably sampled area of 12 km^2, **C** – poorly sampled area of 64 km^2).
Obr. 3. Skúmané územie v kvadráte DFS 7377 v roku 2007 (**A** – dobre preskúmaná plocha 59 km^2, **B** – prijateľne preskúmaná plocha 12 km^2, **C** – slabo preskúmaná plocha 64 km^2).

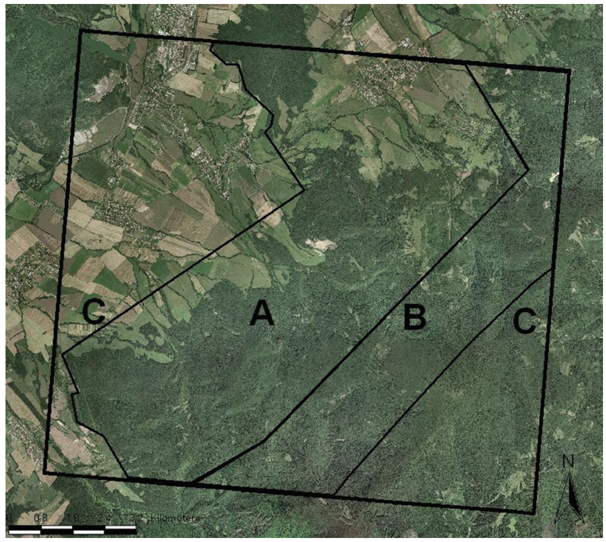

Fig. 4. Study area in the DSF grid square 7377 in 2008 (**A** – well-sampled area of 59 km^2, **B** – acceptably sampled area of 23 km^2, **C** – poorly sampled area of 53 km^2).
Obr. 4. Skúmané územie v kvadráte DFS 7377 v roku 2008 (**A** – dobre preskúmaná plocha 59 km^2, **B** – prijateľne preskúmaná plocha 23 km^2, **C** – slabo preskúmaná plocha 53 km^2).

Weaknesses

- method is very time-consuming, labor-intensive and demanding in terms of other resources (finance, observer knowledge, experience, motivation)
- though accurate, yet it is unable to cope with all the obstacles involved in exhaustive search for nests (e.g. for new nests of some secretive breeding pairs)
- in some cases difficulties arise as to whether a pair is breeding, non-breeding or experiencing a recent breeding failure
- in some cases repeated nest checks may disturb the breeding process.

Sources of bias

- effects of observer – differences in observer experience (both general ecological and species-, site- or habitat--specific), visual acuity, motivation, physical and searching abilities, stamina, number of observers etc.
- effects of environment – terrain pattern, species composition and structure of vegetation (foliage height diversity, patchiness)
- effects of species and individuals – differences in detectability, density, dispersal, behaviour (movements, responses to an observer, territoriality, intra- and interspecific competition, aggregation behaviour etc.), social or breeding system
- effects of weather – precipitation, wind, temperature, fog, snow cover and so on
- effects of study design – site selection (its location and boundaries), plot size, seasonal and diurnal timing, spacing of visits, duration and frequency of nest checks.

So as to handle efficiently the principal sources of bias in our study and to match the assumptions of validity we made use of following means:

- consistent direct checks of each nest that enabled us to identify the nest inhabitants reliably (e.g. to disclose the cases of alternating nest use by Common Buzzard and Goshawk), to estimate the reproductive success, productivity and other breeding parameters
- correct and exact positioning of each nest by means of GPS and orthophotomaps
- repeated nest checks during the breeding period, carried on only in favourable weather conditions and permitting to distinguish successful breeding attempts from those not successful as well as breeding individuals from non-breeders and to estimate their numbers
- small team of 3–6 comparably skilled and trained observers whose fieldwork was carefully coordinated.

If observers, for whatever reason, fail to complete the thorough search over the entire study plot, one can complement the results by estimates of probable and possible breeding pair numbers in remaining part of the study plot. As an aid in making these estimates more accurate, behavioural observations (cues of territoriality, competition, agonistic behaviour etc.) might be of some use.

