Hystrix It. J. Mamm. (n.s.) 20(2) (2009): 101-110

DENSITY AND HABITAT REQUIREMENTS OF SYMPATRIC HARES AND COTTONTAILS IN NORTHERN ITALY

ANNA VIDUS ROSIN[1*], ALESSANDRO MONTAGNA[1], ALBERTO MERIGGI[1], SARA SERRANO PEREZ[2]

[1]Dipartimento di Biologia Animale, Università of Pavia, Piazza Botta 9, 27100 Pavia, Italy
*Corresponding author: anna.vidus@unipv.it
[2]Departamento de Anatomia, Biologia Celular e Zoologia, Facultad de Veterinaria, Universitad de Extremadura, Avda. Universitad sn 10071 Caceres, Spain

ABSTRACT - From 2005 to 2009, densities and habitat selection by the European hare (*Lepus europaeus*) and Eastern cottontail (*Sylvilagus floridanus*) were assessed during feeding activity in an intensively cultivated area in northern Italy. Hare average density (74 ind./km^2) was comparable to the highest values reported for European farming areas. Pre- and post-breeding density fluctuated widely across the study years, probably as a consequence of changes in the carrying capacity of the study area. Cottontail population size progressively increased, as expected for a recently introduced species supported by high reproductive performances. Hares used both crops and spontaneous vegetation during their feeding activity. Conversely, cottontails avoided winter cereals and preferred to feed on alfalfa. Our results suggest that simplified agro-ecosystems cannot maintain high density hare populations even at a short time scale. Landscape heterogeneity could enhance the chances of coexistence between the two lagomorphs.

Keywords: European hare, *Lepus europaeus*, Eastern cottontail, *Sylvilagus floridanus*, density, abundance, habitat selection

RIASSUNTO - ***Densità ed esigenze ecologiche della lepre e del silvilago in condizioni di simpatria in Italia settentrionale***. Tra il 2005 e il 2009, la densità e l'uso del habitat durante l'attività di alimentazione da parte della Lepre europea (*Lepus europaeus*) e del Silvilago (*Sylvilagus floridanus*) sono stati indagati in un'area intensamente coltivata nell'Italia settentrionale. La densità media della lepre nell'area di studio (74 ind./km^2) corrisponde ai valori maggiori riportati per le aree agricole europee. Le densità pre- e post riproduttive della lepre hanno mostrato sensibili fluttuazioni durante il periodo di studio, probabilmente dovute ai cambiamenti stagionali della capacità portante dell'area di studio. L'abbondanza del silvilago è aumentata durante gli ultimi tre anni di studio, come prevedibile per una specie, a bassa densità, ben adattata agli ambienti agricoli e supportata da una elevata performance riproduttiva. Durante l'attività di alimentazione, le lepri hanno utilizzato sia le coltivazioni sia la vegetazione spontanea. Invece, il silvilago ha evitato i cereali autunnali e selezionato l'erba medica. I risultati suggeriscono che ambienti agricoli semplificati non sono in grado di mantenere popolazioni di lepre ad alte densità nemmeno per brevi periodi di tempo. Ambienti eterogenei potrebbero favorire la coesistenza tra le due specie di lagomorfi.

Parole chiave: Lepre europea, *Lepus europaeus*, silvilago, *Sylvilagus floridanus*, densità, abbondanza, uso dell'habitat

INTRODUCTION

European hare populations (*Lepus europaeus*) have declined throughout Europe since the 1960s (Smith *et al.*, 2005; Central Italy, Santilli and Galardi, 2006). As a consequence, the species has been listed in Appendix III of the Berne Convention on the Conservation of European Wildlife and Natural Habitats (Mitchell-Jones *et al.*, 1999). The ultimate cause of hare decline is habitat changes through agricultural intensification (Smith *et al.*, 2005). The loss of habitat heterogeneity has occurred on multiple spatial and temporal scales, and has lead to a decline in farmland biodiversity which has been measured across many different taxa (Benton *et al.*, 2003; Macdonald *et al.*, 2007). The reduction and fragmentation of non-cropped habitats, such as woodlots, grassy habitats, hedgerows and field margins, together with the development of homogeneous agricultural habitats (farming specialization), increase of field size and removal of weeds (agrochemical use) have all been considered as causes of hare decline (Vaughan *et al.*, 2003; Smith *et al.*, 2004; Reichlin *et al.*, 2006; Pepin and Angibault, 2007).

