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SHORT COMMUNICATION

The German wildlife information system: population densities and development of European Hare (*Lepus europaeus* PALLAS) during 2002–2005 in Germany

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Abstract The German Wildlife Information System, founded in 2001, is a long-term monitoring program documenting occurrence, number, and development of game populations throughout Germany. Population numbers are recorded by standardized counting methods in so-called reference areas. The population densities of the European hare are calculated by spotlight strip censuses in the reference areas each spring and autumn all across Germany. From 2002 to 2005, the censuses were carried out by local hunters in 510 to 676 reference areas each year. During these years, the calculated spring densities increased significantly from 11.0 (2002) to 14.5 hares/km^2 (2005) nationwide. The overall increase in spring densities was primarily caused by the population rise from spring 2003 to 2004, which correlates with the high net growth rate in 2003. In 2005, the number of counted hares varied between less than 1 and more than 107 hares/km^2 in spring and between 0 and more than 170 hares/km^2 in autumn. Because of differing landscapes in Germany, three regions were differentiated. In spring 2005, the average population densities (median) in East Germany (5.4 hares/km^2) and Southwest Germany (14.6 hares/km^2) were significantly lower than in Northwest Germany (23.9 hares/km^2). These regional differences had been similarly distinct in former years.

Keywords Monitoring · Reference areas · Spotlight census · Net growth rate · Population growth rate

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Introduction

WILD (Wildtier-Informationssystem der Länder Deutschlands) was founded in 2001 and is the first monitoring program recording population sizes of huntable and nonhuntable game species throughout Germany. The project was initiated on behalf of the German hunting association (Deutscher Jagdschutz-Verband e.V.) as a permanent integral part of environmental assessment with the aim to develop strategies for conservation and sustainable use of game populations.

The hare populations declined in many European countries in the 1960s to the 1990s (e.g., Smith et al. 2005). In Germany, substantial differences in the development of the hare populations in East and West Germany are remarkable. Whereas in East Germany, the population reduced strongly at the beginning of the 1960s, in many regions of West Germany, the decline took place between 1980 and 1990 (Deutscher Jagdschutz-Verband e.V. 2004; Strauss and Pohlmeyer 2001). Since the middle of the

1990s, the population seems to have been stable or has been slightly rising all over Germany, respectively.

Intensification of agriculture and predation are the most mentioned causes for the declines (Jennings et al. 2006; Panek et al. 2006; Schmidt et al. 2004), although the main influencing factors (e.g., climate, habitat, predator) differed in all studies.

As a result of the different used methods, a comparison of densities of local (hare) populations on a German level was not possible. Therefore, WILD established a network of so-called reference areas, in which the densities of European hare (*Lepus europaeus*), red fox (*Vulpes vulpes*), badger (*Meles meles*), and the carrion crow (*Corvus corone*) are recorded using standardized methods. In addition, the numbers of breeding pairs of partridges (*Perdix perdix*) are estimated in a multitude of hunting grounds. These data serve as a basis for further research.

For the years 2002–2005, densities, developments, and growth rates of the European hare will be described in this short communication.

Materials and methods

Since 2002, the project has established more than 800 reference areas, evenly distributed all over Germany. The mean size of the reference areas is 738 ha (minimum 95, maximum 4,500 ha). Because of several reasons (e.g., organizational matters, weather, etc.) the number of reference areas providing data differs within the years and seasons.

Within WILD, hares are counted with spotlight strip censuses (Langbein et al. 1999; Pegel 1986; Salzmann-Wandeler and Salzmann 1973) by local hunters. The hunters are instructed and trained according to the WILD manual, which includes detailed descriptions of the used methods (Deutscher Jagdschutz-Verband e.V. 2003). Here are just some references to the method:

1. The census is carried out in spring (March and April) and autumn (October–December), each time before vegetation growth and after the harvest.
2. Two censuses are conducted for each reference area and in each season.
3. In case the results of these two censuses diverge more than 25%, a third census will be conducted.
4. The range of the used spotlight is approx. 150 m.
5. The illuminated area should be at least 200 ha.
6. The illuminated area should be evenly distributed and representative for the open landscape of the reference area.

