

Population status, habitat associations, and distribution of the steppe polecat *Mustela eversmanii* in Europe

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Abstract The steppe polecat *Mustela eversmanii* is a medium-sized mustelid species whose European population has significantly declined over the past century. However, due to the lack of systematic surveys, little is known about its status and distribution. In this paper, we review the current distribution, habitat associations, and population trends of steppe polecats in Europe and assess the main factors associated with these trends. Our results reveal ongoing population declines in most of the studied countries, which led to fragmentation and local population extinctions at the beginning of the twenty-first century. The species was assessed as rapidly declining in Austria, Czech Republic, Moldova, Slovakia, and Ukraine; declining in Bulgaria; and stable in Hungary. Due to insufficient data, its status was not evaluated for Romania, Poland, and Serbia. *M. eversmanii* naturally occurs in steppe habitats, but recently seems to have adopted open agricultural landscapes consisting of a mosaic of grasslands, small fields with hedges, and dry embankments. Its distribution often coincides with populations of ground squirrels and hamsters. However, in intensively used agricultural landscapes, smaller

rodents (especially voles) could also be an important dietary component. Intensive agricultural production, habitat loss, the degradation of steppe and grassland habitats, and significant declines in the availability of its main prey are the crucial factors for the species' current population decline. Further research is urgently needed to fill the gaps in our knowledge of its distribution, population densities, feeding ecology, habitat associations, and population genetics. This would enable first steps towards its effective conservation and management strategies.

Keywords Steppe polecat · *Mustela eversmanii* · Distribution · Habitat associations · Population status · Europe

Introduction

The steppe polecat *Mustela eversmanii* Lesson, 1827 is a medium-sized Palearctic mustelid species with a range from

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northeastern China and Mongolia and southeastern Siberia (Russia), through Central Asia, southern Russia, and northern Georgia, reaching Central Europe (Heptner et al. 1967; Wolsan 1999). In its European range, the distribution of steppe polecat overlaps with European polecat *Mustela putorius*, except in the eastern part of Ukraine, southern Russia, and Georgia (Fernandes et al. 2008). As a typical inhabitant of open steppe habitats (Wolsan 1993), its distribution has fluctuated, especially in Europe, as shifting climates have shaped the amount of suitable habitat. During the Middle Pleistocene and especially in the Late Pleistocene, the species was widespread, stretching from Western and Central Europe to western Siberia (Wolsan 1993; Guérin and Patou-Mathis 1996). However, after the intensive forestation of the continent, caused by Holocene warming, the western limit of the species range retreated eastwards in Europe (Spasov 1982; Wolsan 1993). The more recent steppe polecat distribution on the continent is mainly a result of massive deforestation during the beginning of the twentieth century that led to a renewed western range expansion (Heptner et al. 1967). Its current European distribution comprises two populations (subspecies) that are separated by the Carpathian Mountain range. The western population (subspecies *M. eversmanii hungarica*) inhabits Central Europe (Czech Republic, Austria, Slovakia) and spreads further through the Pannonian region (Hungary, western Romania, western Ukraine, Serbia). The eastern population (nominat subspecies) is found in Bulgaria, eastern and southern Romania, Moldova and Ukraine east and north of the Carpathians, and southeastern Poland (Wolsan 1993, 1999). The visible closeness of the populations of both subspecies to the north of the Carpathians could be a relatively recent effect of the movement of the eastern population to the west with the noted expansion (Heptner et al. 1967) related to the deforestation.

This current distribution of the steppe polecat in Europe is mainly associated with open steppe and grassland habitats as well as agricultural land with a mosaic of pastures, fields, and shrubland vegetation (Spasov 2007; Anděra and Červený 2009). Similar to steppe polecat, these habitats are also used by the European polecat; however, this species is known as a habitat generalist with preference for humid areas like freshwater lakes, rivers, and wetlands or inhabit more forested areas (Blandford 1987; Lodé 1994; Baghli et al. 2005; Fernandes et al. 2008). The steppe polecat's habitats often coincide with the distribution of its main prey, the European ground squirrel *Spermophilus citellus* and the common hamster *Cricetus cricetus* (Kratochvíl 1962; Heptner et al. 1967; Wolsan 1993; Spitzenberger 2001; Spasov et al. 2002; Lanszki and Heltai 2007). Populations of the steppe polecat (as well as of the aforementioned rodent species) in the European range have declined, and in many areas, its distribution became fragmented (Volokh

2004; Anděra and Červený 2009; Spasov 2007). The main causes of this trend could be widespread habitat loss and fragmentation of the steppe and grassland habitats, intensive agriculture, depletion of the main prey, and hunting pressure. Similarly, the species may be threatened by introgressive hybridization with European polecats or free-ranging domestic ferrets *Mustela cf. furo* (Wolsan 1993; Davison et al. 1999; Vallo et al. 2007).

