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Diurnal raptor community wintering in an extensively used farmland

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The raptor community wintering in an extensively managed farmland was studied in Western Poland during seven winters (2006–2013). Data on raptor presence and numbers was obtained using the point count method. In the present paper we focus on the variance in abundance and habitat selection of diurnal predators: Common Buzzard (*Buteo buteo*), Rough-legged Buzzard (*Buteo lagopus*), Common Kestrel (*Falco tinnunculus*), Eurasian Sparrowhawk (*Accipiter nisus*), Northern Goshawk (*Accipiter gentilis*) and Great Grey Shrike (*Lanius excubitor*). The study species were governed by two major habitat gradients in farmland: from amount of mowed meadows towards increasing coverage of arable fields and from non-mowed meadows and shrubs towards increasing coverage of forests. Particular species showed specific responses to habitat variables: plots with large coverage of meadows and high heterogeneity were preferred by Rough-legged Buzzard and Common Kestrel. Great Grey Shrike and Northern Goshawk selected linear habitats, mostly shrub lines, and non-mowed meadows, while Eurasian Sparrowhawk was associated with forests and urban areas. Rough-legged Buzzard avoided arable fields, while Common Buzzard had broader preferences and was more associated with arable fields. We also found that Common Buzzard and Great Grey Shrike abundance was positively related with winter temperature, while Rough-legged Buzzard showed a negative relationship. Our study shows the importance of heterogeneity in farmland as well as meadows as optimal habitats for wintering raptors, and we underline the role of extensive agriculture in conservation of raptors.

† Passed away during manuscript preparation.

1. Introduction

The growing recognition of the value of farmland biodiversity has sparked major national and international conservation initiatives, but nevertheless, farmland biodiversity is still under threat in much of Europe. Some of the major drivers of biodiversity loss in farmland are linked to management intensification and land use change (Tryjanowski *et al*. 2011). Birds are among the species most rapidly responding to changes in farmlands and the majority of them are showing declining trends (Donald *et al*. 2001). However, even among birds, different species react in different ways to habitat changes. It has recently been debated which species are the most useful indicator to express environmental changes and impacts on biodiversity. Sergio *et al.* (2008) suggested that top predators may reflect changes in biodiversity for two reasons: (a) predators may directly cause high biodiversity, or (b) they may be spatio-temporally associated with biodiversity and thus act as indicators. However, the majority of tests of relationships between predators and habitat traits have been carried out for single species only. Nevertheless, in ecological communities, there are usually several predators occurring together. The complexity of ecosystems is generally much higher than the simple predator-prey interaction or one predator and its habitat preference (Newton 1979, Barbosa & Castellanos 2005).

Several authors underline the role of interspecific competition and habitat separation as the primary factors that determine the co-existence of predators within niche overlaps (review in: Sergio *et al.* 2007, 2008). Many studies demonstrate the habitat characteristics of raptor populations during the breeding season (Sánchez-Zapata & Calvo 1999, Palomino & Carrascal 2007, Krüger & Lindström 2008, Carrete *et al.* 2009), while habitat preferences during the winter period are definitely less surveyed (Tornberg & Colpaert 2001, Wuczyński 2005, Luo *et al.* 2010, Schindler *et al.* 2012). In most papers, the authors focus only on a single species or pairs of similar species; only a handful of studies consider whole raptor assemblages (Preston 1990, Kasprzykowski & Rzępała 2002). Habitat sharing and relationships between species are especially important in winter because resource availability is limited and energetic costs rise in low temperatures (Warkentin & West 1990, Tornberg & Colpaert 2001, Wuczyński 2005, Wikar *et al.* 2008, Kasprzykowski & Cieśluk 2011). Large species wintering in Central Europe have challenges due to subzero temperatures, decreasing daylight (shortening foraging time) and snow cover that hinders prey availability (Wuczyński 2005).

