J Insect Conserv (2011) 15:743–746
DOI 10.1007/s10841-011-9424-5

SHORT COMMUNICATION

Uphill distributional shift of an endangered habitat specialist

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Received: 18 November 2010 / Accepted: 7 July 2011 / Published online: 21 July 2011

Abstract The rove beetle *Emus hirtus* (Linnaeus, 1758) is an endangered habitat specialist, which occurs in long-term cattle pastures where it forages on cattle dung. We studied this species' historical and recent altitudinal distribution and habitat requirements in the centre of its distributional range in the Czech Republic. The species had experienced a sharp decline and was for nearly 20 years considered as regionally extinct within the Czech Republic. Nowadays, *Emus hirtus* is present and occurs in relatively high population densities. However, the beetle has shown an uphill shift and is distributed at significantly higher altitudes in sun-exposed localities in foothills and mountains compared to its historical distribution in the lowlands. *Emus hirtus* is one of many organisms that seem to indicate the openness of the pastured woodland landscape in the past. The main reason for its uphill shift could be habitat loss in densely populated and intensively managed lowlands and restoration of grazing at higher elevations due to agricultural subsidies.

Keywords Agricultural landscape · Altitudinal distribution · Coleoptera · *Emus hirtus* · Habitat requirements and loss · Pasture management · Rove beetles · Staphylinidae

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Introduction

During the last millennia, landscape cover has dramatically changed, and the structure and composition of the remaining semi-natural fragments has greatly altered over time (Lawton 1997). Exploitation of the landscape in the past resulted in a mosaic of temporally and spatially altering habitats. However, in the second half of the 20th century the landscape became largely homogenous and land use intensified (Hansson et al. 1995). Intensive agricultural and forest management affected many organisms. Farmers and foresters are being confronted with an increasing abundance of potential pests and conservationists are facing the decline of formerly common species. A general decrease in environmental heterogeneity leads to the absence of some types of habitats or even to broken metapopulation structure and increases the risk of extinction for habitat specialists (Matson et al. 1997).

There is growing worldwide evidence of ongoing change in the distribution of some species, including range extinctions and altitudinal shifts (Channell and Lomolino 2000; Sikes and Raithel 2002; Konvicka et al. 2003).

Beetles are often used in biodiversity studies, although only a few studies have dealt with habitat requirements (e.g. Horák et al. 2011). The rove beetles (Staphylinidae) are sometimes considered as bioindicators (Bohac 1999). Nevertheless, their taxonomy and lower rate of specificity to the (micro)habitat substrate make them very difficult to study (Bouchard et al. 2009).

The aims of our paper are to determine the altitudinal distributional pattern and habitat preferences of an endangered rove beetle *Emus hirtus* (Linnaeus, 1758; Coleoptera: Staphilinidae: Staphilininae) in the Czech Republic, the centre of its distribution area.

Materials and methods

Study species

The rove beetle *Emus hirtus* is a large (1.8–2.8 cm) and conspicuous beetle. This species is distributed in many parts of Europe, except the northernmost regions, and is also found in parts of Anatolia in Asia (Smetana 2004). This species was reported to be a habitat specialist occurs in low numbers only in long-term pastured areas with cattle dung and manure. *Emus hirtus* is one of the most impressive predators on Earth, foraging on other insects (Smetana 1958) and in the Czech Republic is red-listed as endangered following IUCN criteria (Farkač et al. 2005).

Study design and variables

We analyzed the dataset from Chobot (2010), which included all published historical records from the territory of the Czech Republic, supplemented with (published and unpublished) recent records. We determined the historical distribution (threshold in 1990, referred to as old) of *Emus hirtus* and compared this dataset with recent data (1990–2009, referred to as new). We chose the year 1990 based on the temporal absence in the modern distribution of the species in the study region (Kočárek 1997).

Faunistic records coming from non-systematic surveys are often spatially and temporally biased, which could compromise the description of the distribution and environmental responses of many endangered species (Dennis and Hardy 1999; Dennis 2001; Rocchini et al. 2011). Unfortunately, our data does not allow using the methods commonly used to determine whether there is any temporal bias in the altitudinal range surveyed (Lobo et al. 2007; Hortal et al. 2008). However, there is a long-standing tradition of beetle collection at the Czech Republic, and *Emus hirtus* is a large and conspicuous rove beetle species which is recorded almost any time it could be observed, being common in many private collections. In addition, there is a well-established tradition of sharing these collections with other collectors through local publications and, recently, through the internet via very active websites such as www.entoforum.cz. Due to this, we consider that it is highly unlikely that there is any significant bias in the altitudinal ranges surveyed at different times within the temporal range used for our analyses. Therefore, we consider that any change in altitudinal range measured with the records used in this work corresponds to actual changes in the altitudinal distribution of *Emus hirtus*.