All resulting estimates are the smallest numbers observed (i.e. minima in the range) and we obtained them with the help of following classification of the study area:

- **A** well-sampled, i.e. 90–95 % of the area was thoroughly searched for nests
- **B** acceptably sampled, i.e. *c*. 80 % of the area was thoroughly searched for nests
- **C** poorly sampled, where only 1–3 visits were made.

Division of the study area into these three categories in 2007 and 2008 is depicted in Fig. 3 and Fig. 4, respectively. On the plot A and B we complemented the estimates by the estimated number of probable breeding pairs (minimum 10 pairs) and on the plot C by the estimated number of possible breeding pairs (minimum 30 pairs). In 2008 we recorded also time spent searching for nests and nest checking (Table 1).

Results

Density and distribution of breeding pairs in 2007

In the DSF grid square 7377 we found 90 active buzzard nests, 70 of them in forests, 12 in agricultural woodlots and 8 in riparian vegetation (Fig. 5). The density on the study plot was 129 pairs/100 km^2.

Within the district of Prievidza we found 150 breeding pairs in total, 96 of which bred in forests, 32 in agricultural woodlots and 22 in riparian vegetation.

Population processes: natality and mortality

Successful initiation of breeding was observed in 87 pairs, of which 60 were repeatedly checked during the whole breeding process. Their 60 nests produced 9 × 1, 26 × 2, 16 × 3, 2 × 4 and 6 × minimum 1 fledgling, i.e. minimum of 123 fledglings in total.

Known causes of breeding failure in 63 pairs were as follows: logging operations (13 cases), fall of the nest tree or nest itself (3 cases), nest desertion after human intrusion (2 cases), egg destruction (eggshell remains below the nest, 2 cases), predation of young (most likely by Goshawk, 2 cases), and infertile clutch (hatched by female even on 6 June, 1 case). In another 6 instances the nest was deserted probably even before the first egg was laid and in 34 cases the cause of failure remains unknown.

Density, distribution and number of breeding pairs in 2008

In the DSF grid square 7377 we found 76 active buzzard nests, 57 of them in forests, 12 in agricultural woodlots and 7 in riparian vegetation (Fig. 6). The density on the study plot was 93 pairs/100 km^2.

In the whole district of Prievidza we found 110 breeding pairs in total, 69 of which bred in forests, 22 in agricultural woodlots and 19 in riparian vegetation. When comparing with last year, we found 13 new breeding pairs. In 17 instances pairs shifted their nest sites and bred as close as 50–150 m from the last-year nest. Furthermore, we documented 10 instances of „twin nests“, i.e. pairs of nests equally equipped for breeding (including fresh twigs inside) *c*. 50–100 m apart, of which always only one nest was used by one pair. Some pairs bred deep in forest interior, *c*. 3–5 km from the nearest field or meadow. Some pairs successfully bred even in altitudes of 1060 m and 1100 m (Table 2, Fig. 13).

The highest breeding density with strikingly clumped nest dispersion we registered in a pine-oak woodlot (area of 5.3 km^2) at the northern boundary of the grid square 7377. During 2002–2008 the woodlot was inhabited by 15–18 breeding pairs and densities thus reached up to 340 pairs/100 km^2 of the forested area (Fig. 7).

We estimated the buzzard population size in the DSF grid square 7 377 in 2008 at minimum of 130 breeding pairs, i.e. 96 pairs/100 km^2. In the whole district of Prievidza we estimate the buzzard population size at minimum of 500 pairs, i.e. on average 52 pairs/100 km^2, *c*. 350 of them in forests (Fig. 11, Fig. 14, Fig. 15), 80 in agricultural woodlots (Fig. 10) and 70 in riparian vegetation (Fig. 12). Accordingly, our rough estimate for the whole territory of Slovakia is *c*. 15 000 buzzard breeding pairs, i.e. mean breeding density of 31 pairs/100 km^2.