Accordingly, the population dynamics of the European hare is known to be strongly related to habitat diversity, because the species requires a variety of habitats to satisfy its own daily and seasonal requirements (Tapper and Barnes, 1986; Meriggi and Alieri, 1989; Meriggi and Verri, 1990; Lewandowski and Nowakowski, 1993; Reitz and Leonard, 1994; Pepin and Angibault, 2007).

The lack of high quality resources in simplified agro-ecosystems could magnify the negative effects of predation, extreme weather conditions, diseases and human disturbance on hare density and stability (Schneider, 2001; Smith *et al.*, 2005).

In contrast, several studies have pointed out the positive effects on hare abundance of the establishment of large un-dissected protected areas, promotion of set-aside and organic farming for increasing weed abundance and increase of non-cropped habitats at the between-field scale (Reichlin *et al.*, 2006; Santilli and Galardi, 2006; Pepin and Angibault, 2007; Roedenbeck and Voser, 2008).

In northern Italy, many areas within the species range are undergoing increasing human impact, mainly as a consequence of the expansion of monocultures and urbanised areas, overhunting, restocking with allochthonous hares and repeated attempts to introduce Eastern cottontails (*Sylvilagus floridanus*) for hunting purposes (Meriggi 2001a, b; Meriggi *et al.*, 2001; Spagnesi, 2002; Vidus Rosin *et al.*, 2008). In particular, since the 1960s cottontails have been repeatedly introduced in several areas of NW Italy. Thanks to its high reproductive performances, the cottontail has colonised the hare's historical range and currently interspecific competition may represent an important factor limiting hare populations (Vidus Rosin *et al.*, 2008).

Between 2005 and 2009, we carried out spotlight counts of both species in an intensively cultivated area of northern Italy, which has been colonised by the Eastern cottontail since 2007. The aims of the study were: i) assess pre- and post-breeding hare densities, ii) estimate cottontail abundance during the last three study years iii) evaluate and compare the habitat preferences of both species during their feeding activity.

STUDY AREA

The study area (4.3 km^2) is located in the dry-crop plain in Province of Pavia, northern Italy (45° 05' 09.40" N, 9° 13' 22.94" E; Fig. 1). The climate is continental-temperate; annual rainfall average 700 mm, concentrated in spring and autumn. Yearly temperature averages 12° C (January: 1.0° C; July: 22.5° C). Crops comprise the largest habitat type (81.9%), especially winter cereals (35.5% of the whole study area) in rotation with alfalfa. Spontaneous vegetation is present in small and few woodlots, fallow fields, hedgerows and field edges (7.7%). Farmsteads, villages and road networks occupy 10.5% of the study area. Canopy and bushy species include hop hornbeams (*Ostrya carpinifolia*), locusts (*Robinia pseudoacacia*), poplars (*Populus* spp.), oaks (*Quercus* spp) brambles (*Rubus* spp.), elders (*Sambucus* spp.), whitethorns (*Crataegus oxyacantha*), and false indigos (*Amorpha fruticosa*). Common herbaceous species were meadow grass (*Poa ssp.*), red fescue (*Festuca rubra*), timothy (*Phleum pratense*) and erect brome (*Bromus erectus*). In the study area hunting was forbidden; hares were caught for restocking the surrounding hunting areas only in December 2008.