The surveyed raptors wintering in western Poland differ in their migration status. The Polish breeding populations of Northern Goshawk (*Accipiter gentilis*; hereafter Goshawk) and Common Buzzard (*Buteo buteo*) are mainly sedentary, whereas Eurasian Sparrowhawk (*Accipiter nisus*;

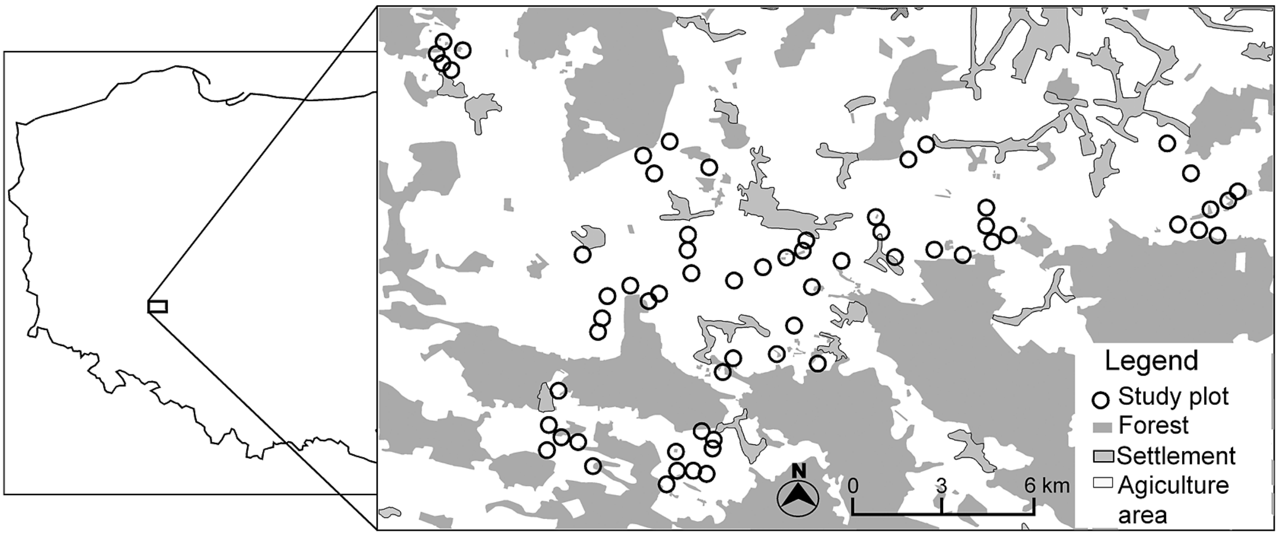

Fig. 1. The study area in Poland and the location of 64 counting sites.

Table 1. Seasonal characteristics of counts and weather during the studied winters. XII, I, II (December, January, February) – total number of plots conducted in the given winter season, N_{plots} – number of different plots which were surveyed in the given winter season, A_{plots} – average number of counts per one study plot, σ^2_{plots} – variation for count number mean, Snow cover – number of days with snow cover, Subzero temperatures – number of days with temperatures < 0°C; T [°C] – mean temperature of winter season.

Winter season	XII	I	II	N_{plots}	A_{plots}	σ^2_{plots}	Snow cover	Subzero temperatures	T [°C]
2006/07	63	33	14	63	1.8	0.89	14	22	3.00
2007/08	15	4	6	19	1.3	0.34	15	25	1.96
2008/09	21	30	26	42	1.8	0.53	46	48	–0.47
2009/10	16	17	27	31	1.9	0.80	73	65	–3.09
2010/11	32	30	13	48	1.6	0.42	69	57	–2.70
2011/12	13	50	59	62	2.0	0.46	34	38	–0.48
2012/13	44	55	42	62	2.3	0.73	73	58	–1.79
Total	204	219	187	64	–	–	–	–	–

hereafter Sparrowhawk) and Common Kestrel (*Falco tinnunculus*; hereafter Kestrel) are partially migrant.