Population processes: natality and mortality

From 27 checked nests 6 × 1, 14 × 2, 2 × 3 and 5 × minimum 1 young were successfully fledged in 2008, giving the minimum of 45 fledglings in total. Breeding failed in 83 instances, of which 6 were due to logging operations, 2 due to treefall (windthrow) and 75 due to unknown factors. Most likely explanation would combine the unavailability of dominant prey (*Microtus arvalis*) with adverse weather during the breeding period (excess of cold, rainy and windy days with rapid temperature fluctuations) and elicited buzzard population response. Most females ceased breeding as soon as during egg hatching. In addition, we documented 4 cases of siblicide in young 5–20 days old.

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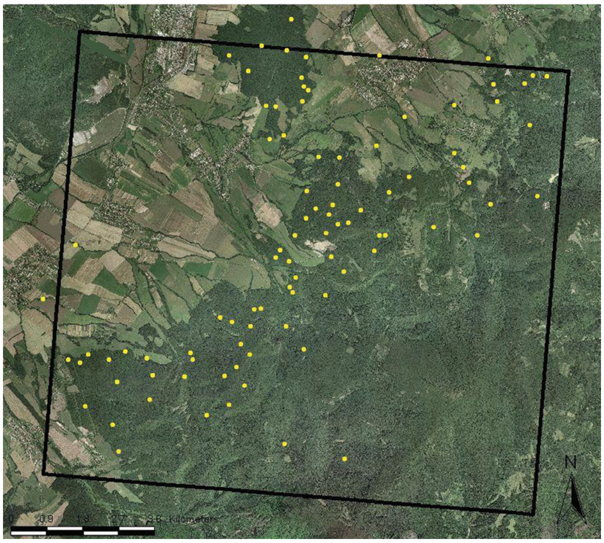

Fig. 5. Search for nests in 2007 (90 active nests found).
Obr. 5. Vyhľadávanie hniezd v roku 2007 (dohľadaných 90 obsadených hniezd).

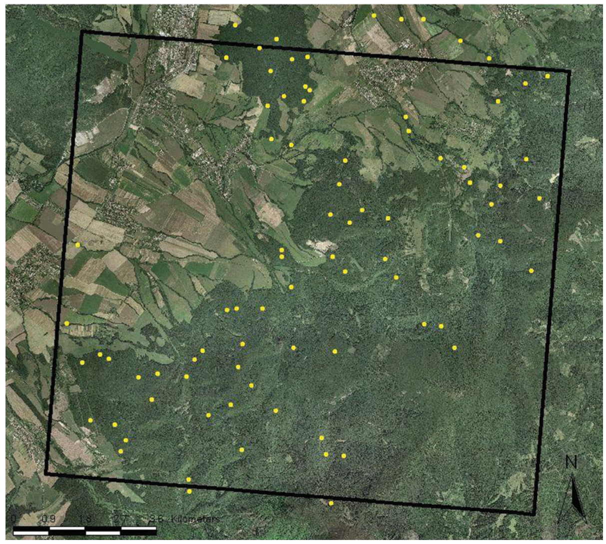

Fig. 6. Search for nests in 2008 (76 active nests found).
Obr. 6. Vyhľadávanie hniezd v roku 2008 (dohľadaných 76 obsadených hniezd).

Population dynamics

Our account of the buzzard population dynamics is based on four year results. In 2005 the total of 27 checked nests produced 80 young, i.e. on average 2.16 young per 1 active nest. In 2006 the productivity of 43 checked nests was 35 young in total, i.e. 0.81 young per 1 active nest. Siblicide was observed in 9 instances with 11 young died. The overall breeding loss amounted to 51.2 %. In 2007 the productivity was 1.03 young per 1 active nest and overall breeding loss 52.5 % (Šotnár 2007). The lowest nest productivity occurred in 2008 when barely 0.41 young per 1 active nest was successfully fledged and breeding failed in 75 % of checked pairs. Over the whole four-year period (2005–2008) in the Horné Ponitrie Region of 310 checked nests 1.2 young per 1 active nest was successfully fledged.

Breeding behaviour and other factors affecting nest search results

Of 76 checked active nests in 2008 we located 26 breeding pairs with only one nest. In 25 pairs we found one additional earlier nest (not active) up to 100 m from the active nest, in 2 pairs we found two such nests and in another 2 pairs even three additional nests of various age. Elsewhere some pairs used two nests in an irregularly alternating manner.

