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Authors: Tillmann, Jörg E., Beyerbach, Martin, and Strauss, Egbert

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Original article

Do hunters tell the truth? Evaluation of hunters' spring pair density estimates of the grey partridge *Perdix perdix*

Jörg E. Tillmann, Martin Beyerbach & Egbert Strauss

Hunters' estimates of pair densities of the grey partridge *Perdix perdix* as derived from an annual questionnaire survey ('Game Survey Lower Saxony', WTE) were evaluated by comparison with detailed ground-truthing censuses in 123 randomly chosen hunting districts representing 63,847 ha potential grey partridge habitat. Estimates and evaluation-census-densities were highly significantly correlated. The median of the hunters' estimate errors, disregarding the direction of the relative discrepancy, was 24.2%. Hunters underestimated the density per 100 ha potential habitat by 0.16 breeding pairs on average. The discrepancy increased with higher grey partridge densities and increasing size of the hunting district. The satisfactory agreement between the estimates of the hunters, in most cases local farmers, and the evaluation survey is explained by their comprehensive year-round presence through their hunting, farming but also their leisure activities and their special interest in this charismatic bird combined with its site fidelity. We recommend the consultation of WTE data as a valuable source of basic information on distribution and abundance of grey partridges to identify spatial conservation priorities, to justify conservation initiatives and to adapt management practices.

Key words: adaptive management, conservation, grey partridge, hunters, Perdix perdix, questionnaire survey, wildlife monitoring

Jörg E. Tillmann & Egbert Strauss, Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover, Foundation, Bischhofsholer Damm 15, D-30173 Hannover, Germany - e-mail addresses: joerg.tillmann@tiho-hannover.de (Jörg E. Tillmann); egbert.strauss@tiho-hannover.de (Egbert Strauss)
Martin Beyerbach, Department of Biometry, Epidemiology and Information Processing (IBEI), University of Veterinary Medicine Hannover, Bünteweg 2, D-30559 Hannover, Germany - e-mail: martin.beyerbach@tiho-hannover.de

Corresponding author: Jörg E. Tillmann.

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Until the late 1970s, the grey partridge *Perdix perdix* was one of the most numerous birds in agricultural landscapes in Germany and of extraordinary significance as a game bird. The winter of 1978/79 resulted in a nationwide collapse of the grey partridge population due to a prolonged snow cover in combination with exceptionally unfavourable weather conditions during the reproduction seasons from 1979 to 1981, and unlike previous population declines, the population has never recovered from this collaps for various reasons (e.g. Tucker & Heath 1994, Potts 1997, Hagemeijer & Blair 1997, Putaala & Hissa 1998, Bro et al. 2000, Tillmann 2006, 2009, Joannon et al. 2008). This population history is representative of a dramatic decline in grey partridge numbers throughout its European range (compare Potts & Aebischer 1995, Hagemeijer & Blair 1997, Bro et al. 2001, Aebischer & Ewald 2004, De Leo et al. 2004, Panek 2005). Average spring densities in its currently populated habitats in Germany are estimated to be ca 1 pair/100 ha (Tillmann et al. 2007). The decline in hunting bags, which are considered to reflect coarse population trends in grey partridges, further illustrates the population collapse: in the German state of Lower Saxony, for example, annual grey partridge bags dropped from an average of 188,922 during 1936-1939 to only 797 in 2010. The 'unfavourable conservation status' of the grey partridge across the continent gave rise to the question, if legal hunting of the grey partridge was still justifiable.

According to the Red Lists of breeding birds, the grey partridge is of conservation concern in every federal German state, being categorised between 1 (critically endangered) and 3 (vulnerable). On the European level it is categorised as vulnerable (BirdLife International 2004). In Lower Saxony until 2006, the grey partridge was listed as critically endangered on the Red List (Südbeck & Wendt 2002). In the latest edition of the Red List of threatened birds in Lower Saxony (Krüger & Oltmanns 2007), the grey partridge is only listed as endangered. This is not due to a population recovery, but rather to a much more comprehensive survey of its status compared to the data basis of the list from 2002 (Tillmann et al. 2007).

On the other hand, the grey partridge still has an open hunting season in nine out of the 16 federal states in Germany. As a consequence, a conflict has evolved between the conservation status of the grey partridge and the fact that it is still being hunted.