The final dataset consisted of records of locality, year and GPS (Appendix). In the case of historical records we used GPS based on the location of the indicated locality. Some historical records had no indication of year, and thus we analysed them as old. All of them were certainly from the period 1900–1950. For further analyses we used only data with good descriptions of variables. Altitude, as the continuous variable, was measured using ArcView GIS (ESRi, Redlands, CA, USA), then log transformed to reach normality and tested with linear regression. Normality of dependent variables was tested with the Shapiro–Wilks test. Descriptive analyses were done with the parametric t-test and non-parametric Mann–Whitney *U* test for independent samples. All analyses were carried out using Statistica 7.0 (StatSoft, Tulsa, OK, USA).

Results and discussion

The rove beetles *Emus hirtus* experienced a sharp decline after the 1950s. There were only three records during the 1960s and 1970s and all of them were, surprisingly, from compensatory habitats such as carcasses and waste dumps (e.g. Jelínek 2001). Thus, the beetle was thought not to be a pasture specialist and able to exploit disparate habitat types like most other rove beetles (Kočárek 1997). For almost 20 years the species was regarded as regionally extinct in the Czech Republic. Nevertheless, from 1990 the species has been spreading throughout its distribution area (Gerend and Braunert 1997; Boháč et al. 2001; Telnov et al. 2005; A. Smetana, pers. comm.). Nowadays, *Emus hirtus* seems to occur in some sun-exposed localities at high population densities (Fig. 1a). Most of these sites are characterized as long-term and year-long cattle pasture with the presence of large amounts of cattle dung, although this dependence was not significant (Fig. 1b).

Our analyses showed that *Emus hirtus* has undergone an uphill shift from habitats in the lowlands and neighbouring areas ($N = 15$; $Ave_{old} = 309.3$; $Med_{old} = 257.9$; $Min_{old} = 188.6$; $Max_{old} = 490.2$; $SD_{old} = 104.7$ m a. s. l.)

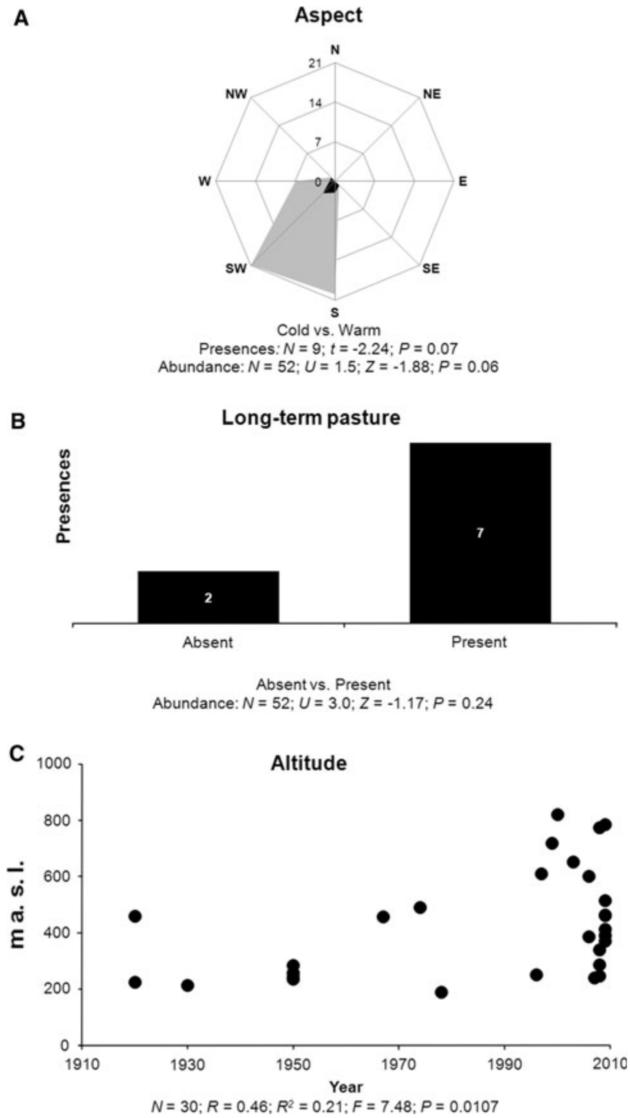

Fig. 1 Altitudinal distribution and habitat requirements of *Emus hirtus* in the Czech Republic: **a** aspect (*black* colour is for presences and *grey* for abundance, cold is for NW, N, NE and E, warm for SE, S, SW and W aspect), **b** presence of long-term pasture and **c** altitude. Note that statistics in **c** is for log transformed altitude