Although the steppe polecat is classified as Least Concern with a stable population trend in the IUCN Red List of threatened species (Tikhonov et al. 2008), the situation revealed by regional and national lists is more alarming as it is classified as Endangered in EU25 regional Red List category as well as in many national Red Lists throughout Europe (Głowaciński 2001; Anděra and Červený 2003; Spitzenberger 2005; Spasov and Spiridonov 1985, 2011).

The steppe polecat is one of the least known and studied European carnivore species with very limited information available on its current population status, habitat associations, and distribution. There is also a paucity of knowledge about its recent distribution on the continent (Schreiber et al. 1989). The main objectives of this study are to summarize recent knowledge about this species and identify major population threats in Europe. These information should act as the basis for broad discussions regarding conservation and management of the species. Finally, we aim to identify the main gaps in research and propose future research priorities.

Material and methods

The distribution and current status of the steppe polecat was assessed in its western distribution range, located in Europe (west of 40° E). The study area spreads from Ukraine at the easternmost side and continues through the countries around the western side of the Black Sea towards the western distribution limit in Central Europe, covering a total of 12 countries. Data were mostly gathered through extensive literature search of zoological databases (zoological records, Web of Science), local scientific and hunters' journals, and web pages. The data were supplemented with questionnaires which were sent to local experts in each of the countries, with a request for information about population trends over the last 30 years (categorized as rapid decline >50 %, decline—10–50 %, stable—decrease or increase about 10 %, increase >10–50 %, rapid increase >50 %, extinct, and unknown), distribution range, habitat associations, major population threats, conservation status, proposed conservation measures, and legislation. Data on the distribution and population densities of small-sized carnivores are generally hard to obtain due to their relatively low abundance, secretive habits, and wariness of humans. We therefore relied

primarily on indirect methods in order to determine distribution and population status. However, the quality of data used for estimation of population trend and distribution varied substantially among study countries. Based on the reliability of data, we distinguished three categories of their quality:

Data quality 1—the countries where distribution and population trend was determined on the basis of nationwide standardized research (>1980) and the Atlas of Mammals or Red Data Books from individual countries. Similarly, historical data and current local research about steppe polecat are known.

Data quality 2—the countries where distribution and population trend was determined on the basis of the Atlas of Mammals or Red Data Books from individual countries. Historical data and current local research were conducted in a limited area without systematic research on national level.

Data quality 3—the countries where distribution and population trend was determined on the basis of the estimates made by local experts.

Results

Although the steppe polecat seems to remain widely distributed in European countries (Fig. 1), its status appears to be uncertain or precarious in many of those countries (Table 1).

Austria

In Austria, the steppe polecat occurs in the Pannonian north-eastern parts of the country. The range more or less corresponds to the distribution of the European ground squirrel (Enzinger 2011) and includes the Lowlands of Northern Burgenland, Southern and Northern Wiener Becken, the Weinviertel, and the very eastern edge of the Waldviertel (e.g., Weitersfeld and Horn) (Spitzenberger 2001), which might represent the western limit of the Austrian distribution.

Hunting of polecats in Lower Austria is allowed during the entire year (NÖ Jagdgesetz 1974). In the Burgenland, hunting is allowed except during a closed season from the 16th March to the 31st May (Bgl. Jagdgesetz 2004). Analysis of hunting statistics shows a dramatic decline of killed polecats (European and steppe polecats are listed as a single species in hunting statistics: “polecats”) since 1970. Because the hunting of polecats in recent decades was carried out in predominantly open landscape in order to protect small game species, steppe polecats were especially at risk from intensive hunting (Spitzenberger 2005; Enzinger 2011; Neumann and Gnad 2011).

Historical data show that the steppe polecat usually was found in dry pasture grasslands in Austrian Pannonian lowlands, where European ground squirrels were numerous (Enzinger et al. 2006). However, the steppe polecat also inhabits cereal, clover, and root crop fields—habitats where European ground squirrels are rarely found (Spitzenberger 2001; Enzinger et al. 2006; Enzinger 2011). The species is listed as endangered in the Austrian Red List of threatened animals (Spitzenberger 2005).

Fig. 1 Current distribution of the steppe polecat *Mustela eversmannii* in Europe. *Black dots*—confirmed occurrence. Austria—Enzinger (2011); Bulgaria—Spasov and Spiridonov (2011); Czech Republic—Anděra and Červený (2009), Koubek and Červený (2001); Hungary—Ottlecz et al. (2011); Moldova—Munteanu and Lozanu (2004); Poland—Romanowski, personal communication, Ciechanowski and Bogdanowicz (2013), Romania—Botnariuc and Tatole (2005), Murariu and Munteanu (2005), Hegyeli (2009); Slovakia—Kristin et al. (2013); Ukraine—Volokh (2004)