The seasonal density of hares (N hares/km^2 illuminated area) in a reference area is ascertained by the average number of hares and the average illuminated area during all spotlight strip censuses in a reference area per season. The net growth rate (%), as a result of reproduction, mortality, and dispersal (Pegel 1986; Pfister 1984; Rimathé 1977), is estimated by accounting for the difference of spring and autumn density in one year (see Formula 1).

$$\text{net growth rate}\,[\%] = \frac{\left(\text{density}_{\text{autumn}} - \text{density}_{\text{spring}}\right) \times 100}{\text{density}_{\text{spring}}}$$

The population growth rate (%) from year to year is calculated by the spring density of those reference areas in which the populations were surveyed in any two consecutive years (see Formula 2). Data from reference areas where no survey was conducted in consecutive years are not considered.

$$\text{population growth rate}\,[\%] = \frac{\left(\text{density}_{\text{spring(year}+1)} - \text{density}_{\text{spring(year 0)}}\right) \times 100}{\text{density}_{\text{spring(year 0)}}}$$

Because of the differing landscapes in Germany, three regions were distinguished. The federal states Bremen, Hamburg, Lower Saxony, Northrhine-Westphalia and Schleswig–Holstein are considered in the region Northwest Germany, including the western parts of the German lowlands. This area is influenced by the Atlantic climate (e.g., Hamburg, average temperature (a) winter 3.9°C, (b) summer 11.9°C, precipitation=650 mm per annum) and has intensively farmed land. The federal states Berlin, Brandenburg, Mecklenburg Western Pomerania, Saxony, Saxony–Anhalt, and Thuringia are in the region East Germany and belong mostly to the eastern parts of the German lowlands. A continental climate (e.g., Berlin, average temperature (a) winter 4.3°C, (b) summer 13.0°C, precipitation=450 mm per annum) influences this region as well as intensive agricultural management. The main difference in agricultural practices between the East German region and the two other regions is reflected in the field size, which is, in East Germany, larger by far. The landscapes of the federal states Baden-Württemberg, Bavaria, Rhineland-Palatinate, the Saarland, and Hesse—grouped into Southwest Germany—are dominated by low mountain ranges (altitudes 250 and 700 [1,200] m above sea level) with various landscape structures and climatic conditions. In these areas, high- and low-productive agricultural regions alternate.

Results

During springtime and autumn in the years 2002–2005, spotlight censuses were carried out in 518–688 reference areas of approximately 166,000–206,000 ha for each season. The mean illuminated surface per reference area ranged from 261 to 285 ha.

Table 1 Density and net growth rate of the European hare in Northwest, Southwest, and East Germany in 2005

Regions	Spring density 2005				Autumn density 2005				Net growth rate 2005			
	Number	Median	Min	Max	Number	Median	Min	Max	Number	Median	Min	Max
		(hares/km^2)				(hares/km^2)				(%)		
Northwest Germany	271	23.9	2.6	107.2	280	28.5	3.6	147.0	239	18.5	−53.2	175.8
Southwest Germany	188	14.6	1.9	73.4	158	15.7	2.1	170.3	127	3.3	−70.4	244.0
East Germany	176	5.4	0.2	48.3	180	5.0	0.0	48.0	161	−4.2	−100	538.1
Germany	635	14.5	0.2	107.2	618	15.2	0.0	170.3	539	8.7	−100	538.1

Densities and net growth rates in 2005

In Northwest Germany, the mean density of the hare was 23.9 hares/km^2 in spring 2005. The population densities in East Germany (5.4 hares/km^2) as well as in Southwest Germany (14.6 hares/km^2) were significantly lower than in Northwest Germany (analysis of variance [ANOVA], one-way, Duncan test, $p<0.05$).