It is commonly accepted that decisions concerning the management of wildlife have to be based on discreet information on the population status and dynamics as well as the distribution of the respective wildlife species. Consequently, hunting associations have been increasingly concerned with gathering data on wildlife populations to evaluate the sustainability of hunting, to document spatio-temporal changes in wildlife populations and changes in wildlife utilisation.

With the aim of monitoring wildlife populations, assessing hunting modalities and providing a database for decisions in the context of the hunting law and guidelines, the Hunting Association of Lower Saxony (Landesjägerschaft Niedersachsen, LJN) introduced the monitoring programme 'Game Survey Lower Saxony' ('Wildtiererfassung in Niedersachsen', WTE) in 1991. State-wide, every year, owners or tenants of each hunting district are asked to complete a questionnaire about their estimate of the numbers of grey partridge pairs in spring among other questions about further wildlife species in their hunting district. However, these data provided by hunters are subject to much criticism. The objections include the validity of the data gathered by hunters, as little is known about how hunters arrive at their estimates, and as to whether their data might be adjusted to assuage political pressures. In our study, hunters' estimates on grey partridge densities are for the first time evaluated using the example of the WTE in Lower Saxony. Data accuracy was assessed by ground truthing, and the data quality is discussed in light of the background of the social environment of the responsible hunters.

Methods

Selection of study areas

In Lower Saxony, on average 89.3% out of 8,067 private hunting districts participate in the WTE each year. In order to evaluate the WTE-data concerning the estimates on grey partridge spring densities, a total of 137 hunting districts in Lower Saxony were randomly chosen. More than 90% of the initially contacted tenants or owners of hunting districts agreed to participate in the grey partridge count (N = 123). The tenants or owners of the hunting districts were not enlightened that these counts were conducted in order to evaluate their estimates as given in the context of the WTE. The hunting districts had to fulfil the following criteria: the tenants or owners of the hunting district had to have been participating in the WTE on a regular basis, and the hunting districts had to be at least 200 ha in size. To explicitly select hunting districts with minimum 100 ha of potential grey partridge habitat, only districts with a maximum forest cover of 50% were accepted. The evaluation took place during the springs of 2002-2006 including 15-36 hunting districts/year.

Evaluation census

The counts were organised and coordinated by a field researcher from the Institute of Wildlife Research and a field ornithologist from the Ornithological Station of Lower Saxony (Staatliche Vogelschutzwarte Niedersachsen) to guarantee that the standardised method was adhered to and that consistency was maximised. On average, nine people (the two scientific supervisors as mentioned above plus local ornithologists and hunters) participated in the evaluation censuses. Hunting districts had a mean area extent of 652.5 ha, and their shares of open land cover types suitable as grey partridge habitat ranged from 108 to 1,537 ha (arithmetic mean = 515.2, SE = 26.95).

To evaluate the hunters' estimates, area-wide spring-call counts were conducted to exactly the same extent as the hunting district but focussing only on the potential grey partridge habitat. The method used here is a combination of the standardised but relatively time- and labour-intensive method introduced by Pegel (1987) with the 'point-stop-count', as described by Bibby et al. (2000).

On a topographical map (1:25,000) of each hunting district, line transects with a length of between 1,000 and 1,500 m were established predominantly oriented to the existing road network, field borders or other accessible linear landscape features. The transects were at least 300 m but no more than 500 m apart from each other. The distance between the survey transects was a result of the acoustical reach of the rusty gate call of the grey partridge that can usually be heard up to a distance of 100-300 m depending on the environmental noise and landscape structure. The acoustical coverage of a line transect and a person, respectively, therefore ranged between 56 and 76 ha with this method. The length of the line transects results from the peak call activity phase of grey partridges that begins 15 minutes after sunset and lasts 30-45 minutes (see Rotella & Ratti 1986, 1988, Panek 1998). With four breaks of five minutes each during the transect counts and a slow steady walking pace, 1,000-1,500 m could be comfortably covered during the targeted 40-60 minutes duration of the count. These five minute breaks were established to give the observers the chance to intensively concentrate and interpret the acoustical environment.