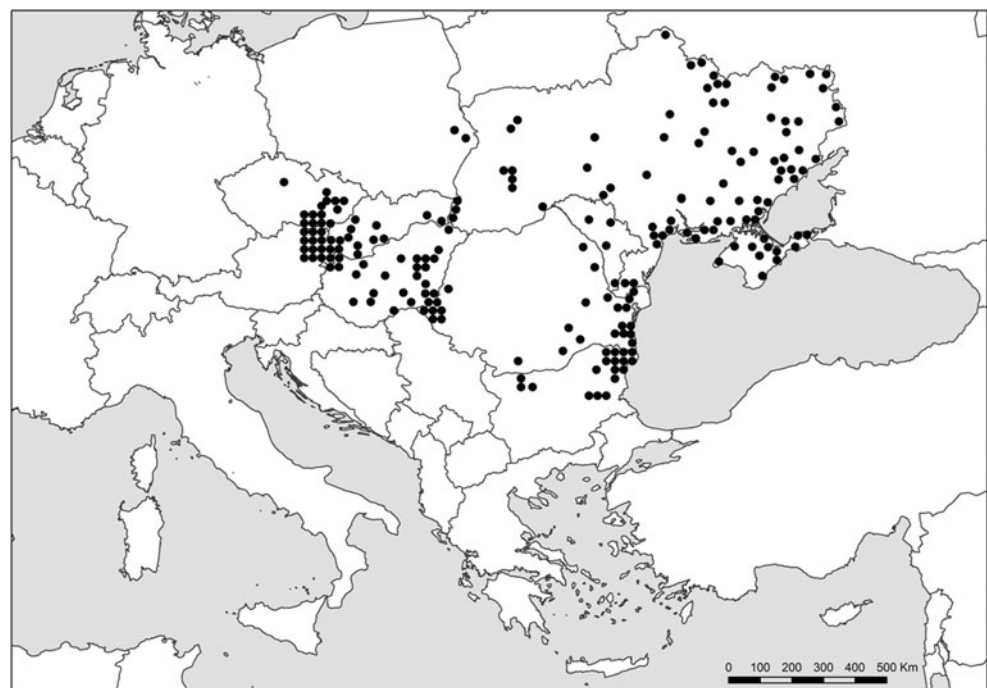


Table 1 Population trends and conservation status of the steppe polecat *Mustela eversmanii* in Europe

Country	Subspecies	Population trend estimate	Data quality	Hunting legislative	National red list status
Austria	<i>M. eversmanii hungarica</i>	Rapid decline	2	Game species	Endangered
Bulgaria	<i>M. eversmanii eversmanii</i>	Decline	2	Protected	Vulnerable
Czech Republic	<i>M. eversmanii hungarica</i>	Rapid decline	1	Protected	Endangered
Hungary	<i>M. eversmanii hungarica</i>	Stable	1	Protected	–
Moldova	<i>M. eversmanii eversmanii</i>	Rapid decline	2	Protected	Endangered
Poland	<i>M. eversmanii eversmanii</i>	Unknown	2	Protected	Near threatened
Romania	<i>M. eversmanii hungarica</i> , <i>M. eversmanii eversmanii</i>	Unknown	2	Protected	Vulnerable
Serbia	<i>M. eversmanii hungarica</i>	Unknown	3	Protected	–
Slovakia	<i>M. eversmanii hungarica</i>	Rapid decline	2	Protected	Data deficient
Ukraine	<i>M. eversmanii eversmanii</i> , <i>M. eversmanii hungarica</i>	Rapid decline	2	Protected	Endangered

Data quality: 1 = good, 2 = medium, 3 = poor (see “Material and methods”)

Bulgaria

The steppe polecat inhabits an area of about 20,000 km² in northeastern and north-central Bulgaria (Spassov and Spiridonov 2011). In the west, its range reaches the villages of Chomakovtsi (near the town of Cherven Bryag) and Kneja (Spassov and Spiridonov 1985, 2011; Spassov et al. 2002). The area of distribution is in general limited in the south by the Balkan mountains; however, it reaches its southeast margin on the southern slopes of the Eastern Balkan range at the Beronovo and Varbishki pass (very recent confirmation of this southernmost boundary of the species area in Europe: Spassov and Ivanov, unpublished data) as well as at Daskotna just to the north of the Aytos pass. An uncertain report exists for the Sofia region (Spassov 2007; Koshev and Genov 2008; Spassov and Spiridonov 2011). Since antiquity, boundaries of the species’ range have fluctuated due to climatic and anthropogenic changes that caused periodic forestation and deforestation; Early to Middle Holocene subfossils of the species are known from Northern Bulgaria and especially from the far northeastern part of the country, where the steppe influence was always present (Spassov 2007). Recent estimates suggest about 2,000 individuals with a probable density in the Dobruja region of 1 individual/5.5 km² and a density of 1 individual/12 km² in the rest of the territory (Spassov and Spiridonov 2011).

