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Rough-legged Buzzard *Buteo lagopus* wintering in central eastern Poland: population structure by age and sex, and the effect of weather conditions

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Conditions at wintering grounds affect the numbers of birds of prey to various extents. Weather may influence the latitudinal winter distribution of short-distance migrants, such as the Rough-legged Buzzard, with respect to age and sex. Inventories were conducted in central eastern Poland during 2003–2006 on a sample plot with very high densities of Rough-legged Buzzards. In particular years, Rough-legged Buzzards wintered in different numbers, but there was no significant variation in numbers among phenological periods of winter. The mean daily temperature but not the depth of snow influenced numbers so that lower daytime temperatures were associated with higher numbers of wintering Rough-legged Buzzards. The observed age and sex structures were similar to the latitudinal winter distribution of these parameters in the Rough-legged Buzzard population in the Nearctic region: adults significantly outnumbered immatures, and among adults there were more females than males.

1. Introduction

During winter, the occurrence of birds of prey is affected by numerous factors (Newton 1990). Some of these, such as food abundance, have a direct effect, while others are indirect, affecting e.g. the availability of prey. This latter group of factors includes weather conditions, such as temperature and precipitation (Sonerund 1986), which particularly impact the numbers and aggregations of short-distance migrant wintering birds of prey. Some migrants may also exhibit differences in the proportions of age and sex classes in their wintering populations (Kjellén 1992, 1998, Mueller *et al.* 2000). A number of hypotheses have been put forward to explain intraspecific differences in wintering patterns (Searcy 1980, Mueller *et al.* 2000, Olson & Arsenault 2000). In the case of birds of prey, factors associated with competition and allocation of energy are regarded as important in explaining these differences (Kjellén 1994).

The Rough-legged Buzzard is a short-distant migrant with a Holarctic distribution (Pasanen & Sulkava 1971, Sylvén 1978, Cramp & Simmons 1980, Newton 1990). This species abandons its northern breeding grounds completely in winter (Kjellén 1994). The numbers of Rough-legged Buzzards vary within the species' regular wintering range, especially near the southern edge of this range (Schmid 1988, Dobler *et al.* 1991). In Poland, this species occurs regularly in winter, with greater numbers in the north-eastern part of the country (Kasprzykowski & Rzępała 2002, Tomiałojć & Stawarczyk 2003). North-eastern Poland is part of the wintering range primarily of the breeding population from northern Finland (Cramp & Simmons 1980, Dobler *et al.* 1991). Studies at the species' wintering grounds have so far been conducted mostly on Nearctic populations (e.g., Beaver & Roth 1997, Ferguson 2004).

The aims of the present study were (1) to determine how the numbers of wintering Rough-legged Buzzards are affected by weather conditions, and (2) to determine the age and sex ratios of wintering Rough-legged Buzzards in East-Central Poland. Particular attention was paid to mean daily temperatures and depth of snow cover. The influence of food and weather on the density of breeding pairs and breeding parameters of the Rough-legged Buzzard in the Palaearctic region has been recently studied (Potapov 1997). However, no detailed data in this respect are available on Rough-legged Buzzards wintering in central Europe, and little is known about the age and sex structure of wintering Rough-legged Buzzard populations. The few papers on this topic have focused on birds wintering in southern Sweden (Kjellén 1994) and in North America (Beaver & Roth 1997, Mueller *et al.* 2000, Olson & Arsenault 2000). Our second objective was to evaluate the sex and age distribution, and to compare these with north American results. Studies conducted in North America have shown distinct changes in the proportions of immature and female Rough-legged Buzzards with decreasing latitude (Palmer 1988, Olson & Arsenault 2000). East-central Poland is near the northern limit of the wintering range of the Rough-legged Buzzard. Thus, one would expect the age and sex structure at the same latitude as in North America to be similar, i.e., there should be more adult birds than immatures, and more females than males.

2. Material and methods

The study was conducted on a 18.9 km^2 sample plot located in the upper Liwiec river valley (52°10'05 N, 22°30'15 E), in a mosaic of hay meadows and pastures of diverse humidity, crisscrossed by numerous drainage ditches. This sample plot supported the highest densities of wintering Rough-legged Buzzards among twenty plots studied in east-central Poland (Kasprzykowski & Rzępała 2002).