All surveys during the 5-year study were conducted between 15 March and 30 April, which is the period with the highest vocal activity. At this stage, approximately from four weeks before the first egg is laid and onwards, grey partridges are already relatively site faithful, which means that the detected grey partridges are representative for the considered site.

Surveys were only conducted under rainless and calm weather conditions to reduce the weather-induced bias in calling activity of the males. During the survey, the type of observation was noted, i.e. rusty gate call, the number of calls or grey partridges being observed, and the exact time of the observations were noted. The observers marked their observations exactly on the general map in the case of optical observations and in the case of an 'acoustical observation' with the assumed location of the grey partridge. If grey partridges were flushed, the direction of the escape flight was noted and, if possible, the landing position also. On this basis, all observations were checked for double counts as a potential source of bias after the survey.

The survey was conducted in all of the 123 hunting districts a second time after at least four days and no later than 10 days, following the same procedure except that the observers started from the other end of the line transects. The survey was repeated a third time if the variation coefficient between the two counts was > 25%. This was the case in nine hunting districts.

Categorisation of the evaluation census observations

The acoustical and optical grey partridge observations of the two counts per hunting district were categorised according to the internationally accepted codes for breeding evidence (*sensu* British Trust for Ornithology 2011): 'probable breeding' (PrB); a locally established breeding pair was assumed once a grey partridge pair had been observed during one of the two counts. When a pair was also observed during the other count within a radius of 150 m around the first count, this pair was assumed to be the same. The radius of 150 m was chosen as the respective circle covers an area of 7.1 ha, which reflects the lower end of the territory size in the grey partridge before nesting and before the breeding season (compare Döring & Helfrich 1986, Panek 2002, Šálek et al. 2002). When one count observed a call of or saw a grey partridge, but no evidence of the bird was found at the second count within the radius of 150 m around the same observation, the observation was categorised as 'possible breeding' (PoB). In case a single grey partridge was acoustically or optically detected at both surveys within a radius of 150 m, it was categorised as PrB.

Due to this single piece of evidence of a grey partridge being at a certain location and given the male surplus in grey partridge populations as described e.g. by Szederjei et al. (1959) or Dwenger (1991), PoBs were assumed to not directly represent a breeding pair. However, even though not assured, a single grey partridge observation can also be an evidence of the presence of a breeding pair that could not be substantiated during the two counts. Birkan & Jacob (1988) correct the unbalanced sex ratio in spring by dividing the number of single bird observations by 2.1. Accordingly, Reitz & Berger (1994) and Bro et al. (2005) use this procedure to estimate the number of grey partridge pairs from single bird observations in addition to the assured number of grey partridge pairs. Therefore, it was restrictively hypothesised that a single observation (PoB) of a grey partridge at a certain location counts only for 0.5 breeding pairs, whereas PrBs were considered as directly representing a breeding pair. As result of the ground-truthing surveys, the number of PrBs and 0.5

PoBs were summed up (hereafter Breeding Pair Census; BPC) to evaluate the respective hunters' spring pair density estimates as derived from the WTE (hereafter Breeding Pair Estimates; BPE).

Statistical analysis

Assumptions underlying the statistical tests used in our study, normality and homogeneity of variance, were checked using Kolmogorov-Smirnoff and Levene's tests, respectively. When the assumption of normality was satisfied, the distribution of the variables was characterised by the arithmetic mean (mean) and the standard error of the arithmetic mean (SE). Otherwise, it was characterised by the median and the 25th and 75th percentile (P_{25} and P_{75}), respectively. To compare the data resulting from counts and estimates, Wilcoxon signed rank test was applied. To test for correlation, the Spearman Rank Correlation was applied as BPC and BPE data were not normally distributed.

All statistical comparisons were two-tailed with an alpha level of 0.05. The statistical analyses were performed using SAS statistical package version 9.1 (SAS Institute Inc., Cary, North Carolina, USA) and SPSS version 16.0 (SPSS Inc., Chicago, Illinois, USA).