Thus, the wintering population of the above species are a mix of sedentary or nomadic birds and those which come from North-Eastern Europe that are mostly short-distance migrants (Perrins 1998, Polakowski *et al*. 2014). Rough-legged Buzzard (*Buteo lagopus*) is a short-distance migrant, that only winters in western Poland. Additionally, we included Great Grey Shrike (*Lanius excubitor*) into the studied predator guild. This species is not taxonomically closely rated to raptors, but is very similar in ecology and behavior (Cade 1995, Hromada *et al.* 2002) because in Central Europe it feeds mainly on voles and small passerines during winter (Lorek *et al.* 2000, Antczak *et al.* 2005, Brzeziński *et al.* 2010). This species is mainly sedentary, however in Western Poland is a partial migrant (Kuczyński *et al.* 2009).

The first aim of this study focuses on the selection of habitat characteristics of these species. According to Niche theory (Rosenzweig 1981) we predict that species having similar ecological demands should avoid each other and select different habitats. Secondly, we stress conservational problem presenting how different anthropogenically-dominated agricultural landscapes attract raptors assumed to be good indicators of biodiversity. The last aim of this study is to test the effect of winter weather conditions on raptor abundances.

2. Material and methods

2.1. Study site

The study was conducted in the agricultural landscape of Western Poland, near Odolanów (51°34'N, 17°40'E). The study area (141 km^2) was an extensively used an agricultural landscape and comprised a mosaic of meadows and pastures (44%), arable fields (42%), midfield woodlots of different ages (6%), scattered trees and discontinuous linear habitats, mainly mixed rows of trees and bushes. Uncultivated areas and fallow lands occupied 2% and rural settlements nearly 6% of the total area (Fig. 1). The dominant species of trees were Scots Pine (*Pinus sylvestris*), Birch (*Betula pendula*), Black Poplar (*Populus nigra*), Aspen (*Populus tremula*) and Black Alder (*Alnus glutinosa*). Habitats along linear structures like roads and field borders consisted of Willow (*Salix* spp.), Elderberry (*Sambucus nigra*), Hawthorn (*Crataegus* spp.), Blackthorn (*Prunus spinosa*), Wild Rose (*Rosa canina*), Black cherry (*Padus serotina*) and Blackberry (*Rubus* sp.)

2.2. Bird data

To obtain bird data, five-minute point counts were carried out on 64 sites (Fig. 1) each month (December–February) during seven consecutive winter seasons from 2006/07 to 2012/13. The sites were randomly selected. Every single site comprised three points (each as a vertex of the triangle) at a distance of at least 300 m from each other where observers counted birds in three independent directions. The frequency of counts was [mean value ± SD (range: min–max)] 46.7 ± 17.2 (19–63) (Table 1). All counts were performed from half an hour after sunrise until 4.5 hours after it and were done only during favorable weather conditions, with no rain, snow or strong wind. In Western Poland during winter months (December–February) the migration of birds of prey is generally completed, hence all observed raptors were considered as sedentary or nomadic. However, exceptional movements over larger distances may occur due to weather conditions, such as rapid increases in snow cover (Lorek *et al.* 2000, Kasprzykowski & Rzępała 2002, Wuczyński 2005, Żmihorski & Rejt 2007, Kasprzykowski & Cieśluk 2011). To avoid counting individuals on migration, we exluded records of birds displaying migration behavior (directional flight at high attitude) from the analysis. Weather data were obtained from the weather station in Kalisz, ca 20 km eastward from the study area ("Russia's Weather" 2013). The winter characteristics are shown in Table 1.

2.3. Habitat data

To relate bird data and habitat characteristics on each of the 64 sites we designed a circular plot 250 m in radius. All habitat types and landscape elements were measured within this plot. The landscape composition of these circular study plots were characterized by 12 variables measuring the percentage cover of arable fields (ARF), pasture and meadows (PAM), non-mowed meadows (NMM), shrubs (SHR), other woodlands (OTW), buildings (BUI), roads (ROA), water corridors (WAC), water reservoirs (WAR), fallow lands (FAL), forests (FOR), roads with shrubs (RWS). A second group of variables included linear structures measured in meters: wood lines (WOL), shrub lines (SHL) and power lines (POL). We also measured habitat heterogeneity (HET), obtained by counting the number of transitions between different habitats along the two orthogonal lines through the study plot circle. All measurements were done by Quantum GIS software, version 1.7.2 on ortho-images taken in 2005. To evaluate changes in habitat during the study period we compared the ortho-images to habitat cover recorded during fieldwork in 2010. We used only corrected data from 2010, but the comparison of land cover variables between 2005 and 2010 did not show any significant differences (*t*-tests, for all variables $p > 0.05$).