The densities fluctuated to a great extent within the regions. The minimum densities of hares varied from 0.2 to 2.9 hares/km^2 in the three geographical regions, whereas the maximum was between 48.3 and 107.2 hares/km^2 (Table 1 and Fig. 1).

In comparison to the spring densities, autumn population densities also differed significantly between the three regions and were 28.5 hares/km^2 in Northwest Germany, 15.7 hares/km^2 in Southwest Germany, and 5.0 hares/km^2 in East Germany, again with great variances in each region (Table 1).

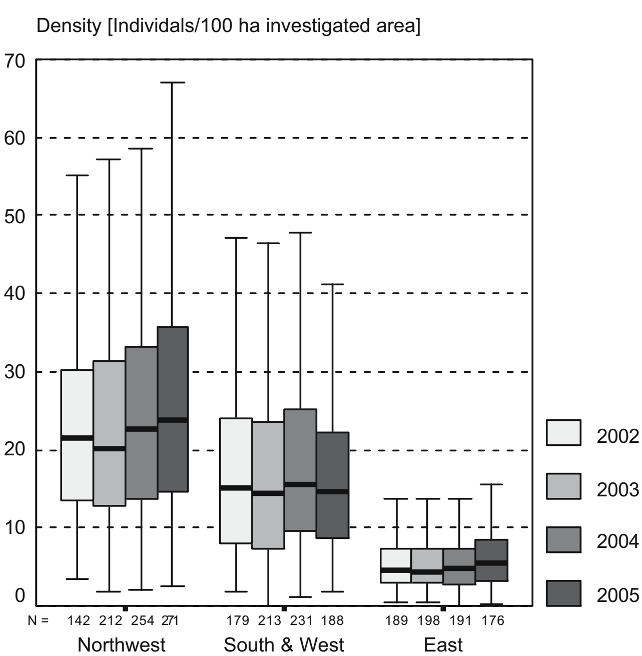

Fig. 1 Spring densities of hare in Northwest, Southwest, and East Germany from 2002 to 2005

The population densities are remarkably high in the very productive agrarian landscapes with intensive agriculture on fertile soils, for instance in the “Börde” regions, the Rhine Valley, and the Northwest German lowland. Similarly, high population densities can be found in the marshlands with intensive grassland managements in coastal regions (Fig. 2).

The differences in the population densities of the regions are clearly visible in the distribution of the density classes (Fig. 3). The majority of reference areas in Northwest Germany recorded between 10.0 and 30.0 hares/km^2. Reference areas with higher densities are not rare. In contrast, most of the reference areas in Southwest Germany recorded 5.0 to 20.0 hares/km^2, and the number of reference areas with lower densities increased. In East Germany, the reference areas with densities lower than 10.0 hares/km^2 predominated. None of the densities in these regions' reference areas exceeded 50 hares/km^2 either in spring or in autumn.

In 2005, the average net growth rate in Germany was 8.7% (Table 1). Differentiated analysis considering the aforementioned regions showed that the average net growth rates were (slightly) more positive in Northwest and Southwest Germany (18.5 and 3.3%, respectively), whereas the number of hares slightly decreased in East Germany from spring to autumn (−4.2%). Because of the high variances of the individual reference areas, no significant differences between the three regions could be determined.

In Northwest Germany, the values of the net growth rate of 2005 varied between −53 and 176%, whereas in 20% of the reference areas, net growth rates of 50–100% were achieved. In contrast, a higher proportion of reference areas with negative net growth rates were registered mainly in East Germany. More than half of the reference areas in East Germany indicated negative values. However, also in Southwest Germany, negative net growth was not unusual.