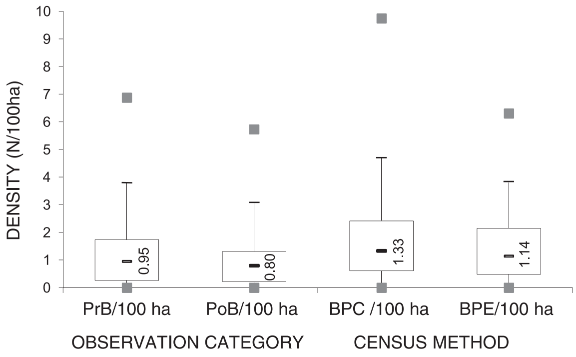

Figure 1. Number of probable breeding pairs (PrB), possible breeding pairs (PoB), the resulting breeding pairs as yielded by the census (BPC) and the number of breeding pairs as estimated by the hunters (BPE), respectively, per 100 ha. Median indicated as figures within the box, boxes indicating P_{25} and P_{75}, bars indicating standard deviation and squares indicating minima and maxima.

Results

Altogether, 63,847 ha were covered by the evaluation census in order to ground-truth hunters' estimates. With 123 hunting districts and 255 counting dates, a total of 1,978 people participated in the evaluation counts.

During the 5-year evaluation study in the 123 hunting districts, 761 assured grey partridge detections were made at the first census date and 769 assured detections at the second census date. Overall, 767 of those 1,530 grey partridge observations were categorised as PrB and another 631 as PoB resulting in 1,096.5 breeding pairs (BPC), which were used for evaluating the hunters' BPE (BPE = 871/63,847 ha).

In Figure 1, the value distribution of the ornithological categories PrB and PoB related to 100 ha potential grey partridge habitat is shown together with the resulting BPC and test statistics for the BPE of the hunters. On average, when analysing the two survey dates, the grey partridge observations were significantly more often classified as PrB (median = 0.95) than as PoB (median = 0.80; N = 123, Wilcoxon: P = 0.029). Comparing the resulting breeding pair density as a result of the evaluation surveys (BPC) with the hunters' estimates concerning spring pair density (BPE), on average the results of the evaluation surveys were significantly higher (median = 1.33) than the hunters' estimates (median = 1.14; N = 123, Wilcoxon: P = 0.0001).

Hence, hunters underestimated the density of grey partridge pairs per 100 ha potential habitat on average by 0.16 breeding pairs (P_{25} = -0.67, P_{75} = 0.07). In 56.9% (N = 70) of the hunting districts, the grey partridge densities were underestimated, in 22.0% (N = 27) the density was overestimated and in 21.0% (N = 26) hunter estimates matched evaluation census densities exactly. The median of the hunters' estimate errors (N = 123) was 24.2% (P_{25} = 5.3, P_{75} = 47.1), disregarding the direction of the discrepancy between hunters' estimates and evaluation-census densities.

The estimated breeding pair density was highly significantly positively correlated with the breeding pair density as yielded by the evaluation surveys (Spearman correlation coefficient r = 0.854, P < 0.0001). In Figure 2, the relation of the BPC/100 ha with the respective BPE/100 ha is shown as a scatter plot as well as the algorithm of the corresponding generalised linear regression model. Assuming that the evaluation census yielded unbiased results, the line x = y, indicated as a dashed line, describes the ideal correlation, and dots below the ideal represent underestimates.

The hunter's estimate error calculated as the difference between BPE/100 ha and BPC/100 ha was highly significantly negatively correlated with the number of breeding pairs per 100 ha as determined in

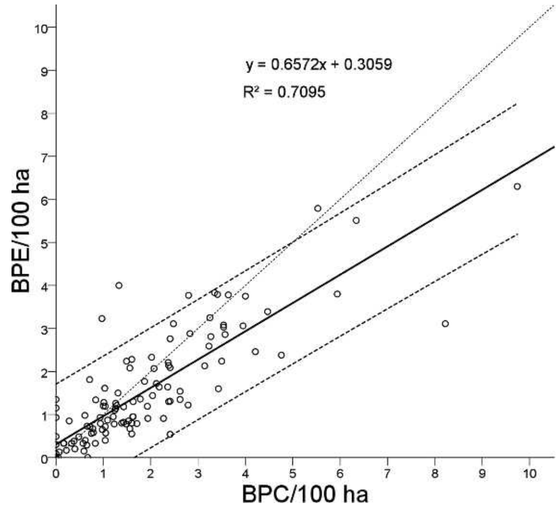

Figure 2. Relation of the number of breeding pairs as estimated by the hunters per 100 ha (BPE/100 ha) and breeding pairs as yielded by the census per 100 ha (BPC/100 ha; N = 123). 95% confidence limits indicated as bold dashed lines.

the evaluation counts (Spearman correlation coefficient r = -0.512, $P < 0.0001$). This underestimation increased with higher grey partridge density.