2.4. Bird and habitat data statistics

The Canonical Correspondence Analysis (CCA) was applied to test the relationship between environmental variables (set of variables describing habitat composition and heterogeneity) and the abundance of particular species. CCA is a direct multivariate analysis technique which enables testing the importance of each variable and species response. This method allows the creation of ordination diagrams, in our case a biplot, where the length of each arrow represents the importance of an environmental variable as maximal variation linked to axes. This approach provides information on the similarity of habitat requirements within a bird community where similar species are related closer to each other. The significance of environment variables was done by *F*-statistics with a Monte Carlo Permutation Test with 5,000 runs. Each effect of environment variable was tested when other variables were added to the model. For this analysis the software Canoco 4.5 (ter Braak & Smilauer 2002) was used. The 12 variables measuring the percentage cover of circular plots were arcsin-transformed and added as environmental variables. The linear structure and heterogeneity variables were supplied also as environmental data in original scale. Species variables were entered as overall sum per circular plot.

To test the relationship between raptors abundance and weather conditions we performed generalized linear mixed model (GLMM; with log-link and Poisson error distribution) for each raptor. To each species the dependent variable was characterized as abundance of individuals recorded on point counts. Independent variables were winter month (December, January, February) and monthly mean temperature. We used only temperature, excluding snow cover to avoid multicollinearity

Table 2. Total number of observed diurnal raptors and their number per one count during winters 2006/07–2012/13. *N* – Total number of individuals, *A* – index of density (total individuals/total controls),% – percentage among raptors in the community.

	December			January			February			Whole winter		
	N	*A*	%	*N*	*A*	%	*N*	*A*	%	*N*	*A*	%
Common Buzzard	116	0.65	60.1	75	0.4	45.7	103	0.6	70.1	294	0.55	58.3
Great Grey Shrike	33	0.19	17.1	30	0.16	18.4	20	0.12	13.6	83	0.15	16.5
Rough-legged Buzzard	16	0.09	8.3	32	0.17	19.5	10	0.06	6.8	58	0.11	11.5
Eurasian Sparrowhawk	10	0.06	5.2	11	0.06	6.7	9	0.05	6.1	30	0.06	6
Northern Goshawk	7	0.04	3.6	13	0.07	7.9	2	0.01	1.4	22	0.04	4.4
Common Kestrel	11	0.06	5.7	3	0.02	1.8	3	0.02	2	17	0.03	3.3
Total no. of individuals	193	1.08	–	164	0.88	–	147	0.85	–	504	0.94	–
Total no. of controls	178	–	–	187	–	–	173	–	–	538	–	–

issues due to these variables being highly correlated (Pearson correlation, $r = -0.789$, $p < 0.01$) (in Table 1 to summarize weather conditions we included temperature means and sum of days with snow cover for every winter). As random variables we included count site (“Site”: 64 different sites) and year of survey (“Year”: 2006/7–2012/13). Scaled identity covariance was assigned to both random effects (intercepts). All GLMM Poisson models were checked for overdispersion by extracting the Pearson residuals (Lesnoff & Lancelot 2013) and overdispersions were not detected (for all models $p > 0.05$). Statistical analyses were run in R (R Core Team 2014) using package lme4 (Bates *et al.* 2014). We considered results with $p < 0.05$ to be statistically significant.

3. Results

3.1. General composition of the raptor community

In total, 610 point counts were carried out. The most abundant species were, in descending order, Common Buzzard, Great Grey Shrike and Rough-legged Buzzard. Sparrowhawk, Goshawk and Kestrel were seen in lower numbers, though they were regular each winter (Table 2). We excluded raptor species from the analysis that occurred occasionally. These were: White-tailed Eagle (*Haliaeetus albicilla*) – 10 observations, Merlin (*Falco columbarius*) – 3 observations, Golden Eagle (*Aquila chrysaetos*) – 1 observation.