Development of the spring population densities from 2002 to 2005

Population data for the hare have been available since 2002 for most of the federal states of Germany. Considering the results of all reference areas, the average population density

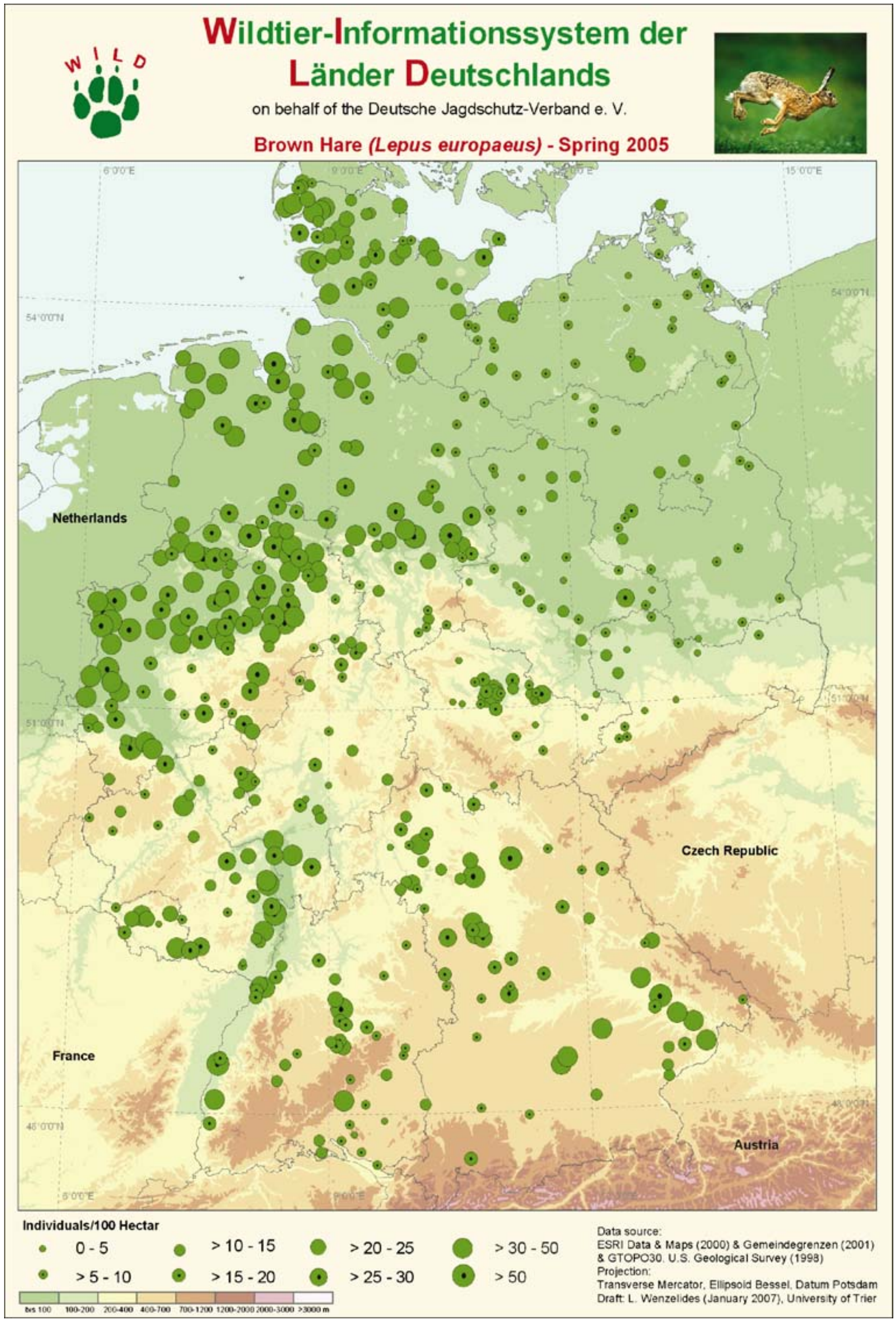

Fig. 2 Population density of European hare (*Lepus europaeus* PALLAS) in the reference areas of the German Wildlife Information System (WILD), spring 2005

of the hare increased significantly from 11.0 to 14.5 hares/km^2 in Germany (ANOVA, $p<0.05$) in the years from 2002 to 2005. This increase was essentially caused by the population increase in Northwest Germany from 21.6 to 23.9 hares/km^2 (+11%), while the highest population growth rate was documented for East Germany, where the mean population density increased from 4.6 to 5.4 hares/km^2 (+17%; Fig. 1).