Common Buzzard was found breeding in nests of *Aquila pomarina*, *Accipiter gentilis*, *Pernis apivorus*, *Ciconia nigra* and, conversely, some nests of Common Buz-

Fig. 7. Area with highest breeding densities of Common Buzzard (pine-oak woodlot, Nováky, 5.3 km², 18 breeding pairs).
Obr. 7. Územie s najvyššou hniezdnou hustotou myšiaka hôrneho (borovicovo-dubový háj, Nováky, 5.3 km², 18 zistených párov v roku 2008).

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Fig. 8. Nestling of Common Buzzard, still alive, but with head and eye injuries as a direct outcome of sibling aggression (attacks of two older siblings were observed; 8 June 2005, Malá Čausa).
Obr. 8. Ešte živé mláďa myšiaka hôrneho so zraneniami hlavy a oka v dôsledku súrodeneckej agresivity (na hniezde naň stále útočili dvaja starší súrodenci; 8. jún 2005, Malá Čausa).

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Fig. 9. A nest of Common Buzzard in Larch (*Larix decidua*) used by buzzard continuously for at least 20 years (8 June 2005, Malá Čausa).
Obr. 9. Hniezdo myšiaka hôrneho na smrekovci (*Larix decidua*), obsadzované myšiakom minimálne 20 rokov po sebe (8. jún 2005, Malá Čausa).

zard were used, besides all four mentioned species, also by *Falco tinnunculus*, *Strix aluco* and *Corvus corax*.

Interesting were particularly the instances of buzzard nests occupied by Long-eared Owl (*Asio otus*). A nest used last year by buzzard was attended by Long-eared Owl at the onset of breeding period, but in June we found there one nearly full-grown young buzzard. Another case involved a buzzard pair finishing the nest construction in early March, but in May we found breeding Long-eared Owl in that nest.

Though Common Buzzard exploits a wide variety of breeding habitats and often switches its breeding sites, in the Horné Ponitrie Region we recorded two exceptional cases of nest site tenacity. One nest site was used continuously for 16 years and another even for 20 years (Fig. 9).

Ecological factors affecting population processes

Our long-term data from the Horné Ponitrie Region point to a link between Common Buzzard reproductive success and numbers/availability of its dominant prey – Common Vole. Unfavourable weather conditions (cold, rainy and windy days, rapid temperature fluctuations) can add substantially to the effect of prey shortage on buzzard reproductive rates and, together with endogeneous factors, are suggestive of strong negative feedback control over population processes. Observed cues are as follows:

- some pairs didn't initiate breeding
- pairs that have initiated breeding either failed to lay eggs or deserted the clutch
- pairs that laid a clutch of small size (1–2 eggs) hatched only one or no young
- in majority of pairs with larger clutch sizes the sibling aggression or even siblicide took place soon after hatching.

We made direct observations of two sibling aggression events. In both cases older nestling approached the younger siblings and made pecking attacks at their heads (Fig. 8). During our following visits attacked young were not found in the nest. In other instances dead nestlings have been found in the nest or outside the nest, largely with head injuries apparently caused by pecking of their siblings.

Discussion

Comparation of density and population size estimates

In the earlier past Common Buzzard in both Slovakia and Czech Republic has been breeding almost exclusively in forests. Since the early 1980s more and more breeding attempts were made in open agricultural landscape

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Fig. 10. A nest of Common Buzzard in Cherry (*Cerasus vulgaris*) 2 m above ground in an open agricultural landscape (13 April 2005, Prievidza).
Obr. 10. Hniezdo myšiaka hôrneho na čerešni (*Cerasus vulgaris*) 2 m vysoko v otvorenej poľnohospodárskej krajine (13. apríl 2005, Prievidza).

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Fig. 11. An unusually placed nest of Common Buzzard on a lateral branch of Scotch Pine (*Pinus sylvestris*) *c.* 4 m from the tree trunk (June 2006, Nováky).
Obr. 11. Neobvykle umiestnené hniezdo myšiaka hôrneho na bočnom konári borovice lesnej (*Pinus sylvestris*) ca 4 m od hlavného kmeňa (jún 2006, Nováky).