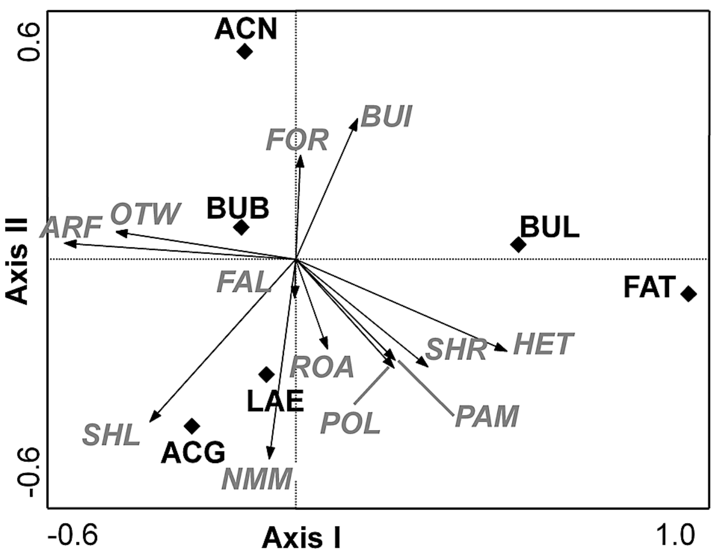

Fig. 2. Canonical Correspondence Analysis ordination diagram of the raptor species and environment variables. The length of the arrows indicates the relative effect. Codes for species: ACG – Northern Goshawk (*Accipiter gentilis*), ACN – Eurasian Sparrowhawk (*Accipiter nisus*), BUB – Common Buzzard (*Buteo buteo*), BUL – Rough-legged Buzzard (*Buteo lagopus*), FAT – Common Kestrel (*Falco tinnunculus*), LAE – Great Grey Shrike (*Lanius excubitor*). Codes for environmental variables: ARF – arable fields, BUI – buildings, FAL – fallow land, FOR – forests, HET – heterogeneity, NMM – non-mowed meadows, OTW – other woodlands, PAM – pasture and meadows, POL – power lines, ROA – roads, SHL – shrub lines, SHR – shrubs.

Table 3. The results of the CCA Monte Carlo Permutation Tests for environmental variables explaining variation in birds of prey abundance. Each effect of an environment variable was tested with 5,000 permutations when the other variables were added to the model. The columns present the *F* statistic, probability (*P*) and percentage of variance explained by an environmental variable (%).

Variable	*F*	*P*	%
Heterogeneity (HET)	5.24	0.000	18.66
Arable fields (ARF)	3.78	0.003	14.60
Shrub lines (SHL)	3.08	0.010	10.50
Non-mowed meadows (NMM)	2.30	0.044	7.45
Water corridors (WAC)	1.81	0.114	6.22
Other woodlands (OTW)	1.36	0.229	4.34
Wood line (WOL)	1.36	0.243	4.30
Pasture and meadows (PAM)	1.88	0.099	5.99
Fallow land (FAL)	1.84	0.114	5.99
Buildings (BUI)	1.32	0.253	4.03
Power lines (POL)	1.15	0.325	3.72
Forests (FOR)	1.08	0.364	3.41
Roads with shrubs (RWS)	1.07	0.367	3.10
Water reservoirs (WAR)	1.07	0.367	3.10
Roads (ROA)	0.57	0.590	1.86

3.2. Habitat gradients and habitat use

Two major habitat gradients were detected by CCA. The first axis can be seen as a gradient from amount of meadows towards increasing coverage of arable fields (Fig. 2). This gradient was associated with the most important variable, the habitat heterogeneity, which describes how heterogeneous study sites were. Kestrel and Rough-legged Buzzard were related with increasing coverage of meadows and heterogeneity. The second axis represents a gradient from open farmland landscape with shrubs and non-mowed meadows to forest and urban area. Goshawk and Great Grey Shrike were connected to the negative end of the gradient – i.e. to shrubs and non-mowed meadows. In contrast, Sparrowhawk was associated with forests and urban areas. Common Buzzard was not related to any of the presented gradients. According to CCA Monte Carlo Permutation Test the variables that explained most of the variance were heterogeneity, arable fields, shrubs lines and non-mowed meadows (Table 3).