With 12.5%, the increase in the population size in Germany from spring 2003 to spring 2004 was remarkably high, whereas the growth rates from 2002 to 2003 (−4.6%) and 2004 to 2005 (0.7%) were obviously smaller.

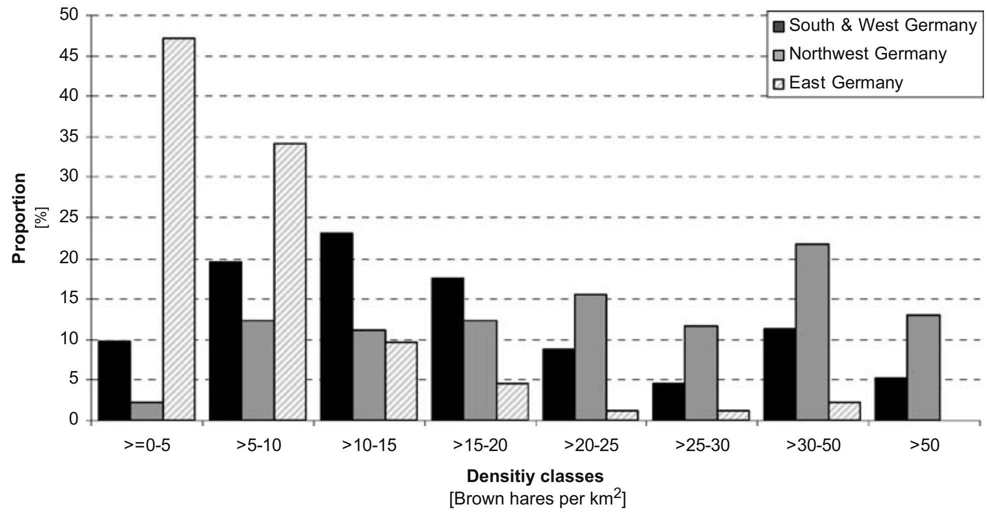

Fig. 3 Relative proportion of the density classes in spring 2005 in the three geographical regions (*N*=635 reference areas)

Discussion

Long-term monitoring programs such as WILD can only be established on a large scale using practical and reasonably priced methods and with the help of volunteers. Therefore, the spotlight strip census meets all requirements for evaluating the population densities of the hare. The method provides significant data (Pegel 1986; Pfister 1984; Rimathé 1977), although the real population densities are underestimated in general (Focardi et al. 2001).

Although the method is well trained, the fact that a lot of different volunteers carry out the censuses in different landscape structures needs to be considered. Thus, the data may deviate more from the real densities than results achieved by scientists.

In the future, the fluctuation of reference areas may influence the results. This challenge will be overcome by establishing new reference areas with regard to habitat structure in the region of the abandoned reference areas. The process will also pay attention to a random selection of a reference area.

In Germany, the population densities varied very much on a local and regional level between 0 and 107 hares/km^2 in spring 2005 and between 0 and 170 hares/km^2 in autumn 2005, respectively. Similar differences in densities are also documented in other studies (Becker 1997; Pegel 1986; Späth 1989; Strauss and Pohlmeyer 2001). In optimal habitats like the northwestern parts of the German lowlands, densities more than 100 individuals/km^2 are possible, although not common. On the other hand, the hare also colonizes in low mountain ranges, but as a result of poor habitat quality within these areas, population densities are lower. In Switzerland, for example, maximum densities do not exceed 19 hares/km^2 (Pfister et al. 2002).

In general, the highest densities of hare were recorded in intensively used agricultural landscapes in Northwest and Southwest Germany (Fig. 2). More than 30.0 hares/km^2 can be found regularly in areas with intensive crop farming. Such high densities can also be confirmed in the pastoral areas of Northwest Germany. Hence, the WILD results cannot give proof of the findings of Smith et al. 2005, pointing out low population densities in pastoral areas.