The study was conducted during 2003–2006, with sampling in each winter beginning on 10 November and ending on 20 February. To facilitate the assessment of variation in numbers of Rough-legged Buzzards during each winter, three phenological periods were distinguished; early (10 November–10 December), mid (11 December–20 January) and late winter (21 January–20 February). Birds were counted at roughly two-week intervals. In total, 20 counts were done: seven in early, seven in mid and six in late winter. Birds were counted between 07:40 and 13:40 by walking along a fixed transect. The route was designed to maximize the area covered by the observer. Confirmed observations were spatially-referenced to a 1:10,000 map, allowing a precise assessment of the number of birds present on the count day. Only local individuals were considered; possible migrants were excluded. The majority of individuals used a sit-and-wait hunting strategy and remained within a particular foraging area throughout the winter. With regard to individuals observed in flight, the direction of flight was considered so that only birds flying in the direction opposite to that of the observer were counted. Age was recorded whenever possible: the birds were divided into immatures and adults. The sex of adults was determined on the basis of the phenotypic characteristics given by Clark (1999). Not all birds could be aged and sexed because of the observation distance, weather and/or occasionally extensive individual plumage variation. Sixteen percent of the Rough-legged Buzzards could not be aged, and 29% of adults were not sexed.

The thickness of snow cover was measured at ten randomly-selected sites within the study plot during 13 bird counts, i.e., during 65% of all counts. Mean daily temperatures were obtained from an automatic weather station located 20 km from the study plot; mean daily temperature expectedly differed between the three study winters (ANOVA, $F_{2,357} = 15.62$, $P < 0.001$) and between the three phenological periods ($F_{2,357} = 89.44$, $P < 0.001$).

A generalized linear model (GLM) approach was used to determine the influence of winter (the

Table 1. General linear model for the observed number of Rough-legged Buzzard individuals, proportion of adults, and proportion of females (sex ratio). Model factors consist of weather-related variables (see text). Statistically significant results are indicated with ** (*P* <0.01) and *** (*P* <0.001).

Variable	No. individuals	% adults	Sex ratio
Year	30.56***	0.27	0.03
Phenological period	2.57	0.59	0.21
Daily temperature (°C)	22.48**	0.01	0.15
Snow depth (mm)	3.69	0.23	0.01
Constant	116.10***	57.11***	27.19***

Table 2. Density, sex and age structure of Rough-legged Buzzards, and weather conditions, shown separately for each of the three study winters. Standard deviations are given in parentheses.

	2003/2004	2004/2005	2005/2006
Mean density (indivs/km^2)	0.76	0.23	1.16
% adults among all aged individuals	0.94	0.80	0.92
% females among adults	0.72	0.74	0.77
Daily temperature (°C)	–0.4 (5.3)	+0.3 (4.6)	–2.6 (5.7)
Snow depth (cm)	4.8 (5.3)	2.1 (2.9)	7.4 (4.4)

three winters), phenological period (early, mid and late winter), daily temperature and snow depth. Prior to the analysis, the distribution of temperature and snow depth data were examined with the Newman-Keuls post hoc test (Sokal & Rohlf 2001). Paired *t* test was used to determine variation in the numbers of males, females and immatures among winters and periods. The analyses were done using the Statistica 6.0 software (StatSoft 2003).

3. Results

The numbers of Rough-legged Buzzards varied significantly among the three winters and were also dependent on daily temperature (Table 1). Lower temperatures were associated with higher numbers of observed individuals. The numbers of individuals varied among counts within each winter and also between years: they were lowest in the second and peaked in the third winter (Fig. 1). The mean number of observed individuals did not significantly vary among the three phenological periods (Table 1, Fig. 1). The highest numbers were observed in mid-winter of the third winter, being 28.0 individuals per count. The depth of snow did not have a significant influence on numbers of Rough-legged Buzzards.

The proportion of adults and the sex ratio remained stable among the three winters and the three phenological periods, and showed no significant response to weather conditions (Table 1). Adults significantly outnumbered immatures when all winters were combined ($t = 2.59$, df = 38, $P < 0.001$). The "bias" toward adults was most distinct in the first and third winters, and varied between 0.80 and 0.94 (Fig. 1, Table 2). Among adults, females predominated to a significant extent ($t = 5.09$, df = 38, $P < 0.001$) and maintained a relatively constant proportion throughout the three study winters.