The primary habitats of the steppe polecat in Bulgaria are open steppe areas, meadows and pastures, small-scale arable fields as well as riverside shrubs, and small patches of forests on the periphery of open agricultural landscapes (Spassov and Spiridonov 1985; Spassov 2007). In the eastern Stara Planina mountains, at the periphery of its distribution, the species was recorded in non-typical, forested territories (results from phototraps). The species is protected in the country and in the updated Red Data Book of Bulgaria it is considered as vulnerable (Spassov and Spiridonov 2011).

Czech Republic

The database of steppe polecat records in the Czech Republic (1887–2006) contains about 130 localities (107 mapping quadrats of 11 × 12 km or 15.8 % of the country), lying predominantly in lowlands of Bohemia, Moravia, and the Czech part of Silesia (Anděra and Červený 2009). In the 1950s and 1960s, it was ascertained to be a rather common species, but it seems that its range has declined dramatically over the past 50 years (Kratochvíl 1962; Mazák 1965; Anděra and Červený 2009). The first records of the species are from the late nineteenth century (Southern Bohemia—České Budějovice and Strakonice regions, Hanák and Mazák 1965; Mazák 1965) and early twentieth century (Northern Bohemia—Teplice region, Jirsík 1952; Silesia—Opava region, Beneš 1985). However, at this time, it was confused with the European polecat, and accurate data were obtained only after the re-examination of museum specimens. The current distribution of the steppe polecat covers mainly the lowland areas of southern Moravia (roughly south of Olomouc). Rarely, it is found on the border of central and eastern Bohemia (Koubek and Červený 2001; Anděra and Červený 2009).

In the Czech Republic, the steppe polecat is a typical inhabitant of the so-called cultivated steppe. The steppe polecats are typically found in dry and open habitat types in agricultural landscapes, with fields accompanied by game sanctuaries, coppices, fallow land, bushy hedges, overgrown gullies, and abandoned quarries (Anděra and Červený 2009). For shelter, it utilizes the burrows of the European ground squirrel, common hamster, and European rabbit *Oryctolagus cuniculus*, in addition to rock cavities, heaps of debris and rocks, as well as spaces among tree roots. It does not occur in continuous woodland and human settlements. The majority (89.9 %) of occupied localities are

situated in altitudes below 400 m a.s.l. (mean=273, $n=136$). In the Red List of mammals of the Czech Republic, it is listed as an endangered species (Anděra and Červený 2003) and its hunting is prohibited.

Germany

The possible occurrence of the steppe polecat in Saxony as well as in the whole of Germany was summarized in the Atlas of Saxonian Mammals (Hauer et al. 2009). In 1934, a pelt assigned to the steppe polecat was found in Saxony close to the Czech border; however, it was later re-determined as belonging to the European polecat. Similarly, a possible record of a juvenile individual found in 1997 in southern Saxony was questioned. Thus, occurrence of the steppe polecat has not yet been reliably demonstrated in Germany.

Hungary

Ottlecz et al. (2011) evaluated 629 records of the steppe polecat in Hungary for the period 1900–2010, confirming the presence of the species in 106 (10×10 km) UTM quadrats covering 10.1 % of the country's UTM grids. During 1900–1990, steppe polecats were documented in 66 quadrats, but during 1990–2010, they were found in 51 quadrats. The steppe polecat is distributed mostly in the following regions: (1) the Great Hungarian Plain, which is situated in the eastern and southeastern part of Hungary (Csongrád, Békés, Jász-Nagykún-Szolnok, and Hajdú-Bihar county) and (2) the Little Hungarian Plain, situated in northwestern Hungary on the border with Austria and Slovakia (Győr-Moson-Sopron county). The species has also been found in the southwestern (Zala county), central (Fejér county), and northern part of Hungary (Nógrád and Borsod county), indicating a more widespread distribution than previously thought (see also Heltai 2002).

The steppe polecat is a typical inhabitant of open grassland areas, pastures, meadows, and agricultural fields, but does not occur in large forest areas as well as human settlements (Széky 1974). It occurs to a smaller extent in hilly and mountain habitats (Lanszki et al. 2007). The steppe polecat is protected from hunting.

Macedonia

There is only one record of a steppe polecat skull from the southeastern part of Macedonia—Valandovo (Milenkovič 1990). The identification was based on the shape of the postorbital constriction; however, due to variability of the European polecat from Turkish Thrace, the designation was later questioned (Kurtonur et al. 1994; Kryštufek and Petkovski 2003).

Moldova

The steppe polecat was common and widespread over all Moldova during the 1950s–1960s, and it numbered about 2,000 individuals (Corcimari 1965; Munteanu and Lozanu 2004). Due to loss and degradation of steppe habitats, large-scale changes in land use and intense extermination of the main prey (i.e., the European ground squirrel and the speckled ground squirrel *Spermophilus suslicus*), its population became fragmented and rapidly declined (Munteanu and Lozanu 2004). At present, the species is represented by about 150 individuals and found in only a few places, and it continues to decline (Munteanu and Lozanu 2004). The species inhabits open land ecosystems, mostly steppe regions in the northern (Balti steppe) and southern (Bugeac steppe) parts of the territory. The steppe polecat is classified as endangered in the second edition of the Red Book of Moldova (The Red Book of the Republic of Moldova, 2001).