METHODS

Habitat cover types were mapped seasonally by direct surveys and then digitalized by ArcView 3.2. Spotlight counts were carried out from a moving car (maximum speed: 5 km/h) along a permanent, 7 km long transect, lighting up both sides of the transect by a handle lamp (100 W). The transect route was selected from the existing road network so as to survey each habitat type in proportion to its relative extension; in this way the distribution of hares and cottontails within the sampled area did not differ from that of th e whole study area (Meriggi, 1989; Langbein *et al.,* 1999). Each year, spotlight counts were carried out from March to April and from October to November for a total of 10 surveys; in spring and early summer the growth of crops and herbaceous cover make this method unusable. Each count started at least two hours after sunset and ended no later than two hours before dawn. Groups were considered as singular observations, and their

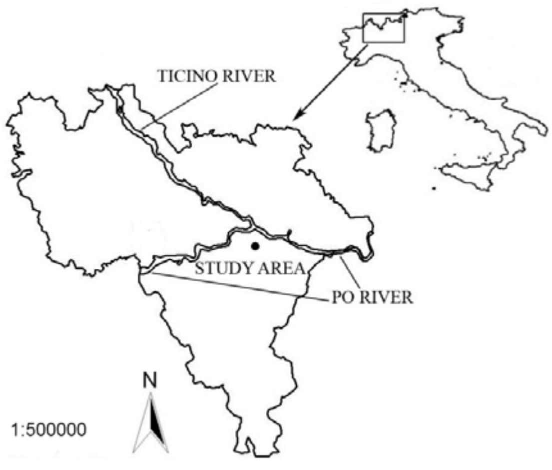

Figure 1 - Study area.

perpendicular distance from the transect was measured from the centre of each group; sightings on the transect were registered at 0 m. Sightings, as well as the sampled areas, were mapped and the number of hares and cottontails recorded. All information was digitalized by ArcView 3.2.

Hare mean density (individuals per km^2) and 95% confidence intervals were estimated in pre- and post-breeding periods (March-April and October-November, respectively) by the software Distance 5.0 (Burnham *et al.,* 1985; Buckland *et al.,* 2001; MacKenzie and Kendall, 2002). Mean cottontail abundance was assessed by the Kilometric Abundance Index (IKA= n° of cottontails / km) in each of the last three study years, cottontail observations being too few to assess pre- and post-breeding densities as for hares.

Habitat breadth of hares and cottontails was calculated by Hurlbert's standardized index of niche breadth (Hurlbert, 1978; Krebs, 1999):

$$B'_a = [1/ \sum (p_i^2/a_i)] - a_{\min} /(1- a_{\min}),$$

where: p_i = proportion of individuals found in habitat i ($\sum p_i = 1$), a_i = proportion of habitat i in the study area ($\sum a_i = 1$), $a_{\min}$= smallest habitat proportion (minimum a_i); B'_a ranges from 0 to 1.

Habitat preference by both species was evaluated by Manly's α preference index (Manly *et al.*, 1972; Manly *et al.*, 1993; Krebs, 1999):

$$\alpha_i = r_i / n_i (1/ \Sigma^{m}_{j=1} (r_j/n_j)),$$

where: r_i, r_j = proportion of habitat i or j used by the species, n_i, n_j = proportion of habitat i or j in the study area, m = total number of habitats.

The α values were normalized, so that $\sum^{m}_{i=1} \alpha_i = 1$. When no preference occurs, $\alpha_i = 1/m = 0.167$. When α_i is higher than $1/m$, habitat i is selected.; conversely, if α_i is lower than $1/m$, habitat i is avoided.

Finally, to test the reliability of both indices we re-sampled the surveys 1000 times by the bootstrap method (Dixon, 1993). Then we calculated the median values and 95% confidence intervals of each index. Because the distribution of the preference indices did not significantly differ between pre- and post-breeding periods (Kolmogorov-Smirnov Test: $Z_{(\text{winter cereals})}= 0.656$, $Z_{(\text{ploughed fields})}= 0.656$, $Z_{(\text{alfalfa})}= 0.863$, $Z_{(\text{spontaneous vegetation})}= 1.208$, $Z_{(\text{vineyards})}= 0.380$, $Z_{(\text{buildings})}= 0.656$; $P > 0.05$ for all tests), the above analyses were carried out on pooled data. Statistical analyses were performed by SPSS/PC + Version 15.0.

