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Numerical response of the Common Buzzard *Buteo buteo* to the changes in abundance of small mammals

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Abstract I investigated the numerical response of the Common Buzzard to variations in density of small mammals. The study was carried out at the Hortobágy region in 2000-2001. During nest visiting periods clutch size, number of hatched and fledged young were recorded. Population of small mammals were also monitored by live-trapping. Effect of weather on the survival of overwintering rodents was also investigated. There was significant difference in clutch size between 2000 and 2001 (means 2.3 and 3.1). It can be explained by the remarkable differences in abundance of small mammal populations between the two years. The density of rodents was very low (9 specimen/ha) in 2000. During 2001 the amount of small mammals has increased more than eightfold (76 specimen/ha). In February and March, 2000 there were 4 short mild periods alternating with 4 freezing periods, when distribution of significant precipitation (6-8 mm rainfall in each) coincided with the mild periods. Thus the overwintering population almost extincted from the area because the tunnel complexes of voles are repeatedly flooded and huge part of the animals died, resulting very low density during the breeding season. In 2001 there was no such alternating periods, mild weather started 3 weeks earlier, thus voles overwintered successfully and their numbers increased rapidly producing a peak during the breeding season.

Keywords: Common Vole, effect of weather, prey density, reproductive success, resident raptor

Összefoglalás A kisemlősök denzitás változásainak az egerészölyv reprodukciójára gyakorolt hatását (un. numerikus választ) vizsgáltam a Hortobágyon, 2000-2001-ben. A fészekellenőrzések során regisztráltam a lerakott tojások, valamint a kikelt és a kirepült fiókák számát. Az egyik legfontosabb zsákmánycsoport, a kisemlősök állomány változásait élvefogó csapdázással monitoroztam. Vizsgáltam az időjárásnak az áttelelő kisemlősök túlélésére gyakorolt hatását is. Az ölyvek átlagos fészekalja a két évben szignifikánsan különbözött: 2000-ben 2,3, míg 2001-ben 3,1 tojás volt. Ez a kisemlősök – 2000-ről 2001-re bekövetkezett – jelentős mértékű állománynövekedésével magyarázható. 2000-ben nagyon alacsony volt a kisemlősök egyedszáma (9 példány/ha), míg 2001-ben ennek nyolcszorosát regisztráltam (76 példány/ha). A kisemlősök egyedszámában tapasztalt óriási eltéréseket a vizsgált két év tél végi-tavasz eleji időjárási különbségei okozhatták. 2000 február-márciusában, a napi minimum hőmérsékleteket tekintetve, 4 rövid, enyhe periódus váltakozott 4 fagypont alattival, ugyanakkor az enyhe időszakokban jelentős mennyiségű (6-8 mm) eső is hullott. Ekkor az áttelelő kisemlősök járatai ismételten beáztak, az állatok megfáztak, kihűltek, szinte kipusztultak a területről, ezért létszámuk a költési időszakban is rendkívül alacsony volt. 2001-ben a tél vége sokkal enyhébb volt, 3 héttel korábban emelkedtek fagypont fölé a napi minimum hőmérsékletek, mint 2000-ben, nem alakultak ki váltakozó hideg-meleg időszakok sem. Ez kedvezően hatott az áttelelő kisemlősökre, létszámuk gyorsan emelkedett és nyár elejére mezei pocok gradáció alakult ki.

Kulcsszavak: időjárás hatása, mezei pocok, ragadozó madár, reprodukciós siker, zsákmány sűrűség

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Introduction

The relationships between predators and variations in prey density can be separated into two types, numerical and functional responses, with the former describing how the per-capita reproductive rate changes with resource density and the latter how the consumption rate of individual consumers changes with respect to resource density (Solomon 1949). Numerical response may result by two different mechanism: i) increased rate of predator reproduction when prey is abundant or ii) attraction of predators to prey aggregations. The latter, the aggregational response of nomadic specialist predators usually occures without time lags, as their numerical responses are based on mobility, tracking changes in prey density without a time lag (Korpimäki & Norrdahl 1991). Delayed numerical response of resident generalist predators to increase in prey abundance is characterized by a time lag through higher natality and lower mortality (Goszczynski 1977). Delayed numerical response has been documented in resident mammalian predators (Korpimäki *et al*. 1991, Korpimäki & Krebs 1996, Krebs 1996, O'Donoghue *et al*. 1997), and in birds of prey as well (Keith *et al*. 1977, Doyle & Smith 1994, 2001, Rohner 1995, Nielsen 1999, 1996, Rohner *et al*. 2001). Three types of functional responses – linear, convex and sigmoid – are distinguished according to the nature of relationship between predation rate and prey density (Holling 1959). The functional response is mostly determined by foraging and behavior of the predator (Andersson & Erlinge 1977, Korpimäki & Norrdahl 1991). Numerical and functional responses have been shown in the same species as well (Luttich *et al*. 1971, Village 1987). Most studies of generalist predators have focussed on their functional response to only one prey species (Salamolard *et al*. 2000), however consumption by a generalist predator is expected to depend on the densities of all its major prey species (Yodzis 1994, Smout *et al*. 2010).