(Danko et al. 1994). Authors interpret this phenomenon as a partial shift in buzzard habitat distribution from forests to agroecosystems, but it may have to do also with growth/saturation of certain local populations, emigration of some individuals and colonization of new environments. (However, testing of this hypothesis would deserve the reliable data on long-term population trends in large regions.) Accurate density estimation in sufficiently large Common Buzzard populations poses serious problems whose solution depends primarily on adequate sampling method. Direct search for nests is being considered as one of the most accurate yet also most laborious methods (Janda & Řepa 1986). It has been used by several authors to examine the buzzard population densities in Slovakia.

Highest breeding densities in lower altitudes are known from Danubian floodplain forests near Gabčíkovo (southwestern Slovakia) and approached 83 pairs/100 km^2 (Kropil 1993). In higher altitudes near the Mt. Veľký Milič (Slanské Vrchy Mts, eastern Slovakia) the density reached 45.2 pairs/100 km^2 and in southern part of the Slanské Vrchy Mts 71.4 pairs/100 km^2 of the forested area (Danko et al. 1994).

In the Orava Region (northern Slovakia) during 1996–2001 on a study plot with an area of 65.3 km^2 (69.8 % forest cover) and altitudinal range 700–1687 m a. s. l. Karaska et al. (unpubl.) estimated the buzzard density at 50.6 pairs/100 km^2. They assume even higher densities in patchy landscapes of the Oravská Vrchovina Mts, Podbeskydská Vrchovina Mts and Oravská Kotlina Basin.

In the Žiarska Kotlina Basin and adjacent part of Vtáčnik Mts (central Slovakia) in a study area of 61.9 km^2 (28.2 % forest cover) density estimates varied between 27.5–43.6 pairs/100 km^2 and in the Zvolenská Kotlina Basin (study area of 37.5 km^2) between 37.3–50.7 pairs/100 km^2 (Kicko 2002, 2004).

Our remarkably high density estimates from the study area in the Horné Ponitrie Region may be explained by several factors. Southwestern slopes of the Vtáčnik Mts in contact with the Hornonitrianska Kotlina Basin provide high-quality breeding sites and hunting grounds, presumably owing to high landscape heterogeneity, great amount of edge habitats, moderate intensity of human disturbances and favourable topological relationships between potential breeding and hunting grounds (simply put, there is a lot of good breeding sites close to profitable hunting grounds). Such an environments might be viewed as nearly optimal and within the West Carpathian buzzard metapopulation they may constitute an important source (Pulliam 1988) with elevated emigration rates that promote the colonization of adjoining agroecosystems and other sink habitats. Our method of large-scale thorough search for nest may be also of some importance since

Fig. 12. A nest site of Common Buzzard in riparian vegetation amid the fields in Grey Poplar (*Populus ×canescens*) with trunk circumference at breast height 3.6 m (Jan. 2009, Prievidza).
Obr. 12. Hniezdisko myšiaka v brehovom poraste uprostred polí na topoli sivom (*Populus ×canescens*) s obvodom kmeňa v prsnej výške 3.6 m (január 2009, Prievidza).

Fig. 13. Highest-elevation nests of Common Buzzard in the DSF grid square 7377 were found just below the highest Mt. Vtáčnik (1346 m a. s. l.) (20 April 2008, Lehota pod Vtáčnikom).
Obr. 13. Najvyššie zistené hniezda myšiaka hôrneho v kvadráte DFS 7377 sa nachádzali pod najvyšším vrchom Vtáčnik (1346 m n. m.) (20. apríl 2008, Lehota pod Vtáčnikom).

Fig. 14. Breeding habitat of Common Buzzard in the DSF grid square 7377 in high-altitude forests dominated by Beech (*Fagus sylvatica*) in the Vtáčnik Mts (15 March 2007, Čereňany).
Obr. 14. Hniezdne stanovište myšiaka hôrneho v kvadráte DFS 7377 v lesoch vyšších polôh pohoria Vtáčnik s prevahou buka lesného (*Fagus sylvatica*) (15. marec 2007, Čereňany).