RESULTS

Hare density averaged (±SE) 74.1 (± 9.40) individuals per km^2 through the entire study period. Post-breeding densities were significantly lower than pre-breeding densities during the two first study years (Fig. 2). In 2007 and 2008 no significant difference was found between the hare densities recorded in the two breeding periods. Pre-breeding densities fluctuated widely through the study years (Fig. 2). In contrast, cottontail abundance seemed to grow across the last three study years ($IKA_{2007}= 0.9$ individuals per km, $IKA_{2008}= 1.8$, $IKA_{2009} = 2.5$).

Hare habitat breadth averaged 0.72 (95% confidence intervals: 0.62- 0.75) and it was slightly higher than that of cottontails (0.51; 95% confidence intervals: 0.34- 0.68). Hares preferred alfalfa and winter cereals and used spontaneous vegetation in proportion to its availability. Ploughed fields, vineyards and buildings were avoided. Cottontails used alfalfa, spontaneous vegetation, followed by vineyards and buildings. Ploughed fields and winter cereals were avoided. Out of all habitat types, hares

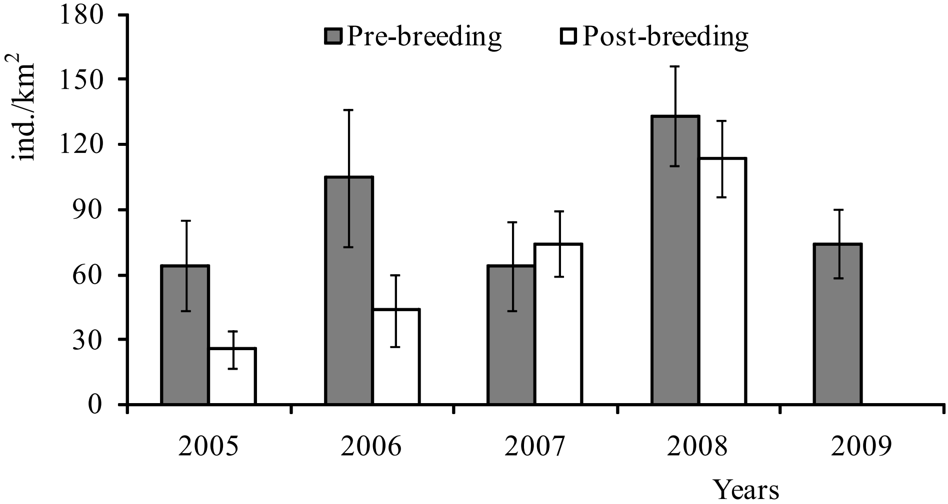

Figure 2. Hare density in pre- and post-breeding periods between 2005 and 2009 (bars represent 95% confidence intervals).

used winter cereals and ploughed fields more than cottontails (Fig. 3).

DISCUSSION

Average density of hares in our study area was comparable to the highest values reported by Smith *et al*. (2005), who examined several farming areas throughout Europe; in our case pre-and post-breeding densities fluctuated widely across the study years. The same pattern had already been described by Meriggi and Verri (1990); these authors related the variation of hare numbers to changes in the carrying capacity of their study area, which mostly consisted of poplar monocultures. Frylestam (1979) pointed out that hare population growth and size are mainly affected by food scarcity in summer and winter, followed by human disturbance and predation. In our study area field ploughing probably limited the availability of good quality food in autumn, and, together with human disturbance due to intensive agricultural practises, it could have generated the observed counter intuitive pattern of pre- and post-breeding densities. When hare density is high and feeding grounds are limited, hares become aggressive and hierarchical, in relation to their body size (Lindlof, 1978; Monaghan and Metcalfe, 1985). Boutin (1984) found out that the aggressive behaviour of *Lepus americanus* on feeding areas induced the dispersion of young hares and decline of population size. Moreover, hares tend to extend their home-range to include a wider variety of crops (Tapper and Barnes, 1986); locally, this behaviour could lead to a decrease in hare abundance. The drop of hare density in the post-breeding period of 2009 could depend on two further factors: *i*) the translocation of some individuals for hunting pur-