Hoffmann (2003), who analyzed 40 reference areas in Schleswig–Holstein, which are part of WILD, could not confirm coherences between densities and farming intensity (e.g., field size). This supports Smith et al. 2005, who stated that agriculture and landscape structures are not predominantly responsible for different densities. In contrast to this, the population densities have been significantly lower in East Germany than in Northwest Germany since implementing WILD. It can be assumed that the deviating agricultural structures in both areas (West and East Germany) are responsible for the different population densities. The main differences between the regions are predominantly linked to the size of the agricultural fields, which are larger in East Germany (a result of the agricultural system in the former German Democratic Republic) than in Northwest Germany (Strauss and Pohlmeyer 2001). To assess the influence of different landscape structures, biotope mapping is a part of the comprehensive study design.

The net growth rate between −4% in the East and +19% in Northwest Germany appears to be relatively low. However, it must be taken into consideration that the net growth rate also includes the mortality of the adult hares, which Pegel (1986) estimated at being about 30% during summer. Net growth rates of −19 to +250% are reported in a series of German investigations (Pegel 1986; Späth 1989). According to Averianov et al. 2003, the autumn population densities are on average about 50% higher than the spring densities.

Negative net growth rates, on the one hand, could be caused by methodological errors; with the hares frequenting different habitats in spring and autumn, incorrect results may occur here. On the other hand, diseases, especially those induced by unfavorable weather and predation, may cause an actual reduction in the hare population. In East Germany, a maximum net growth rate of more than 500% was essentially influenced by reference areas that had a spring density less than 1 hare/km^2 and a growth increase in few hares during summer. Although the absolute figures are small, high proportional net growth rates are the result.

To evaluate the population dynamic of populations of hares, continuous surveys are necessary in the same reference area. However, this cannot be ensured in a long-term monitoring program like WILD, as the investigations are conducted by volunteers. Therefore, the number of reference areas varies between and within the years because some were newly established and some did not participate any longer in the project.

Spring population densities of the hare in Germany increased on average significantly from 11.0 to 14.5 hares/km^2 between 2002 and 2005. The increased densities are primarily caused by the positive population growth from spring 2003 to 2004, this correlating with the high net growth rate in 2003. These high net growth rates may be caused by the climatic conditions during 2003. The summer of 2003 was the warmest summer since 1901, and the average precipitation was 23% below the long-time mean (DWD 2003). Reasons for the comparatively lower net growth rates in both of the other parts of Germany during the same year are unknown.

Focusing on the reference areas' level, some of the densities did not develop according to the regional trend. For example, in some reference areas, the number of hares decreased significantly. This could be a result of an outbreak of European Brown Hare Syndrome. The epidemic caused major decreases in the German hare populations during the 1990s (Eskens et al. 2000), and still, the virus is widespread within the hare population (Frölich et al. 2003). However, because accurate monitoring data are missing, coherences between occurrence of the disease and development of the density can only be assumed.

In future, further analyses in WILD will associate population development with landscape structure, climate data, and predation to obtain a detailed understanding of the processes within the ecosystem leading to different population densities of the hare in Germany.

References

Averianov A, Niethammer J, Pegel M (2003) *Lepus europaeus* PALLAS, 1778-Feldhase. In: Krapp F (ed) Handbuch der Säugetiere Europas. AULA, Wiebelsheim

Becker R (1997) Zum Ergebnis des hessischen Feldhasen-Untersuchungsprogramms. Beitr Jagd-Wildforsch 22:141–148

Deutscher Jagdschutz-Verband e.V. (eds) (2003) Wildtier-Informationssystem der Länder Deutschlands (WILD). Projekthandbuch, Bonn

Deutscher Jagdschutz-Verband e.V. (eds) (2004) DJV-Handbuch. Dieter Hoffmann, Mainz

DWD (2003) Witterungsreport. Jahresausgabe 2003. Deutscher Wetterdienst, Offenbach