After a decadic logarithmic transformation, the hunter's estimate error was negatively correlated with the size of the hunting district (Spearman correlation coefficient r = -0.187, P = 0.0358). Therefore, the larger the hunting district was, the higher the chance was of the breeding pair density being underestimated by hunters.

Discussion

Knowing the absolute densities of grey partridge pairs as reproductive stock is a fundamental factor in the study of its population status and dynamics (Pepin & Birkan 1981). Gathering data via questionnaire surveys among local hunters has the potential to yield data on the population status continuously and over a large scale for comparatively low costs. As hunters are usually not professional ornithologists, the quality of their estimates has to be evaluated by ground-truthing.

To evaluate hunters' spring pair density estimates as derived from the WTE, a labour intensive search of the entire area was found to be the most practical and accurate method. Furthermore, a repeat count in every hunting district allowed for a qualification of the observation into the categories PrB and PoB. The high consistency of grey partridges detected per transect between the two counts substantiates the established site confidence right before the breeding season as also found by other authors (e.g. Döring & Helfrich 1986, Potts 1986).

Additionally, the chance is that at low densities grey partridge populations are underestimated, whereas with high densities, grey partridge population are overestimated because of obvious social interactions.

Comparing these evaluation census densities with the respective estimates of the hunters, hunters were on average found to underestimate grey partridge spring pair densities in their hunting districts. Underestimation of wildlife population densities by amateurs is a common phenomenon (see Genet & Sargent 2003, Newmann et al. 2003). Hunters are less likely to notice the acoustic signals of the grey partridge, because of the crepuscular habits of the grey partridge in spring time. Additionally, between mid March and the end of April, which is the period with the highest vocal activity of grey partridges, the hunting activity and therefore also hunters' presence in the field are traditionally very low. The rusty gate call is the most evident indicator of grey partridge presence in spring. Relying predominantly on incidental optical records as basis for their breeding pair estimates might be the main reason for the average underestimation of breeding pairs by 0.16/100 ha by the hunters. In respect of a sustainable grey partridge management, the average underestimation of grey partridge densities by the hunters can be appreciated as erring on the side of caution.

The average deviation of 24% of the hunters' estimates from the evaluation census densities, disregarding its direction, presents a remarkable accordance compared to other studies evaluating bird census methods (e.g. Raman 2003). The growing discrepancy of evaluation census densities and hunters' estimates with increasing grey partridge densities might be due to the clarity of the situation with lower densities and vice versa. When the grey partridge densities are low, the few and often only covey is individually known, and its fate can be followed over the winter. This applies accordingly to the resulting breeding pairs after covey break-up. If the grey partridge density is higher, the estimated number becomes more diffuse; single coveys/pairs might be mistaken with other coveys/pairs, leading to an underestimation. Concerning the increasing discrepancy between hunters' estimates and evaluation census densities with increasing size of the hunting district, it can be hypothesised that the presence of hunters per ha decreases with increasing size of the hunting district resulting in a rather incomplete picture of the grey partridge population compared to a smaller area.

Despite of being unsystematically assessed, it is assumed that $\geq$ 90% of the local hunters, whose estimates were evaluated, were either farmers or involved in agricultural activities. Therefore, in the case of small game hunting districts in agricultural landscapes, local farmers often own or rent hunting districts. This clearly differs from the situation in forest landscapes with big game hunting districts, where a majority of hunters will lack traditional local affiliation. Reading et al. (1996) state in respect to their questionnaire survey on the status and distribution of adders *Vipera berus* that farmers, compared with other respondents, represent a more stable community, and are therefore more likely to have been familiar with their surroundings for a longer period of time and are thus more likely to notice changes in their environment. Observations are usually incidental records, but in the course of a year, these give a more or less clear picture of grey partridge presence. Even though the estimates by hunters are not derived from a consistent actively standardised method, but rather from an individual process and therefore have a high potential bias, it is assumed that a basic degree of standardisation is allowed for by the socio-psychological homogeneity of the respondents. The passive standardisation due to similar interests, similar professions and similar presence phases in the hunting district explains the highly significant correlation of estimates and grey partridge densities as determined by the evaluation censuses.