4. Discussion

The present study was done at a sample plot with the highest density of Rough-legged Buzzards in east-central Poland (Kasprzykowski & Rzępała 2002). Because this species is considerably less abundant in other areas, the present study plot may have produced a more reliable picture of seasonal variation in age-class and sex ratios. Bird counts at a representative plot can be invoked to describe

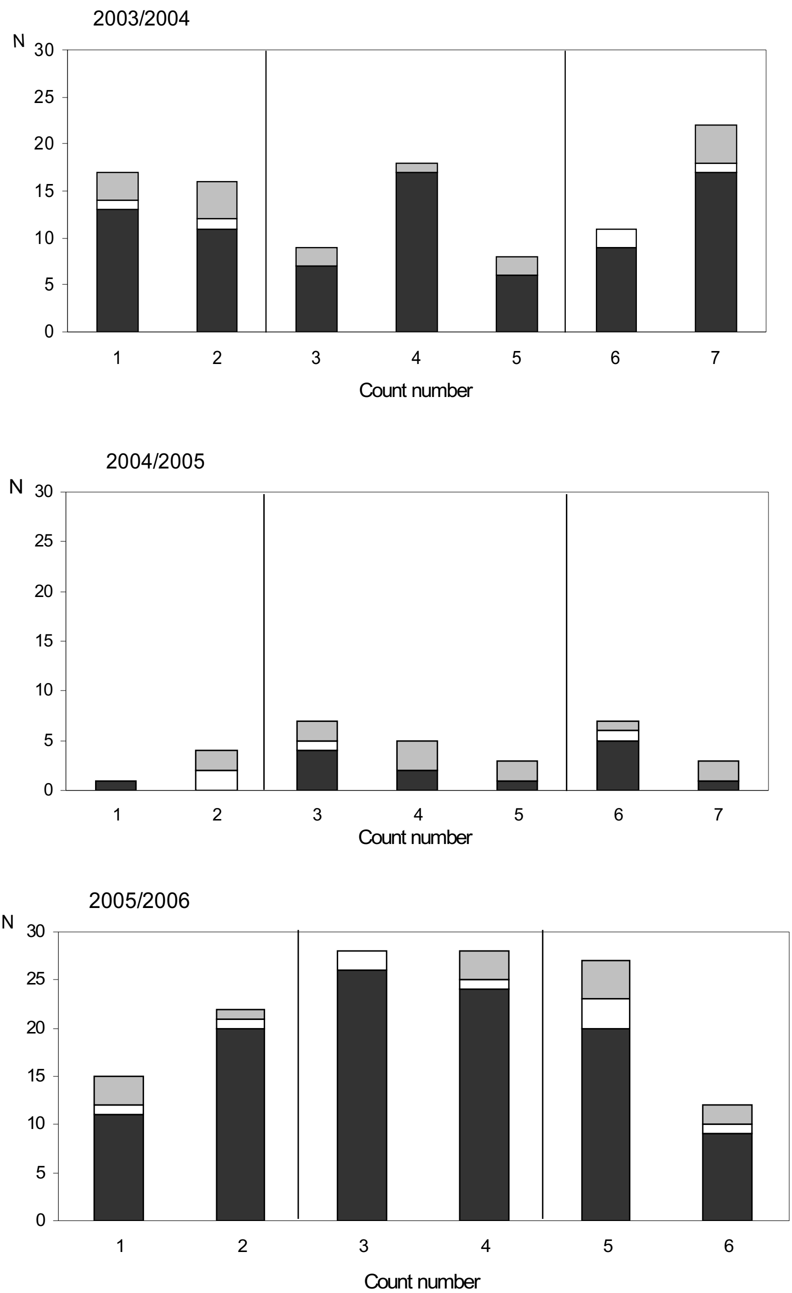

Fig. 1. Numbers of unaged (grey), immature (white) and adult (black) Rough-legged Buzzards in the early-winter counts (numbers 1–2), mid-winter counts (3–5, or 3–4 for the third winter) and late-winter counts (6–7, or 5–6 for the third winter). Column plots are shown separately for the three winters.

changes in the numbers and population structure of wintering birds, and are indeed frequently used in studies of wintering raptors (e.g., Sylvén 1978, Olson & Arsenault 2000, Wuczyński 2003). The numbers of Rough-legged Buzzards wintering in east-central Poland vary from one year to another, but remain relatively constant among phenological periods within a given winter. To a large extent, this may be due to annual food abundance. The Rough-legged Buzzard is a vole specialist and its breeding performance depends on the availability of voles (Pasanen & Sulkava 1971, Newton 1990, Potapov 1997). Raptor and rodent densities during the wintering period correlate positively (Sonerund 1986, Gamauf 1987, Newton 1990, Wuczyński 2003).