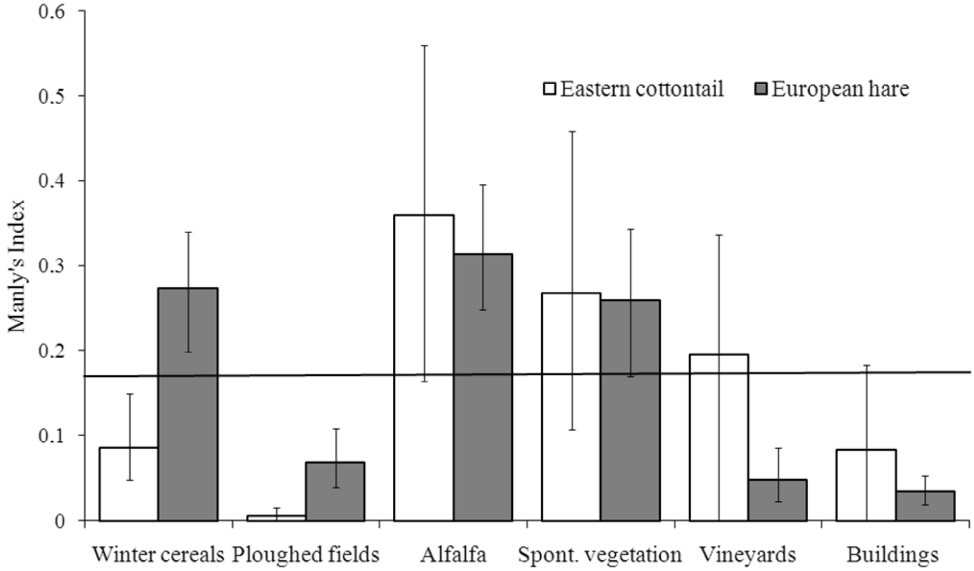

Figure 3. Average values of Manly's Index of habitat preference for hares and cottontails (pooled years and seasons; bars represent 95% confidence intervals).

poses in December 2008, and *ii*) hard winter conditions. January 2009 was snowy and cold (Tmin < -10°C for several days), potentially worsening subadult malnutrition, physical stress and predation (Bresinsky, 1976; Riechlin *et al*., 2006).According to recent colonisation, cottontail abundance in our study area was much lower than that recorded for other protected plain areas of northern Italy (65.6 and 35.6 cottontails per km^2, Vidus Rosin *et al*., 2008). Nonetheless population size progressively increased, as expected for a species well adapted to agricultural landscapes and supported by high reproductive performances (Lockwood *et al*., 2008; Vidus Rosin *et al*., 2008).