In this paper I investigate the response of a resident raptor, the Common Buzzard to variations in density of its main prey in the Hortobágy region, Hungary with the comparison of breeding performance of 2000 and 2001. There was great difference in density of rodents – which is the most important prey type of the species in the Great Hungarian Plain (Palatitz & Tóth 2003) – between the two years. Moreover, my aim was to investigate the effect of weather on population dynamics of small mammals – i.e. the role of winter/spring temperature and precipitation in the survival/abundance of overwintering animals which determines the population size of rodents later, during the breeding season.

Material and methods

Study area and species

The study was carried out in the Great Hungarian Plain at Hortobágy region during 2000-2001. The study area covers about 200 km^2 and is dominated by intensively cultivated fields, arable lands, grasslands and pastures. The region is one of the least forested part of Hungary. Buzzards bred in planted tree lines and forest patches with few hectare extension. There is only one large natural forest (200 hectares) in the study area near Ohat village.

The Common Buzzard is the most common raptor species in Hungary. The multiplication of the breeding populations since the 1980s is the result of the decrease of human persecution, the good adaptability of the species and the previous wood plantation programmes in the plains that enabled the species to spread in the lowlands (Tóth 2009). The number of breeding pairs exceeds 20000 (Ecsedi & Sándor 2004).

Breeding performance and small mammal abundance

In March when birds reconstructed old nest or built new ones the study area was eximaned to find the occupied nests each year. The founded nests were visited by climbing 5-7 times during the breeding season to record clutch size, number of hatched and fledged young.

Main food supply i.e. the population size and changes of small mammals were also monitored in one hectare large sampling area of a grassland in the centre of the study area. At the sampling area a 1 hectare (100×100 m) live-trapping grid was established, consisting of 121 livetraps in a 11×11 configuration with 10 m spacing. The trapping session was in June and it lasted 4 days. Traps were checked three times per day – in the morning, at noon and in the evening (traps were opened overnight as well). Individuals were uniquely marked with claw cutting applying a code table to distinguish the recaptured animals individually. Captured animales were identifed on species level. To assess population size I used the Minimum Number Alive (MNA) method introduced by Krebs (1966) for capture-mark-recapture data.

Data on weather conditions and statistical analysis

To study the effect of weather on the overwintering population of small mammals, data on weather conditions (from 1st February to 30th April in 2000 and 2001) were analysed. Daily minimum temperature values (in °C) and daily amount of precipitation (in mm) come from the nearest meteorological station of the Hungarian Meteorological Service in Debrecen, 45-50 km away from the center of the study area (available from the web site – under the code 128820 99999 DEBRECEN – in both years: ftp://ftp.ncdc.noaa.gov/pub/data/gsod/).

Comparing the clutch size, number of hatchlings and fledglings between 2000 and 2001. I used generalized linear model (GLM) with quasipoisson error distribution (Venables 2002). The statistical analysis was carried out in R 3.0.2 (R Core Team 2013). Completed first clutches were involved only, when mean values of clutch size were calculated. Moreover, mean number of hatchlings and fledglings were calculated based on those nests where one young hatched from eggs at least.