Poland

The first record of the steppe polecat in Poland occurred in 1970 in the southeastern part of the country (Buchalczyk and Ruprecht 1975) and later was proven only from several other localities in this region (Romanowski 2004). Presently, *M. eversmanni* is an extremely rare species, restricted to a few xerothermic sites in eastern Poland, where it appears sporadically on scarce patches of steppe-like grasslands (Romanowski, personal communication; Ciechanowski and Bogdanowicz 2013). The steppe polecat is strictly protected and listed as near threatened in the Polish Red book (Głowaciński 2001).

Romania

The Romanian distribution, current and historical, of the steppe polecat is largely unknown. While generally accepted that it is present in Romanian Dobruja (Wolsan 1999; Botnariuc and Tatole 2005; Murariu and Munteanu 2005), data on its occurrence outside this region also exist. Barbu (1971) provides information on its presence from three sites in Muntenia and one from Oltenia region of southern Romania (see also Almășan 1962; Barbu and Barbu 1968). Nevertheless, these four records, two of which were cited by Wolsan (1993), have been subsequently neglected in relevant literature (Botnariuc and Tatole 2005; Wolsan 1999; Murariu and Munteanu 2005). The distribution of the steppe polecat has been confirmed in the southeastern part of Romania—Dobruja region (Botnariuc and Tatole 2005; Murariu and Munteanu 2005). Its distribution was mainly recorded from steppe habitats and pastures in Constanța and Tulcea counties of Dobruja and the Măcin Mountains (D. Murariu, personal communication); however, we lack any

quantitative information. Recently, the occurrence of the steppe polecat was confirmed at several other sites around Romania, indicative of a more widespread distribution. Hegyeli (2009) provided the first data about the occurrence of the species in Western Romania, namely in Timiș and Arad counties. This population is probably connected with the steppe polecat distribution in Eastern Hungary (Lanszki et al. 2007; Otlecz et al. 2011). Similarly, three new records of the species' presence were obtained in Moldavia (eastern Romania) and Muntenia (southern Romania) regions (Hegyeli, unpublished data). The total population of the steppe polecat in Romania was estimated at 1,000 individuals (Botnariuc and Tatole 2005); however, the estimate is not based on scientific data. The steppe polecat primarily inhabits the steppe and arid plains, and records suggest that in some regions, they frequently use agricultural habitats (Murariu and Munteanu 2005; Hegyeli 2009; Hegyeli, unpublished data), which is also the case in Hungary (Lanszki et al. 2007; Otlecz et al. 2011). The species is listed as vulnerable in the Red Data Book of Romanian Vertebrates and its hunting is prohibited according to the Romanian hunting legislation.

Serbia

The steppe polecat is known only from the northern part of Serbia—Vojvodina (Serbian part of the Pannonian plain), which is characterized by lowlands used mainly for agriculture. The Sava and Danube rivers form the southernmost natural border of its distribution (Mirić 1976). The recent distribution and population status of the species in Serbia is generally unknown (D. Čirović, personal communication). The steppe polecat is a strictly protected species and its hunting is prohibited.

Slovakia

Historical data on the occurrence of the steppe polecat in Slovakia are extremely scarce (Mazák 1965); therefore, both distributional and population trends are difficult to assess. It seems that the distribution is limited to the lowlands and uplands south of the Tatra Mountains. In total, the steppe polecat occurred in 53 mapping squares (11×12 km) of the Slovak Fauna Databank representing about 12.3 % of Slovakia's territory (Kristin et al. 2013). Its present distribution is not well known and it is probably limited to the southern, mainly Pannonian, area of Slovakia. Most records are concentrated in southwestern Slovakia. The population in the southeastern part of the country (Východoslovenská nížina, near Košice) is probably connected with the steppe polecat distribution in the westernmost part of Ukraine (Volokh 2004). Most findings of the steppe polecat were recorded from lowlands (120–350 m a.s.l.). It primarily

inhabits dry field habitats with hedges and dry embankments in agricultural landscapes and is frequently found in roosting sites of its main prey species, e.g., European ground squirrel, common hamster, and European rabbit. In Slovakia, the steppe polecat is protected through hunting legislation and is listed as data deficient in the Red List of plants and animals of Slovakia (Žiak and Urban 2001).