In natural communities, the coexistence between two members of the same guild is favoured when one of the two species is a generalist (wide niche breadth) and the other species is a specialist (narrow niche breadth) (Partridge, 1978; Abramsky, 1981; Pimm and Rosenzweig, 1981; Rosenzweig, 1981, 1991). Our results did not clearly show that the European hare is a generalist species, in terms of habitat requirements, with respect to the Eastern cottontail. Hares used both crops and spontaneous vegetation during their feeding activity, winter cereals and alfalfa providing good quality food during autumn and winter (Tapper and Barnes, 1986; Reichlin *et al*., 2006). During their feeding activity hares seemed to be less selective towards ground protection than cottontails, which avoided winter cereals and preferred to feed on alfalfa, which offers a more homogeneous and continuous ground cover with respect to other crops. Some authors found that cottontails use row crops only during the growing season, when they offer a dense and tall cover (Mankin and Warner, 1999; Bond *et al*., 2002). Both species selected spontaneous vegetation - weeds, bushes and trees - available in few fallow fields, edges and field margins. These habitats can provide both species with forage and protection from predators (Bresinski and Clewski, 1976; Vance, 1976; Swihart and Yahner, 1982, 1984; Tapper and Barnes, 1986; Althoff *et al,*. 1997; Panek and Kamieniarz, 1999; Bond *et al.,* 2001; Vaughan *et al*., 2003; Reichlin *et al*., 2006). The avoidance of ploughed fields, vineyards and buildings by hares could be explained by the lack of weeds and human disturbance. Moreover, in autumn vineyards did not provide enough green food and ground protection because of tillage. Road networks and villages have been reported to have a negative effect on the spatial distribution of hares even in protected areas (Roedenbeck and Voser, 2008). Farmsteads and vineyards may be used by cottontails only if they provide good shelter (piles, small buildings, machinery sheds) and do not harbour domestic cats and dogs (Swihart and Yahner, 1982; Mankin and Warner, 1999; Vidus Rosin *et al*., 2008).

Our results suggest that simplified agro-ecosystems cannot sustain stable, high density hare populations even at a short time scale. In homogeneous agricultural landscapes, hares are likely to be more susceptible to mortality by predation, diseases and hunting (Smith *et al*., 2004; 2005). Habitat heterogeneity should be improved in all agricultural systems through the improvement of mixed cultivations, game-cover crops, field margins and small patches of spontaneous vegetation (woodlots, arboriculture stands, fallow fields), which would ensure year-round quality resources to hares, buffering the negative effects of external factors (climate, human disturbance, and predation), and enhancing the chances of coexistence with allochthonous and competing lagomorphs.

REFERENCES

Abramsky Z. 1981. Habitat relationships and competition in two Mediterranean *Apodemus* spp. *Oikos*, 36: 219-225.

Althoff D.P., Storm G.L. and Dewalle D.R. 1997. Daytime habitat selection by cottontails in Central Pennsylvania. J. *Wildl. Manage*., 61(2): 450-459.

Benton T.G., Vichery J.A. and Wilson J.D. 2003. Farmland biodiversity: is habitat heterogeneity the key? *Trends Ecol. Evol*., 18: 182-188.

Bond B.T., Burger L.W.Jr., Leopold B.D., Jones J.C. and Godwin K.D. 2002. Habitat use by cottontail rabbits across multiple spatial scales in Mississippi. *J. Wildl. Manage*., 66 (4): 1171-1178.

Bond B.T., Leopold B.D., Burger Jr. L.W. and Godwin K.D. 2001. Movements and home range dynamics of cottontail rabbits in Mississippi. J. *Wildl. Manage*., 65(4): 1004-1013.

Boutin S.A. 1984. The effect of conspecific on juvenile survival and recruitment of Snowshoe hare. *J. Anim. Ecol*., 53: 623-637.

Bresinski W.1976. Weather conditions vs European hare population dynamics. In: Pielowski Z. and Pucek Z. (eds), Ecology and management of European hare populations. Warszawa, Polish Hunting Association, 195-197.

Bresinski W. and Clewski A. 1976. Tree stands in fields and spatial distribution of hare populations. In: Pielowski Z., Pucek Z. (eds.). Ecology and management of European hare populations. Warszawa, Polish Hunting Association, 185-193.

Buckland S.T., Anderson D.R., Burnham K.P., Laake J.L. and Thomas L. 2001.

Introduction to distance sampling: estimating abundance of biological populations. Oxford University press, Oxford, 1-432.

Burnham K.P., Anderson D.R. and Laake J.L. 1985. Efficiency and bias in strip and line transect sampling. *J. Wildl. Manage*., 49 (4): 1012-1018.