However, it is proposed that the applicability of questionnaire surveys among hunters to gather data on the distribution and population status of other wildlife species has to be evaluated for each considered species as numerous species-specific biases can rule out the usability of such data. Questionnaire surveys are confronted with severe limitations when emotionally and negatively documented animals are the focal point (e.g. Lensing & Joubert 1977, Boshof 1980), as well as when cryptic species are the focal point. For future studies, it is recommended to include consideration of the professional, cultural and political background of the respondents and the socio-political situation, especially in respect to the huntability of the grey partridge when a questionnaire survey was conducted during such data analysis.

Standard questionnaires can motivate the involvement of local people in wildlife monitoring and management (Msoffe et al. 2007). An annual survey among hunters such as the WTE on wildlife status and management has the potential of actively involving more 'community members' in data collection. By generating data, hunters are made aware of underlying problems, for example the reproductive success in the grey partridge in relation to weather conditions or population changes due to changes in the land-use system (Noss et al. 2005). Hunters are sensitised to the ecology of the grey partridge and follow the fate of 'their' population in their hunting district. As a result of this reflection process, hunters potentially take measures to support partridge populations for example by participating in agri-environmental programmes (see Tillmann et al. 2005). Therefore, such an annual questionnaire survey can have a value for the conservation of the grey partridge, in addition to its initial purpose to provide data on the population status of grey partridges as a basis for decision-making concerning its management. Under the umbrella of its ecological profile, this means that it also has value for a whole set of species with similar requirements.

The evaluation of the WTE data supports the hypothesis that such a monitoring of the grey partridge provides sufficiently accurate assessments of the status in grey partridge populations from a regional to federal state level. Its quality is a product of the reliability of the hunters' estimates combined with the high participation rate of 89.3% out of 8,067 private hunting districts in Lower Saxony. The satisfying quality of hunters' estimates as found in Lower Saxony demonstrates the option of establishing reasonable monitoring programmes in cooperation with hunters also in other parts of the grey partridge distribution with hunting systems guaranteeing a similar presence of hunters in a distinct area. Limitations of hunters' breeding pair estimates particularly in respect to the diminishing quality of such estimates with increasing size of the hunting district and the grey partridge density should be considered.

This questionnaire survey among hunters is a useful monitoring tool for the grey partridge that can not be replaced for example by rule-based habitat models (*sensu* Chamberlain et al. 2004). Such monitoring is vital for detecting population declines, especially given the absence of useful bag records at very low densities, evaluating habitat quality, monitoring conservation action e.g. in the context of agri-environmental measures, monitoring the effect of hunting or carrying out environmental impact assessments.

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References

Aebischer, N.J. & Ewald, J.A. 2004: Managing the UK partridge *Perdix perdix* recovery: population change, reproduction, habitat and shooting. - Ibis 146 (Suppl. 2): 181-191.

Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S.H. 2000: Bird census techniques. 2nd edition. - Academic Press, London, UK, 720 pp.

BirdLife International 2004: Birds in Europe: population estimates, trends and conservation status. - BirdLife Conservation Series No. 12, BirdLife International, Wageningen, The Netherlands, 374 pp.

Birkan, M. & Jacob, M. 1988: La perdrix grise. - Hatier, Paris, France, 284 pp. (In French).

Boshoff, A.F. 1980: Some socio-economic aspects of a bird of prey questionnaire survey. - South African Journal of Wildlife Research 10: 71-81.

British Trust for Ornithology 2011: Breeding evidence. - Available at: http://www.bto.org/volunteer-surveys/birdatlas/taking-part/breeding-evidence (Last accessed on 20 December 2011).

Bro, E., Reitz, F., Clobert, J., Migot, P. & Massot, M. 2001: Diagnosing the environmental causes of the decline in grey partridge *Perdix perdix* survival in France. - Ibis 143: 120-132.

Bro, E., Reitz, F. & Landry, P. 2005: Grey partridge *Perdix perdix* population status in central northern France: spatial variability in density and 1994-2004 trend. - Wildlife Biology 11(4): 287-298.