Ukraine

In the 1970s, the steppe polecat population was estimated at about 30,000 individuals (Volokh 2004). Widespread fur harvesting in the first half of the twentieth century, perhaps exacerbated by reductions in rodent populations, resulted in a visible decline in numbers (Volokh 2004). The steppe polecat is distributed, according to data from 1990 to recent times, throughout all the territories of Ukraine (but mainly in its eastern part), but its status and numbers are poorly known. Despite weaknesses in the data, a precipitous recent decline in numbers has been detectable. It is rare in the peri-Carpathian and Polesie regions and more abundant in steppe and forest steppe areas. Recently, the species is considered rare in Ukraine and its numbers are low even in typical steppe regions such as Dnepropetrovsk, Zaporozhie (Volokh 2004). Not long ago, it was widespread throughout the Crimea region, especially in the open lands of the Kerch peninsula and the Sivash coastal territory, but more recently it is rare there also, likely due to the degradation and loss of the steppe habitats and intensive canal building (Volokh 2004). The population decline is illustrated by the situation in the Donetsk–Priaзовian steppe region, especially the natural reserve of “Streltsovskiy steppe.” The population density was 100–150 individuals/10 km² in the 1970s, 11.5 individuals/10 km² in 1995, and only 1.9 individuals/10 km² in 1997–1998. A similar situation observed in Chernomorskiy State Reserve seems quite dramatic: a density of 30–50 individuals per 1,000 ha in the 1970s, but only 15–20 individuals for the entire nature reserve (73 km²) in the year 2000 (see Volokh 2004 for more citations). The species probably disappeared from the territory of the Transcarpathian region (probably due to the disappearance of the European ground squirrel in the same area) (Bashta and Potish 2007). Its survival is largely dependent on steppe rodents, as well as reversing the trend for destruction and fragmentation of steppe biotopes (Volokh 2004). The species is listed as vulnerable in the Red Data Book of Ukraine (Akimov 2009).

Discussion

The steppe polecat was a widely distributed carnivore species in the open steppe and agricultural landscapes of Central and Eastern Europe during the first half of the twentieth century (e.g., Kratochvíl 1962; Mazák 1965;

Wolsan 1993, 1999). From the 1960s to the 1990s, population declines across much of its European distribution range were recorded. The results of our review suggest that populations continue to decline in most of the studied countries, leading to fragmentation and local population extinctions at the beginning of the twenty-first century (e.g., Anděra and Červený 2009). The species was assessed as “rapidly declining” in the Czech Republic, Austria, Slovakia, Moldova, and Ukraine; “declining” in Bulgaria; and “stable” in Hungary. General conclusions about the distribution and population status of the steppe polecat are frustrated by its cryptic and secretive habits, making it extremely difficult to monitor accurately. Quality of data used in this study varies among countries. In some regions, distribution and population trends were estimated by local experts based on a general impression rather than a scientific methodology (e.g., Serbia), and thus, the reliability of the data is lower. In other regions, long-term nationwide standardized monitoring allowed us to compare relative population trends. For example, in the Czech Republic, the steppe polecat occurred in 48.3 % of quadrats in the period 1951–1980, declining to 25.2 % in 1981–2009, and just 2.7 % after 2000, which probably represents the current distribution of this species (Anděra and Červený 2009). The data for Ukraine demonstrate a dramatic decline in numbers from the 1970s to the end of the twentieth century. The population density decreased by a factor of 50–60 times in natural steppe regions, after agriculture land reclamation (Volokh 2004). In Bulgaria, the overall distribution of the species remained fairly static during the 1960s and 1970s; however, strong fragmentation of populations and a decrease in numbers seemed apparent (Spasov and Spiridonov 2011).

Additionally, population trends could be also estimated from annual counts of harvested individuals provided by regional hunting associations (Helldin 2000). In the case of the steppe polecat, however, this approach is limited by the high risk of confusion with the European polecat *M. putorius* (e.g., Koubek and Červený 2001; Anděra and Červený 2009); thus, the number of harvested individuals is given for both polecat species together. Furthermore, the European polecat can be legally harvested in all countries which also have steppe polecat, and thus, a high risk of confusion between the two polecat species could result in poaching of steppe polecats. Comparison of the numbers of harvested polecats of both species combined during 1983–2010 in Lower Austria showed a 66 % decline over 30 years (Enzinger 2011). However, as hunting statistics only show the number of killed individuals, the question of causality still remains; are the numbers dependent on the prevalence of polecats or on the hunting intensity? Similar to the Austrian statistics, the number of harvested polecats in Slovakia declined by about 90 % during the years 1968–1994 (Kristin et al. 2013).

The original/native habitat of the steppe polecat is represented by dry and open steppe landscapes. This habitat remains present in vast areas of its eastern distribution area in Southern Russia and Central Asia (Wolsan 1999); however, in Europe, its occurrence in steppe habitats is primarily concentrated in Ukraine, Moldova, eastern Romania, and northern Bulgaria (Spasov and Spiridonov 1985; Volokh 2004; Spasov 2007). In most of its European range, the steppe polecat inhabits open agricultural landscapes consisting of a mosaic of grasslands, small parcel fields with hedges, and dry embankments. In some parts, the species occurs in xerothermic habitats such as abandoned quarries, fallow land, and heterogeneous forested patches; however, it is not found in large and densely forested areas (Anděra and Červený 2009; Lanszki et al. 2007; Ottlecz et al. 2011).