to the higher elevations of foothills and mountains (N = 20; $Ave_{new} = 485.4$; $Med_{new} = 437.0$; $Min_{new} = 240.6$; $Max_{new} = 819.8$; $SD_{new} = 188.9$ m a. s. l.). In the past, *Emus hirtus,* as a habitat specialist, preferred localities at lower elevations than in more recent times. This shift in altitude pre 1990 to post 1990 was significant (U = 60.0; Z = −3.00; $P = 0.0027$). The analysis of temporal distribution also showed that the species has probably shifted from lower altitudes to the mountains (N = 30; R = 0.46; $R^2 = 0.21$; F = 7.48; $P = 0.0107$) over time (Fig. 1c).

It is possible that the uphill shift of *Emus hirtus* has been influenced by the loss of long-term pasture at lower altitudes and overall intensification in lowlands (Pysek et al. 2002; Konvicka et al. 2003) combined with past and recent changes in agricultural practices at higher altitude. Pastures were first abandoned after the Second World War at higher elevations due to the displacement of the German population and to early conservation measures which considered pasture as a harmful way to manage protected areas (cf. Krahulec et al. 2001). However pasture management systems are now more common at higher elevations (Hejcman et al. 2004), due to agri-environmental and LFA subsidies and the restoration of traditional management (Matějková et al. 2003), *Emus hirtus* could profit from this. *Emus hirtus* is one of many organisms characteristic of open pastured woodland landscapes in the past (e.g. Vera 2000). Changes in the altitudinal range of this species in the Czech Republic may be reflected in other species with similar ecological requirements.

Acknowledgments We would like to thank to J. Boháč and P. Kočárek for providing the literature, P. Boža, B. Mocek, P. Moravec, M. Ouda and I. Boščík for kindly providing the data, M. Mantič, V. Hula, M. Boukal, J. Šuhaj, K. N. A. Alexander, A. Smetana for discussion, J. Ferrier for correcting the English, J. Hortal and T. Shreeve for valuable suggestions. The comments of two anonymous referees greatly helped to improve the manuscript. This study was supported by a grant from the CZ Ministry of Environment, No. MSM 6293359101.

Appendix

See Table 1.

Table 1 Check-list of study localities (in alphabetical order) of *Emus hirtus* in the Czech Republic

Locality	Year	Latitude	Longitude	Altitude (m)
Benátky	1967	50.2214	16.3293	457.4
Boletice	2003	48.8333	14.1804	651.7
Brloh	1997	48.9262	14.2264	610.0
Brno	ND	49.1964	16.6076	229.1
Dolní Bečva	2009	49.4627	18.1892	462.3
Dolní Hedeč	2008	50.0704	16.7897	774.5
Doubravice	1974	49.1772	13.8292	490.2
Hluboká nad Vltavou	ND	49.0457	14.4393	371.4
Hluboké	2009	49.3267	18.1430	461.3
Horní Planá	2000	48.7749	14.0305	819.8
Hradec Králové	1950	50.2014	15.8609	234.9
Hřivínův Újezd	2008	49.1260	17.6902	287.1
Končiny	2007	48.8607	17.2862	240.6
Kotly	2009	49.6313	18.4653	391.2
Kuklov	1999	48.9346	14.1830	718.2
Kunětická hora	2008	50.0822	15.8084	245.1

Table 1 continued

Locality	Year	Latitude	Longitude	Altitude (m)
Landek	1996	49.8734	18.2742	249.9
Leskovec	2009	49.2889	18.0035	391.2
Mnichov	2008	50.4210	13.8119	339.8
Pavlovské kopce	1920	48.8646	16.6469	458.0
Písek	ND	49.3092	14.1486	373.3
Poděbrady	1978	50.1528	15.1232	188.6
Prosenice	ND	49.4899	17.4861	215.1
Prostějov	1920	49.4712	17.1126	225.1
Protivín	ND	49.2047	14.2162	402.5
Přemyslovské sedlo	2009	50.1125	17.0560	784.4
Přerov	1930	49.4498	17.4517	212.5
Rabí	2009	49.2905	13.6100	514.2
Radotín	1950	49.9940	14.3535	257.9
Stříbrný potok	2009	50.3003	17.0892	412.7
Tvrdkov	2006	49.8862	17.1890	601.0
Vyšní Lhoty	2009	49.6439	18.4503	369.5
Závist	1950	49.9738	14.4018	240.7
Znojmo	1950	48.8581	16.0579	283.1
Žulová	2006	50.3116	17.1038	384.7

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