Results

Breeding success

There was considerable difference regarding the number of breeding pairs between 2000 and 2001. In 2000, 7 buzzard pairs started to breed on the study area, while during 2001 there were 13 breeding attempts. In 2000, 1 breeding attempt out of 7 failed during the incubation period, it was exluded from the analysis because the final number of laid eggs was unknown *(Table 1)*. In

Year	2000			2001			
	$\bar{x}$	SD	N	$\bar{x}$	SD	N	P-value
Number of laid eggs	2.3	0.52	6	3.1	0.86	11	0.0124
Number of hatched young	2.3	0.52	6	2.7	1.41	9	0.3355
Number of fledged young	1.8	0.98	6	2.0	1.33	9	0.4236

Table 1. Breeding results of the Common Buzzard at Hortobágy region in 2000 and 2001 ($\bar{x}$ = mean, SD = standard deviaton, N = sample size, P-value from GLM)
1. táblázat Az egerészölyv költési eredményei 2000-ben és 2001-ben a Hortobágy térségében. Az adatok fészkenkénti átlagok ($\bar{x}$ = átlag, SD = szórás, N = fészkek száma, P-érték GLM-ből)

2001, 2 breeding attempts out of 13 were exluded when mean clutch size was calculated due to similar reason and another 2 nests with completed clutches were exluded from the analyses regarding mean values of hatched and fledged young due to nest failure during the incubation period *(Table 1)*. Mean values of the investigated three breeding parameters were greater in 2001 than in 2000, however significant difference was found in the mean number of laid eggs only (P=0.01242), buzzards laid approximately one more egg on average in 2001 *(Table 1)*.

Abundance of small mammal community

In 2000, the species diversity and the abundance of small mammal community were very low in the study area. Estimated population size (MNA) of small mammals was less than 10 specimen which belonged to three different species: 6 Common Voles *(Microtus*

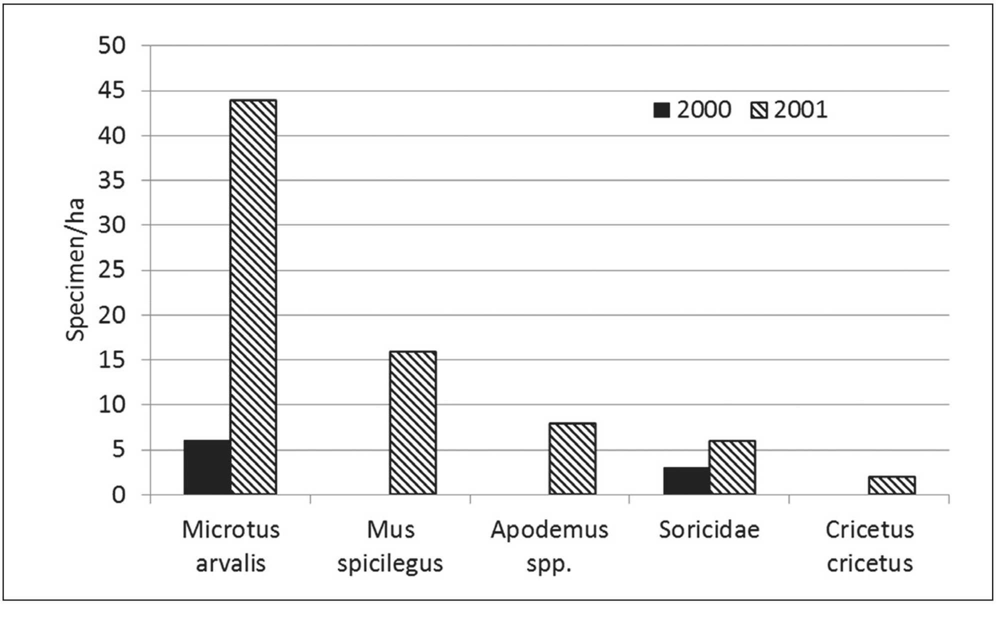

Figure 1. Density of small mammals during the breeding season in 2000 and 2001
1. ábra A kisemlősök egyedsűrűsége a költési időszakban 2000-2001-ben