Eskens U, Frölich K, Kugel B, Frost JW, Streich WJ, Bensinger S (2000) Seroepidemiologische Untersuchungen zur Verbreitung des European Brwon Hare Syndrome (EBHS) und der Rabbit Haemorrhagic Disease (RHD) in Feldhasenbeständen ausgewählter Reviere in der Bundesrepublik Deutschland. Z Jagdwiss 46:61–72

Focardi S, De Marinis AM, Rizzotto M, Pucci A (2001) Comparative evaluation of thermal infrared imaging and spotlighting to survey wildlife. Wildl Soc Bull 29:133–139

Frölich K, Wisser J, Schmüser H, Fehlberg U, Neubauer H, Grunow R, Nikolaou K, Priemer J, Thiede S, Streich WJ, Speck S (2003) Epizootiologic and ecologic investigations of European brown hares (*Lepus europaeus*) in selected populations from Schleswig–Holstein, Germany. J Wildl Dis 39:751–761

Hoffman D (2003) Populationsdynamik und -entwicklung des Feldhasen in Schleswig-Holstein im Beziehungsgefüge von Klima, Prädation und Lebensraum. Dissertation. Universität Trier Kiel, p 220

Jennings N, Smith RK, Hackländer K, Harris S, White PCL (2006) Variation in demography, condition and dietary quality of hares *Lepus europaeus* from high-density and low-density populations. Wildlife Biol 12:179–189

Langbein J, Hutchings MR, Harris S, Stoate C, Tapper SC, Wray S (1999) Techniques for assessing the abundance of Brown Hares *Lepus europaeus*. Mamm Rev 29:93–116

Panek M, Kamieniarz R, Bresiński W (2006) The effect of experimental removal of red foxes *Vulpes vulpes* on spring density of brown hares *Lepus europaeus* in western Poland. Acta Theriol 51:187–193

Pegel M (1986) Der Feldhase (*Lepus europaeus* Pallas) im Beziehungsgefüge seiner Um- und Mitweltfaktoren. Schriften des Arbeitskreises Wildbiologie und Jagdwissenschaft an der Justus-Liebig-Universität Gießen. Stuttgart, F. Enke Verlag, p 224

Pfister HP (1984) Raum-zeitliches Verteilungsmuster von Feldhasen (*Lepus europaeus* PALLAS) in einem Ackerbaugebiet des Schweizerischen Mittellandes. Diss Uni Zürich, Zürich

Pfister HP, Kohli L, Kästli P, Birrer S (2002) Feldhase. Schlussbericht 1991–2000: Bundesamt für Umwelt, Wald und Landschaft, Bern, und Schweiz. Vogelwarte, Sempach, p 150

Rimathé R (1977) Zur saisonalen Abundanzdynamik des Feldhasen (*Lepus europaeus* PALLAS) im Schweizerischen Mittelland. Diss Uni Zürich, Zürich, p 176

Salzmann-Wandeler I, Salzmann HC (1973) Erste Erfahrungen bei Feldhasenzählungen mit Scheinwerfern. Jahrb Naturhist Mus Stadt Bern 5:201–216

Schmidt NM, Asferg T, Forchhammer MC (2004) Long-term patterns in European brown hare population dynamics in Denmark: effects of agriculture, predation and climate. BMC Ecology 4:1–7

Smith RK, Vaughan Jennings N, Harris S (2005) A quantitative analysis of the abundance and demography of European hares Lepus europaeus in relation to habitat type, intensity of agriculture and climate. Mamm Rev 35:1–24

Späth V (1989) Untersuchungen zur Populationsökologie des Feldhasen (*Lepus europaeus* Pallas) in der Oberrheinebene. Univ. Diss., Freiburg im Breisgau, p 198

Strauss E, Pohlmeyer K (2001) Zur Populationsökologie des Feldhasen. In: Wo liegt der hase im pfeffer: Naturschutz und rote liste—Jagd und Hege? Tagungsband der Natur- und Umweltschutz-Akademie des Landes Nordrhein-Westfalen (NUA), Recklinghausen, pp 5–20