3.3. The effect of weather on birds

The results of the generalized linear mixed models showed that relationship with monthly mean temperature was positive for Common Buzzard and Great Grey Shrike and negative for Rough-legged Buzzard. Monthly difference was found for both Buzzards. In the case of the Common Buzzard in February abundance was higher than in December and for Rough-legged Buzzard we observed higher abundance in January than in December (Table 4).

4. Discussion

4.1. Habitat gradients and habitat use

Studied raptor species differed in habitat use. Diurnal birds of prey were highly connected to a gradient from mowed meadows towards increasing coverage of arable fields. Rough-legged Buzzards and Kestrels were connected to large meadow coverage and heterogeneity. Both of these species are rodent specialists (Andrle 2011, Schindler *et al.* 2012), which explains their use of rodent-rich meadows (Adamczewska-Andrzejewska *et al.* 1982). Similar results for these species have also been shown in a study conducted in Central-Eastern Poland (Kasprzykowski & Rzępała 2002).

A second gradient described landscape change from open land – scattered bushes and non-mowed meadows – to increased coverage of forests and

Table 4. The generalized linear mixed models showing the relationship between monthly average numbers of a given predator to temperature and winter month.

	Estimate	SE	*z*	*p*-value
Common Buzzard				
Intercept	–0.859	0.127	–	–
Month: January vs December	–0.096	0.165	–0.58	0.561
February vs December	0.419	0.159	2.64	**0.008**
Mean temperature	0.127	0.253	5.00	**< 0.001**
Variance for Site	0.037	0.193	–	–
Variance for Year	0.379	0.615	–	–
Great Grey Shrike				
Intercept	–2.038	0.254	–	–
Month: January vs December	0.350	0.268	1.30	0.193
February vs December	–0.030	0.306	–0.10	0.922
Mean temperature	0.118	0.044	2.70	**0.007**
Variance for Site	0.215	0.464	–	–
Variance for Year	0.083	0.289	–	–
Rough-legged Buzzard				
Intercept	–5.209	0.002	–	–
Month: January vs December	0.785	0.251	3.1	**0.002**
February vs December	–0.291	0.368	–0.80	0.429
Mean temperature	–0.129	0.002	–75.5	< **0.001**
Variance for Site	< 0.001	0.018	–	–
Variance for Year	7.397	2.720	–	–
Eurasian Sparrowhawk				
Intercept	–4.496	0.785	–	–
Month: January vs December	0.303	0.512	0.59	0.554
February vs December	0.117	0.519	0.23	0.822
Mean temperature	0.079	0.087	0.92	0.360
Variance for Site	< 0.001	< 0.001	–	–
Variance for Year	3.987	1.997	–	–
Northern Goshawk				
Intercept	–3.509	0.508	–	–
Month: January vs December	0.617	0.497	1.24	0.214
February vs December	–1.177	0.825	–1.43	0.154
Mean temperature	–0.005	0.082	–0.065	0.948
Variance for Site	< 0.001	< 0.001	–	–
Variance for Year	< 0.001	< 0.001	–	–
Common Kestrel				
Intercept	–4.306	0.725	–	–
Month: January vs December	–0.563	0.599	–0.94	0.347
February vs December	–0.896	0.706	–1.27	0.205
Mean temperature	0.069	0.087	0.79	0.427
Variance for Site	2.755	1.660	–	–
Variance for Year	0.054	0.233	–	–