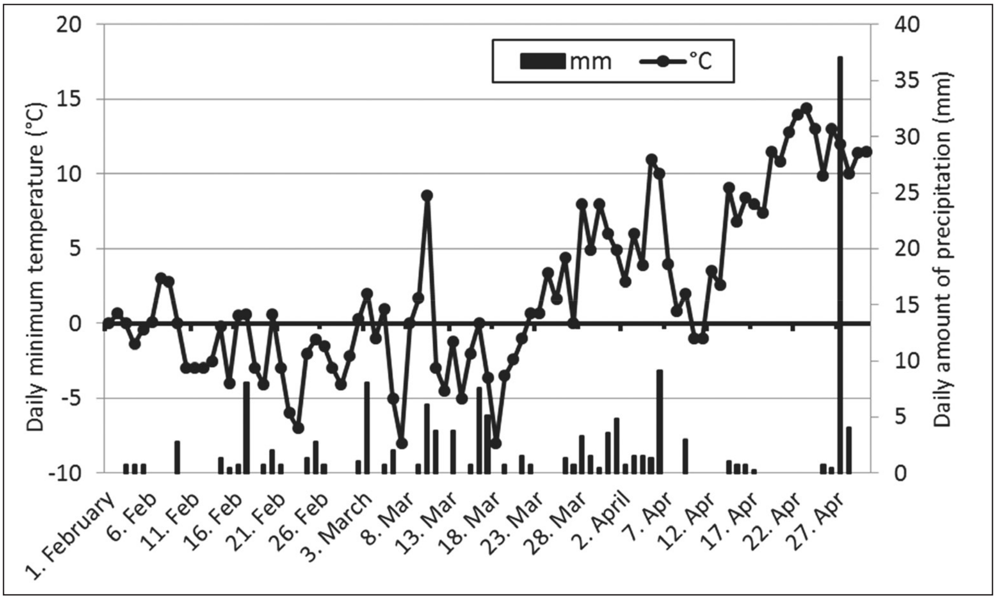

Figure 2. Daily minimum temperature and daily amount of precipitation in 2000, from February to April
2. ábra A napi minimum hőmérsékletek és a napi csapadék mennyisége 2000-ben, februártól áprilisig

arvalis), 2 Common Shrews *(Sorex araneus)* and 1 Bi-coloured White-toothed Shrew *(Crocidure leucodon)* were trapped *(Figure 1)*. In 2001 there were considerable changes in species composition and abundance of small mammals. During the breeding season the amount of small mammals increased eightfold comparing to previous year, the total number of trapped animals (MNA) was 76 specimen *(Figure 1)*. Captured species were Common Vole, Steppe Mouse *(Mus spicilegus)*, Striped Field Mouse *(Apodemus agrarius)*, Wood Mouse *(A. sylvaticus)*, Yellow-necked Mouse *(A. flavicollis)*, Pygmy Field Mouse *(A. uralensis)*, Common Shrew, Bi-coloured White-toothed Shrew, Pygmy Shrew *(S. minutus)* and Common Hamster *(Cricetus cricetus)*. However, Common Vole and Steppe Mouse dominated the food supply, these two species accounted for 79% of trapped animals (44 and 16 specimen, respectively), while proportion of the other 8 species altogether was 21% *(Figure 1)*.

Weather conditions

There were some differences in weather conditions from February to April between 2000 and 2001. Average (±SD) monthly minimum temperature was similar in February (in 2000: -1.6±2.4 °C, in 2001: -2.0±3.5 °C), while in March and April these values differed considerably. Regarding the minimum values, March was colder in 2000 by 3.1 °C than in 2001 (average minimum: 0.0±4.3 °C and 3.1±3.3 °C, respectively). In April, the year of 2000 was warmer than 2001 (average minimum: 7.8±4.6 °C and 5.1±3.1 °C, respectively). Important difference can be observed in changes of daily minimum values. In 2000 the minimum temperature stayed below zero till 21th, March, however there were 5 short periods (7-8., 16-17. February, 2-3., 9-10., 16. March) when values exceeded zero *(Figure 2)*. In 2001 the last decade of February was rather cold, but from the 2nd of March daily