Bro, E., Sarrazin, J.C. & Reitz, F. 2000: Demography and the decline of the grey partridge (*Perdix perdix)* in France. - Journal of Applied Ecology 27: 432-448.

Chamberlain, D.E., Gough, S., Vickery, J.A., Firbank, L.G., Petit, S., Pywell, R. & Bradbury, R.B. 2004: Rule-based predictive models are not cost-effective alternatives to bird monitoring on farmland. - Agriculture Ecosystems and Environment 101: 1-8.

De Leo, G.A., Focardi, S., Gatto, M. & Cattadori, I.M. 2004: The decline of the grey partridge in Europe: comparing demographies in traditional and modern agricultural landscapes. - Ecological Modelling 177: 313-335.

Döring, V. & Helfrich, V. 1986: Zur Ökologie einer Rebhuhnpopulation (*Perdix perdix*, Linné, 1758) im Unteren Naheland (Rheinland-Pfalz; Bundesrepublik Deutschland). - Schriften des Arbeitskreises für Wildbiologie und Jagdwissenschaft an der Justus-Liebig-Universität Gießen. Ferdinand Enke Verlag. Stuttgart, Gießen, Germany, Heft 15, 365 pp. (In German).

Dwenger, R. 1991: Das Rebhuhn. Die Neue Brehm-Bücherei Band 447. - Ziemsen Verlag, Wittenberg Lutherstadt, Germany, 144 pp. (In German).

Genet, K.S. & Sargent, L.G. 2003: Evaluation of methods and data quality from a volunteer-based amphibian call survey. - Wildlife Society Bulletin 31: 703-714.

Hagemeijer, M.J.M. & Blair, M.J. 1997: The EBCC atlas of European breeding birds: their distribution and abundance. - European Bird Census Council, Poyser, London, UK, 903 pp.

Joannon, A., Bro, E., Thenail, C. & Baudry, J. 2008: Crop patterns and habitat preferences of the grey partridge farmland bird. - Agronomy for Sustainable Development 28: 379-387.

Krüger, T. & Oltmanns, B. 2007: Rote Liste der in Niedersachsen und Bremen gefährdeten Brutvögel - 7. Fassung, Stand 2007. - Informationsdienst Naturschutz Niedersachsen, Germany (3/07), 52 pp. (In German).

Lensing, J.E. & Joubert, E. 1977: Intensity distribution patterns for five species of problem animals in South West Africa. - Madoqua 10: 131-142.

Msoffe, F., Mturi, F.A., Galanti, V., Tosi, W., Wauters, L.A. & Tosi, G. 2007: Comparing data of different survey methods for sustainable wildlife management in hunting areas: the case of Tarangire-Manyara ecosystem, northern Tanzania. - European Journal of Wildlife Research 53: 112-124.

Newman, C., Buesching, C.D. & Macdonald, D.W. 2003: Validating mammal monitoring methods and assessing the performance of volunteers in wildlife conservation - "Sed quis custodiet ipsos custodies?" - Biological Conservation 113: 189-197.

Noss, A.J., Oetting, I. & Cuéllar, R.L. 2005: Hunter self-monitoring by the Isoseño-Guaraní in the Bolivian Chaco. - Biodiversity and Conservation 14: 2679-2693.

Panek, M. 1998: Use of call counts for estimating spring density of the grey partridge *Perdix perdix*. - Acta Ornitholgica 33: 143-148.

Panek, M. 2002: Space use, nesting sites and breeding success of grey partridge (*Perdix perdix*) in two agricultural management systems in western Poland. - Game and Wildlife Science 19: 313-326.

Panek, M. 2005: Demography of grey partridge *Perdix perdix* in Poland in the years 1991-2004: reasons of population decline. - European Journal of Wildlife Research 51: 14-18.

Pegel, M. 1987: Das Rebhuhn (*Perdix perdix* L.) im Beziehungsgefüge seiner Um- und Mitweltfaktoren. - Schriften des Arbeitskreises Wildbiologie und Jagdwissenschaft an der Justus-Liebig-Universität Gieβen, Ferdinand Enke Verlag, Stuttgart, Germany, Heft 18, 198 pp. (In German).