urban areas. Great Grey Shrikes were often seen if linear habitats or non-mowed meadows were present. They need trees and bushes for perching and impaling their main prey, rodents (Gorban 2000). This explains the use of linear structures, such as roads, because these structures are partially edged by single trees and bushes. Bushes scattered in meadows are also important night roosts for wintering Great Grey Shrikes (Atkinson 1993, Antczak 2010). The use of non-mowed meadows rather than meadows is probably related to the frequency of shrub occurrence, high density of natural perches and abundance of rodents. *Accipiter* hawks were also related to this gradient, but the habitat use of both species seemed to be contradictory, Goshawks used linear structures while Sparrowhawks used forests and buildings. Goshawk's association with linear structures seems to be in opposition to other studies showing dependence on forests (Tornberg & Colpaert 2001). The observed habitat use of this species is related to higher prey availability, mainly corvids and pigeons, near linear structures (Kenward 1982). The Sparrowhawk prefers to hunt small birds which often concentrate near human settlements where they use bird feeders during the winter (e.g. Newton 1979).

We found that the Common Buzzard was not related to any gradient suggesting that this species had a broad habitat niche, though it seems to be mostly connected to fields. On the contrary, Rough-legged used more meadows thus having a narrower habitat niche. This difference is supported by the fact that Common Buzzard is a more general predator with various hunting techniques modified for different prey, weather or environmental conditions (Pinowski & Ryszkowski 1962, Prytherch 2009). However, rodents are the main food item for both species (Perrins 1998), so a preference for meadows, detected in this study, is in line with previous work (Mülner 2000, Kasprzykowski & Rzępała 2002, Schindler 2002).

Niche segregation theory predicts that to reduce exploitive competition between sympatric species and to allow co-existence, species should differentiate in their niche use. Habitat selection is one of the major mechanisms to reduce competition. Being sympatric species Common Buzzard and Rough-legged Buzzard should compete strongly in wintering areas. It seems that different habitat choice by both species is a key factor in understanding their co-occurrence in farmland in Western Poland. Within the studied raptor guild, Common Buzzard is a generalist, in contrast to Rough-legged Buzzard and Kestrel which seem to be more specialist, and were mostly observed on meadows. On the other hand, Great Grey Shrike and Kestrels are known to be sympatric in terms of habitat requirements, diet and hunting techniques (Gawlik & Bildstein 1993). Both are specialists and prefer meadows, although our study showed that Great Grey Shrike is more related to non-mowed meadows. Sparrowhawk and Goshawk are bird-eating specialists, our results, however, showing that they highly differed in habitat use, the first using forests and buildings, the second preferring open areas with shrub lines.

Intensification of agricultural practices is the main threat for biodiversity in farmlands (Donald *et al*. 2001, Donald *et al*. 2006). Decline in bird species richness due to this process is well described in western EU countries and some authors predicted the accession of former communist countries to the EU will result in declining species numbers (Donald *et al.* 2001). Thus, studies on extensively cultivated farmland are very important because Polish farming is becoming increasingly intensive in ever expanding areas. In the context of intensification, the major threat for the studied raptor guild seems to be the change from meadows and pastures to arable fields and the removal of shrubs. Both of these processes will lead to a decline in farmland heterogeneity and depletion of prey species such as birds and rodents (Tryjanowski *et al*. 2011).

4.2. The effect of weather on birds

In this study we found relationships between abundance of Common Buzzard, Rough-legged Buzzard, Great Grey Shrike and weather characteristics. We found a positive effect of monthly mean temperature on Common Buzzard and Great Grey Shrike and a negative effect on Rough-legged Buzzard numbers. We also discovered month differences in abundance of both Buzzards. The higher abundance of Common Buzzard in February is related to the fact that birds migrate back to the breeding grounds of North-Eastern Europe, and possibly stopover shortly on the study area. In turn, the higher abundance of Rough-legged Buzzard in January compared to other months is linked to the fact that in December some of the North-Eastern European population had not yet started their migration to Western Europe whilst in February some of wintering population had left their wintering grounds in the study area to reach to their breeding areas in North-Eastern Europe, so in effect in both months we observed lower number of Rough-legged Buzzard (Perrins 1998).