Intensive agricultural production and land reclamation along with use of rodenticides and connected with the degradation or loss of steppe and grassland habitats are the crucial factors in the species' population decline (Spasov and Spiridonov 1985; Wolsan 1993; Volokh 2004; Anděra and Červený 2009). Central and Eastern European agricultural landscapes have undergone substantial changes in structure, composition, and management practices in recent decades. In some regions, previously diverse farmlands that practiced small-scale crop rotation (high spatial heterogeneity) beneficial to wildlife were subsequently converted into large monocultures of intensive farming in order to increase yields (Veen and Molnar 2001; Jongman 2002; Čížek et al. 2012). This trend is most obvious in heavily farmed lowland landscapes with fertile soils, which are important areas for the steppe polecat in Europe (Wolsan 1993; Anděra and Červený 2009). The proportion of natural and semi-natural patches, such as steppe and grasslands, which are vital habitats for steppe polecats, significantly decreased as they were converted to cultivated land (Tye 1991; Sundseth 2009). In contrast, in recent decades, grasslands have been negatively influenced by the opposite process, the abandonment of farmed or grazed landscapes. Socio-economic changes in parts of Central and Eastern Europe have thus led to reversion of some grassland to shrub- and forest-dominated landscapes (Kuemmerle et al. 2009; Müller et al. 2009; Baumann et al. 2011). Although in the early stages of succession this could lead to an increase in diversity of open farmland specialist species, in the long term, farmland habitats could degrade and eventually disappear (Preiss et al. 1997; Suárez-Seoane et al. 2002; Moreira and Russo 2007; Sirami et al. 2008; Vallecillo et al. 2008). This is known to be an important factor for steppe polecat decline in the Black Sea region (Volokh 2004; V. Nistreanu, personal communication). The protection of steppe and grassland habitats and the formulation of proper management activities (e.g., prevention of overgrowing or overgrazing) should be crucial for the conservation of steppe polecat

populations (Spassov and Spiridonov 2011). In human-dominated agricultural landscapes, the maintenance of landscape structures such as corridors, hedgerows, or forest edges with structurally diverse vegetation composition could be essential for providing breeding sites and shelter for carnivores (Šálek et al. 2009, 2010; Svobodová et al. 2011; Červinka et al. 2011; Červinka et al. 2013). Moreover, these habitats are also known to be important for several rodent species (e.g., *Microtus* sp., *Apodemus* sp.; Abramsky 1981; Todd et al. 2000; Miklós and Žiak 2002), that are important prey of the steppe polecat in intensively used agricultural landscapes (Ottlecz 2010).

Agricultural intensification and the other extreme, complete lack of any agricultural activities leading to their abandonment and subsequent succession to shrubby meadows and woods are also often cited as primary factors of decline for the European ground squirrel and common hamster (Enzinger et al. 2006; Matějů et al. 2008), which constitute the important prey for the steppe polecat (Kratochvíl 1962; Wolsan 1993; Lanszki and Heltai 2007). The sympatric spatial co-occurrence of ground squirrels and hamsters with the steppe polecat is often referred to as a crucial factor of its distribution (Spassov and Spiridonov 1985; Wolsan 1993; Spitzenberger 2001; Koshev and Genov 2008; Anděra and Červený 2009; Spassov and Spiridonov 2011; Kristin et al. 2013). During the twentieth century, local populations of both rodent species, however, experienced decreases of up to 80 %, and in many regions of Central and Eastern Europe, their distribution is severely fragmented (Wolsan 1999; Enzinger et al. 2006; Matějů et al. 2008; Weinhold 2008). This has only become apparent during the last 10 years when a 30 % decline in the total populations of both species was recorded (Coroiu et al. 2008; Kryštufek et al. 2008). A similar population trend was also recorded for the Romanian hamster *Mesocricetus newtoni* and speckled ground squirrel, which co-occur with the steppe polecat in the Black Sea region (Wolsan 1999; Coroiu and Vohralík 2008; Shekarova et al. 2008; Zagorodnyuk et al. 2008). Similarly, the decline of its primary prey and habitat loss are cited as the most important reasons for the population decrease of the marbled polecat *Vormela peregusna*, which has a sympatric distribution with the steppe polecat in the Black Sea region (Spassov et al. 2002).