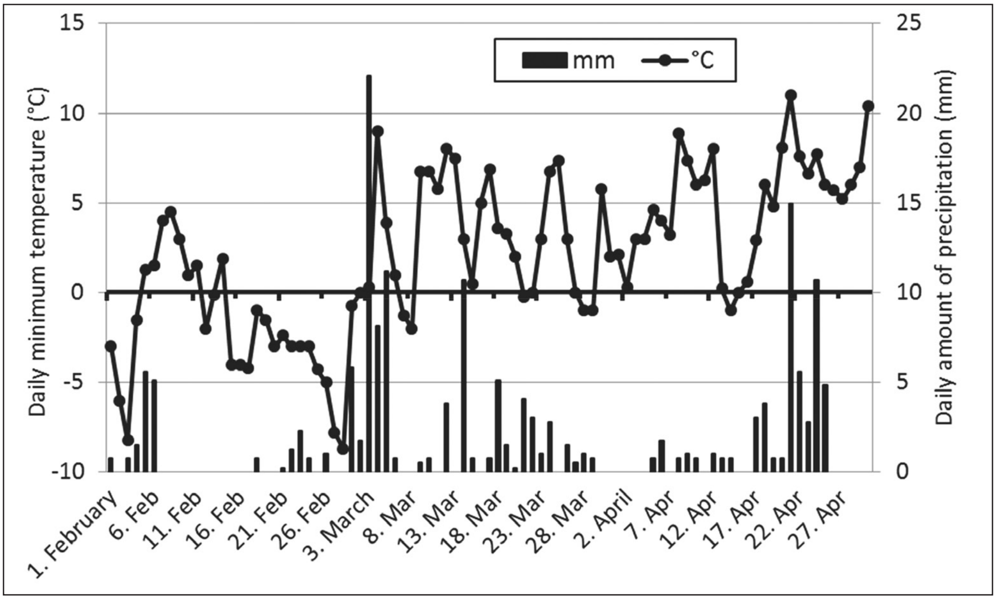

Figure 3. Daily minimum temperature and daily amount of precipitation in 2001, from February to April
3. ábra A napi minimum hőmérsékletek és a napi csapadék mennyisége 2001-ben, februártól áprilisig

minimum temperature exceeded zero – almost permanently – i.e. mild weather started 3 weeks earlier than in the previous year *(Figure 3)*.

Monthly amounts of precipitation were similar during February in 2000 and 2001 (24 and 20 mm, respectively), during March and April there were differences between the two years (2000: 54, 67 mm, 2001: 89, 55 mm). Distribution of precipitation differed considerably during February and March between the two years: in 2000 there were 4 days (17. February, 3., 10., 16. March) when the amount of precipitation was significant (exceeded 6 mm), while in 2001 there were 2 occasions (3-5., 14. March) only *(Figure 2, 3)*.

Discussion

Breeding population size and reproductive success of raptors are determined by the availability of nesting sites, food supply and weather conditions (Korpimäki 1985, Kostrzewa & Kostrzewa 1990, Korpimäki & Norrdahl 1991, Butet & Leroux 1993, Jędrzejewski *et al.* 1994, Korpimäki 1994, Salamolard *et al*. 2000, Reif *et al.* 2001, Tóth & Palatitz 2003, Millon & Bretagnolle 2008, Millon *et al*. 2008, also see a review in Csörgő *et al*. 2012). Nest predation can also play an important role regarding breeding success in fragmented habitats, as well (Chalfoun *et al.* 2002). I found considerable differences in the number of breeding pairs and their breeding success of the studied buzzard population between 2000 and 2001. In 2001 the number of breeding pairs increased twofold comparing to the previous year (from 7 to 13 pairs). There was significant difference in clutch size – mean number of laid eggs was greater in 2001 than in 2000. These changes can be explained by the remarkable differences in abundance of small mammal population between the two years. The density of rodents was very low in 2000 (9 specimen/ha). During 2001 the amount of small mammals has increased more than eightfold (76 specimen/ha). Particularly the population change of the Common Vole was drastic, their density has increased from 6 to 44 specimen/ha. However, there were no significant differences regarding the number of hatchlings and fledglings between the two years. This can be resulted by the higher predation rate in 2001. That year 4 out of 13 nests failed (31%) due to predation in contrast with 14% of 2000. As a result, success of chick raising decreased (there were no hatched young in four nests), thus predation could mask the positive effect of high vole density on reproduction in 2001.

Weather can affect reproductive success either directly – failure of eggs and young due to heavy rainfall and low temperature – or indirectly, e.g. decreasing food availability. Weather conditions during winter and spring determine the overwintering success of small mammal populations. In this respect the most important factors are the changes of temperature and precipitation at the end of winter and the beginning of spring. Overwintering population faces the highest risk when short periods of temperature below and above zero alternates and there is significant rainfall during the mild periods. The tunnel complexes of voles are flooded and huge part of the overwintering animals may die by the cold. During 2000 (in February and March) there were 4 short periods (16-17. February, 2-3., 9-10., 16. March) when mimimum temperature exceeded zero alternating with 4 freezing periods 3-4 degree below zero and lasted 12-14 days. The distribution of significant precipitation (6-8 mm rainfall) coincided with the 4 mild periods, thus the overwintering population almost extincted from the area resulting very low density of small mammals during the breeding season. In 2001 the above mentioned conditions were much more favourable for the small mammal population. There was no alternating mild and freezing periods, mild weather started 3 weeks earlier than in the previous year (March was extraordinaly cold in 2000). Thus voles overwintered successfully and their numbers increased rapidly producing a peak during the breeding season.

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