It is plausible that warm winter weather reduces the distance of migration to Southern and Western Europe of individuals from the North-Eastern Europe populations wintering in Central Europe (Król 1983, Tornberg & Colpaert 2001). Previous studies suggest that birds may migrate much shorter distances due to warmer winters (Coppack & Both 2002, Visser *et al*. 2009). This can be advantageous because earlier arrival to the breeding grounds and occupancy of territories of higher quality consequently increases breeding success (Coppack & Both 2002, Visser *et al.* 2009). On the other hand, a decrease in the number of wintering individuals in Central Europe during harsh winters may result in a longer migration to warmer Western Europe (Gorban 2000). Conversely, we found that during colder months we observed more Rough-legged Buzzards. Our findings are similar to the results of a survey conducted in central eastern Poland (Kasprzykowski & Cieśluk 2011). This can be explained by the fact that during bad weather Rough-legged Buzzard stopover shortly on their way to warmer regions. This species is rodent-eater and since snow cover hinders prey availability (Wuczyński 2003), a reverse correlation should have been expected. However, periodic thick snow cover should be not a factor limiting Buzzard abundance mostly due to their sit-and-wait strategy (Sonerund 1986) and dense rodent population (Wuczyński 2005).

As was shown, severe winters are "bottleneck" period *e.g.* for Great Grey Shrike (Lorek 1995). In our study, the 2009/2010 winter reduced the local breeding population almost by half (M. Antczak unpubl. data). The reason for these abundance fluctuations of birds result probably from changes in the productivity of Great Grey Shrikes caused by corresponding changes in the rodent population size, as shown for northern populations of Northern Shrike in North America (Atkinson 1993). It is worthy of note that smaller-sized raptors, like Sparrowhawks and Kestrels, have relatively higher energetic demands than bigger raptors like Common Buzzards and Goshawks. Therefore, harsh winters affect their survival much more than that of bigger raptors (Kostrzewa & Kostrzewa 1991).

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Talvehtiva päiväpetolintuyhteisö tehomaatalousalueilla Länsi-Puolassa

Intensiivisesti käytetyllä maatalousalueella talvehtivia petolintuja seurattiin seitsemän talven ajan (2006–2013) Länsi-Puolassa. Aineisto havaituista lajeista ja niiden lukumääristä kerättiin pistelaskentamenetelmällä. Tutkimuksessa keskityttiin päiväaktiivisten petolintujen, hiirihaukan (*Buteo buteo*), piekanan (*Buteo lagopus*), tuulihaukan (*Falco tinnunculus*), varpushaukan (*Accipiter nisus*), kanahaukan (*Accipiter gentilis*) ja isolepinkäisen (*Lanius excubitor*), runsauden vaihteluun ja elinympäristön valintaan. Elinympäristöt vaihtelivat niitettyjen niittyjen ja viljeltyjen peltojen sekä toisaalta niittämättömien niittyjen, pensaikkojen ja metsän eriasteisina osuuksina. Joidenkin lajien runsaus vaihteli elinympäristöjen välillä: piekanat ja tuulihaukat viihtyivät alueilla, joilla oli paljon niittyjä ja elinympäristö oli vaihteleva. Isolepinkäiset ja kanahaukat valitsivat pitkittäisiä elinympäristöjä, enimmäkseen pensaikkoja sekä niittämättömiä niittyjä. Varpushaukkoja tavattiin useimmiten metsissä ja kaupunkialueella. Piekanoiden havaittiin välttelevän viljeltyjä peltoja kun taas hiirihaukkoja tavattiin monenlaisista elinympäristöistä ja enemmän viljellyiltä pelloilta. Hiirihaukkojen ja isolepinkäisten runsauden havaittiin olevan positiivisesti – ja piekanoiden runsauden negatiivisesti – yhteydessä talven lämpötilaan. Tutkimus osoittaa vaihtelevan pelto- ja niittymaiseman olevan tärkeä talvehtiville petolinnuille ja siksi kirjoittajat korostavat tehomaatalouden merkitystä petolintujen suojelussa.

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