Fig. 15. Breeding habitat of Common Buzzard in the DSF grid square 7377 in low-altitude forests dominated by oaks (*Quercus sp. div.*) in the Vtáčnik Mts (14 March 2007, Bystričany).
Obr. 15. Hniezdne stanovište myšiaka hôrneho v kvadráte DFS 7377 v lesoch nižších polôh pohoria Vtáčnik s prevahou dubov (*Quercus sp. div.*) (14. marec 2007, Bystričany).

it delivers density estimates with minimum bias (here, minimum underestimation).

Using the direct search for nests there were estimated notably high buzzard breeding densities also in the Pálava Protected Landscape Area & Biosphere Reserve (Czech Republic) amounting to 330 pairs/100 km^2 of the forested area in 1989–1991 (Jagoš 1993). Voříšek (2000) estimated the densities in the same area in 1993–1995 at 140–230 pairs/100 km^2. The area comprises a fragmented colline woodland surrounded by open landscape, not unlike our case of large agricultural woodlot in the Horné Ponitrie Region.

Large-scale sampling of buzzard densities, conducted in the Magura National Park (Poland) by Pikunas (2001) in the study area of 132 km^2 (67.7 % forest cover), yielded the estimates of 56 pairs/100 km^2 (whole area) and 82 pairs/100 km^2 (forested area). Even larger territory near the Iława Lake was studied by Król (1985) who sampled the area of 160 km^2 (13.4 % forest cover) and 290 km^2 (15.7 % forest cover) with densities estimated at 27.5 pairs/100 km^2 and 35.3 pairs/100 km^2, respectively. This is to say that thorough sampling of such a large area is extremely difficult, but it returned one of the highest density estimates in Poland of the time.

Glutz et al. (1971) for central Europe concluded that in large areas where various landscape elements mingle together the density of Common Buzzard would not exceed 2.3–3 pairs/10 km^2. In the light of our recent results and above cited studies we propose a correction and state that these values may be higher and in some areas can reach even 3–5 pairs/10 km^2.

Conclusions

It is obvious that on extraordinarily large study plots (many tens of km^2) one cannot complete an exhaustive census of all Common Buzzard breeding pairs given the limited time of breeding period. Complications arise particularly when searching for new (first-year) nests in remote areas and when distinguishing between non-breeding individuals, breeding pairs and pairs experiencing a recent breeding failure. These and many other kinds of bias with various magnitudes and directions affect our estimates of density, dispersion and population size. Thus apart from well-defined study area, competent observers, adequate timing, spacing plus duration of nest visits and ordered holistic approach (Lorenz 1978) one needs also perseverance and a stroke of luck to approximate the real number of breeding pairs in an area as closely as possible. The results will be misleading unless based on a sample that is sufficiently large (we propose the minimum area of 50 km^2 or minimum 50 active nests sampled during three or more consecutive breeding periods) and representative in terms of ecology, biogeography and other. To obtain such a sample is highly complex task, therefore our generalizations should be treated with some caution (*cf*. Begon et al. 1996) as first approximations. We conclude that estimates of breeding density and population size of Common Buzzard delivered by our method of large-scale thorough search for nests with multiple nest check may reliably account for 70–80 % of the real values in large tracts of (sub)montane West Carpathian landscape.

Employing the described method in the model area of DSF grid square 7377 (district of Prievidza) we estimated the population density of Common Buzzard in 2007 and 2008 at 129 and 93 pairs/100 km^2, respectively. Minimum population size in the whole grid square 7377 reached roughly 130 breeding pairs (96 pairs/100 km^2). Breeding pairs showed clumped dispersion with peak densities loosely concentrated along the regional ecotone between forests of Vtáčnik Mts and non-forest ecosystems of Hornonitrianska Kotlina Basin. Minimum population size for the whole district of Prievidza can be estimated approximately at 500 breeding pairs (52 pairs/100 km^2), *c*. 350 of which breed in mountain forests, *c*. 80 in agricultural woodlots, and *c*. 70 in riparian vegetation. Reproductive success over four year period averaged 1.2 fledgling per active nest.

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