Another important factor that may negatively affect the steppe polecat is lower landscape permeability due to the rapid spread of traffic infrastructure (Csathó and Csathó 2009; Hegyeli 2009). The disintegration of the formerly permeable landscape due to the proliferation of barriers and roads could result in the isolation of remaining populations by reducing dispersal or lead to a higher probability of collisions with vehicles (Grilo et al. 2009). For example, road mortality has been identified as a major anthropogenic factor of European polecat mortality (Blandford 1987; Kristiansen et al. 2007). Human persecution, such as

hunting and fur trapping, which historically had a serious impact on survival rates and other demographic attributes of steppe polecat, now poses a far lower threat due to legal protection in most European countries (except Austria). Finally, increasing densities of some medium- or large-sized generalist carnivores (or even smaller but purely carnivorous rodent-eaters), such as stone martens *Martes foina*, red foxes *Vulpes vulpes*, golden jackals *Canis aureus*, stoats *Mustela erminea*, and least weasels *Mustela nivalis* (Panek and Bresinski 2002; Červený et al. 2003; Volokh 2004; Spassov 2007; Arnold et al. 2012), could lead to increased interspecific competition and/or predation of the steppe polecat and should therefore be an important consideration in its conservation.

Conclusions

Our results suggest that steppe polecat populations are rapidly declining across large parts of the European range of the species, but trends in some regions are difficult to assess due to a general lack of knowledge and the limited availability of research and surveys. Research on the steppe polecat should focus on assessing its current distribution, population densities, and conservation status across different regions and on identifying habitat types important for the species, to provide the first steps in its effective conservation and management. Information about population dynamics and densities in its original steppe habitats is particularly poor. Furthermore, it is crucial to evaluate its tolerance to habitat modifications/loss and land use management, especially in intensively used farmlands where substantial reduction of the natural and semi-natural vegetation has taken place, or conversely, in abandoned habitats with declining farming and grazing. To answer these questions, adaptive habitat modeling based on detailed knowledge of the species' habitat/spatial use and distribution and GIS-based models seems to be a very promising approach (Gough and Rushton 2000). The modeling might serve as a predictor of the impact of land use or different climate scenarios on the species' occurrence and distribution (Thomas et al. 2004; Araújo and New 2007), the identification of suitable areas with high potential for the species to inhabit (Engler et al. 2004; Guisan and Thuiller 2005), and for the assessment of potential threats and effective conservation actions (Rushton et al. 2004; Burneo et al. 2009). The modeling approach could not, however, serve as a substitute for the collection of field data including steppe polecats' population dynamics, population densities, interspecific interactions, or mortality factors, and these results should be published in peer-reviewed journals.

Also, there is a need for more detailed information on the steppe polecat's spatial relationships with ground squirrels and hamsters across different parts of its distribution range.

The rapid decline of its primary prey could cause a shift in its prey preferences and feeding habits, as well as other aspects of the species' ecology and behavior, e.g., resting site selection (Kristin et al. 2013). Increases in the availability of ground squirrels, hamsters, and other small mammal prey species (Ottlecz 2010) seem to be essential in supporting steppe polecat populations (Wolsan 1993; Volokh 2004; Enzinger 2011; V. Nistoreanu, personal communication) and other endangered (steppe-dwelling) species such as the marbled polecat (Spassov et al. 2002; Gorsuch and Larivière 2005), Eastern Imperial Eagle *Aquila heliaca* (Kovács et al. 2008), and Saker Falcon *Falco cherrug* (Nagy and Demeter 2006).

Finally, the rapid development of molecular methods offers great opportunities to study various aspects of the species' population dynamics—population genetics, dispersal, gene flow, phylogeographic patterns—and to provide estimates of population size (Freeland et al. 2011). The severe population decline and fragmentation of the steppe polecat populations could reduce genetic diversity, leading to inbreeding depression and low adaptability to changing human-dominated ecosystems (Maudet et al. 2002). Moreover, there is a growing conservation concern about the genetic integrity of the steppe polecat due to possible hybridization with the European polecat, the two species coexisting throughout most of their European range (Wolsan 1999). Hybridization may be occurring through direct contact with widespread free-ranging domestic ferrets *Mustela cf. furo* (Vallo et al. 2007). Although ferrets were most probably domesticated from European polecat in North Africa (Sato et al. 2003), human movements and captive breeding may have led to the mixing of genes from both polecat species (Davison et al. 1999) and may thus facilitate gene flow between the species in the wild. The first insight into the genetic situation of polecats in the Czech Republic was provided in a pilot study by Vallo et al. (2007), who analyzed specimens of both the European and steppe polecats from Central Europe and compared them to available data from Western Europe and Central Asia. Surprisingly, the Central European steppe polecats revealed a close evolutionary relationship with European polecats, while being paraphyletic with respect to Central Asian steppe polecats. This paraphyly made the actual status of Central European steppe polecats highly questionable and raised the suspicion of past or recent interspecific hybridization with the European polecat (Wolsan 1993). Introgressive hybridization of the endangered steppe polecat with European polecats or ferrets may have significantly affected local populations, leading to a loss of genetic diversity and eventually local extinctions (Allendorf et al. 2001; Randi 2008); however, this subject, along with the issue of genetic pollution, needs further investigation.

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