Pepin, D. & Birkan, M. 1981: Comparative total- and strip-census estimates of hares and partridges. - Acta Oecologica 2: 151-160.

Potts, G.R. 1986: The partridge - pesticides, predation and conservation. - Collins, London, UK, 274 pp.

Potts, G.R. 1997: Cereal farming, pesticides and grey partridge. - In: Pain, D.J. & Pienkowski, M.W. (Eds.); Farming and birds in Europe. The common agricultural policy and its implications for bird conservation. Academic Press, London, UK, pp. 150-177.

Potts, G.R. & Aebischer, N.J. 1995: Population dynamics of the Grey Partridge (*Perdix perdix*) 1793-1993: monitoring, modelling and management. - Ibis 137: 29-37.

Putaala, A., Hissa, R. 1998: Breeding dispersal and demography of wild and hand-reared grey partridges *Perdix perdix* in Finland. - Wildlife Biology 4(3): 137-145.

Raman, T.R.S. 2003: Assessment of census techniques for interspecific comparisons of tropical rainforest bird densities: a field evaluation in the Western Ghats, India. - Ibis 145: 9-21.

Reading, C.J., Buckland, S.T., McGowan, G.M., Jayasinghe, G., Gorzula, S. & Balharry, D. 1996: The distribution and status of the adder (*Vipera berus* L.) in Scotland determined from questionnaire surveys. - Journal of Biogeography 23: 657-667.

Reitz, F. & Berger, F. 1994: Le suivi des populations de perdrix en 1993 dans le Nord, le Bassin parisien et le Centr. - Bulletin Mensuel de L'O.N.C. 186: 13-22. (In French).

Rotella, J.J. & Ratti, J.T. 1986: Test of a critical density index assumption: a case study with gray partridge. - Journal of Wildlife Management 50: 532-539.

Rotella, J.J. & Ratti, J.T. 1988: Seasonal variations in gray partridge vocal behaviour. - Condor 90: 304-310.

Šálek, M., Marhoul, P. & Pintíř, J. 2002: Spring to autumn home range and habitat use of a high density population of the grey partridge (*Perdix perdix*) in Praha, Czech Republic. - Folia Zoologica 51: 299-306.

Südbeck, P. & Wendt, D. 2002: Rote Liste der in Niedersachsen und Bremen gefährdeten Brutvögel - 6. Fassung, Stand 2002. - Informationsdienst Naturschutz Niedersachsachsen, Germany, (5/02), pp. 243-278. (In German).

Szederjei, A., Szederjei, M., Studinka, L. & Sternberg, J. 1959: Hasen, Rebhühner, Fasanen. - Dt. Bauernverlag, Berlin, Germany, 396 pp.

Tillmann, J.E. 2006: Das ökologische Profil des Rebhuhns (*Perdix perdix*) und Konsequenzen für die Gestaltung von Ansaatbrachen zur Lebensraumverbesserung. - (In German with an English summary: The ecological profile of the grey partridge *Perdix perdix*: Consequences for improving habitat for cultivation of fallow fields.) - Beiträge zur Jagd- und Wildforschung 31: 265-274.

Tillmann, J.E. 2009: Fear of the dark: Night-time roosting and anti-predation behaviour in the grey partridge (*Perdix perdix* L.). - Behaviour 146: 999-1023.

Tillmann, J.E., Klein, A., Fischer, M., Strauss, E. & Oltmanns, B. 2007: Zur Situation des Rebhuhns in Niedersachsen - Empfehlungen zu Schutz und Bejagung. - Wild und Jagd, Landesjagdbericht 2006. Niedersächsisches Ministerium für den ländlichen Raum, Ernährung, Landwirtschaft und Verbraucherschutz, pp. 92-99. (In German).

Tillmann, J.E., Strauß, E., Kinser, A. & Kraft, A. 2005: Wildlife conservation by means of green cover set-aside. - First results from a German study founded by the DBU (German Environmental Foundation). - XXVII Congress of the International Union of Game Biologists, Book of extended abstracts, Hannover, Germany, pp. 226-227. (In German).

Tucker, G.M. & Heath, M.F. 1994: Birds in Europe: their conservation status. - Birdlife Conservation Series 3: 366-367.