The present data showed that Rough-legged Buzzards wintering in east-central Poland are significantly influenced by mean daily temperature. A strong, negative relationship between the number of females of this species and daily temperature has earlier been reported at wintering grounds in North America (Olson & Arsenault 2000). Daily temperature has also been shown to affect the number of Common Buzzards (*Buteo buteo*) during winter in south-western Poland (Wuczyński 2003). In both buzzard species this may be due to the influx of individuals from more northerly and easterly wintering grounds (Šálek 1988, Wuczyński 2003).

Migration distances are negatively correlated with winter temperatures, especially where short-distance migrants from dry, open areas are concerned (Visser *et al.* 2009). A change in migratory behaviour, e.g., a shorter migration distance, enables an earlier arrival back to their breeding grounds, which gives them a reproductive advantage (Coppack & Both 2002). However, the second weather factor under scrutiny – snow depth – had no significant influence on the numbers of Rough-legged Buzzards. Nonetheless, this factor should be considered in these sorts of studies as snow cover indirectly determines prey availability. The fact that snow cover did not significantly affect the number of wintering Rough-legged Buzzards may be due to their use of the energy-conserving, sit-and-wait hunting strategy (Sonerund 1986). Hence, in areas with dense rodent populations, periodically thick snow cover should not be a limiting factor for buzzards (Wuczyński 2005).

The present study also showed that adults outnumbered immatures of Rough-legged Buzzards wintering in east-central Poland. In North America, immatures migrate farther south than adults (Palmer 1988). Juvenile Rough-legged Buzzards are not likely to breed in their first season and can thus migrate farther from their breeding areas. However, studies conducted near the limit of their wintering range in northern Europe have revealed juveniles to be significantly more abundant among wintering than among migrant individuals (Kjellén 1994). The proportion of young Rough-legged Buzzards may be higher in sub-optimal wintering regions than in the main wintering areas located farther south, because competition with adults for winter territories may be reduced (Olson & Arsenault 2000).

Our Rough-legged Buzzard population contained proportionally more adult females than adult males, supporting Kjellén (1994) who also observed a higher proportion of Rough-legged Buzzard females in the wintering area of southern Sweden. Sex differences at wintering grounds have also been observed in several other bird species migrating from the north (e.g., Kjellén 1994, Stouffer & Dwyer 2003, O'Hara *et al.* 2005, Schamber *et al.* 2007). Latitudinal winter-season differences in sex ratio of the Rough-legged Buzzard have been recorded in North America, where females tend to winter farther north than males (Olson & Arsenault 2000). This may be explained by dominant and aggressive females preferring to winter closer to the breeding grounds (social-dominance hypothesis), and/or that females – which are larger than males – are able to tolerate poorer weather conditions (body-size hypothesis) (Searcy 1980, Olson & Arsenault 2000). At wintering grounds in north-eastern Poland, the sex ratio during a given phenological period and different winters was relatively constant. Similarly, a stable proportion of female Rough-legged Buzzards has been recorded in different wintering areas in North America (Olson & Arsenault 2000). In view of the greater proportion of adults and females in east-central Poland, the wintering strategy of Rough-legged Buzzards appears to be similar in the Western Palearctic and Nearctic populations.

Keskisen Itä-Puolan talvehtivien piekanoiden ikä- ja sukupuolijakauma ja sään vaikutus

Talvehtimisalueen olosuhteet vaikuttavat petolintumääriin vaihtelevassa määrin. Sää saattaa vaikuttaa lyhyen matkan muuttajien, kuten piekanan (*Buteo lagopus*), talvehtimisen pohjoisuuteen sukupuoli- ja ikäriippuvaisesti. Asiaa selvitettiin 2003–2006 keskisen Itä-Puolan alueella, jolla piekanoiden talvikanta on hyvin tiheä. Talvehtivien piakanoiden määrä vaihteli talvesta toiseen, mutta talven ajanjaksojen sisällä ei ollut merkittävää vaihtelua. Keskimääräinen päivälämpötila vaikutti määriin merkittävämmin kuin lumen syvyys siten, että laskeva lämpötila näkyi korkeampina piekanamäärinä. Yksilöiden sukupuoli- ja ikäjakaumat olivat samankaltaisia kuin Pohjois-Amerikassa vastaavilla leveyksillä: vanhoja oli enemmän kuin nuoria, ja vanhojen lintujen enemmistö oli naaraita.

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