Dixon P.M. 1993. The bootstrap and the jackknife: describing the precision of ecological indices. In: Scheiner S.M. and Gurevitch J. (eds.). Design and analysis of ecological experiments. Chapman and Hall, New York, 290-318.

Frylestam B. 1979. Structure, size and dynamics of three European hare populations in southern Sweden. *Acta Theriol*., 24 (33): 449-464.

Hurlbert S.T. 1978. The measurement of niche overlap and some relatives. *Ecology*, 59: 67-77.

Krebs C.J. 1999. Ecological Methodology. Second Edition. Addison-Welsey Educational Publishers, Inc., 1-607.

Langbein J., Hutchings M.R., Harris S., Stoate C., Tapper S.C. and Wray S. 1999. Techniques for assessing the abundance of Brown Hares *Lepus europaeus*. *Mammal Rev*., 29 (2): 93-116.

Lewandowski K. and Nowakowski J.J. 1993. Spatial distribution of brown hare *Lepus europaeus* populations in habitats of various types of agriculture. *Acta Theriol*., 38: 435-442.

Lindolf B.1978. Aggressive dominance rank in relation to feeding by European hare. *Viltrevy*, 10: 146-167.

Lockwood J.L., Hoopes M.F. and Marchetti M.P. 2007. Invasion ecology. Blackwell Publ. Oxford, 1-304.

MacDonald D.W., Tattersall F.H., Service K.M., Firbank L.G. and Feber R.E. 2007. Mammals, agri-environment schemes and set-aside- what are the putative benefits? *Mammal Rev*., 37: 259-277.

MacKenzie D.I. and Kendall W.L. 2002. How should detection probability be incorporated into estimates of relative abundance? *Ecology*, 83(9): 2387-2393.

Mankin P.C. and Warner R.E. 1999a. Responses of Eastern cottontails to intensive row-crop farming. *J. Mammalogy*, 80: 890-949.

Manly B.F.J., McDonald L.L., Thomas D.L., McDonald T.L. and Erickson W.P. 1993. Resource selection by animals: Statistical design and analysis for field studies. Kluwer Academic Publishers, Dordrecht, The Netherlands, 220 pp.

Manly B.F.J., Miller P. and Cook L.M. 1972. Analysis of a selective predation experiment. *Am. Nat*., 106: 719-736.

Meriggi A. 1989. Analisi critica di alcuni metodi di censimento della fauna selvatica (*Aves*, *Mammalia*). Aspetti teorici ed applicativi. *Ricerche di Biologia della Selvaggina*, 83:1-59.

Meriggi A. 2001a. *Sylvilagus floridanus* (Allen, 1890), Silvilago, Minilepre. In: Prigioni C., Cantini M., Zilio A. (eds), Atlante dei mammiferi della Lombardia. Regione Lombardia e Università degli Studi di Pavia, Milano, 144-146.

Meriggi A. 2001b: *Lepus europaeus* (Palla, 1778), Lepre comune. In: Prigioni C., Cantini M., Zilio A. (eds), Atlante dei mammiferi della Lombardia. Regione Lombardia e Università degli Studi di Pavia, Milano, 134-138.

Meriggi A. and Alieri R. 1989. Factors affecting Brown hare density in northern Italy. *Ethology Ecology & Evololution*, 1: 255-264.

Meriggi A. and Verri A. 1990. Population dynamics and habitat selection of the European hare on poplar monocultures in northern Italy. *Acta Theriol*., 35: 69-79.

Meriggi A., Ferloni M. and Geremia R. 2001. Studio sul successo dei ripopolamenti di Lepre. Greentime, Bologna, 1-253.

Mitchell-Jones A.J., Amori G., Bodganowicz W., Kryŝtufek B., Reijnder

P.J.K., Spitzenberger F., Stubbe M., Thissen J.B.M., Vohralik V. and Zima J. 1999. Atlas of European Mammals. Academic Press, London.

Monaghan P. and Metcalfe N.B. 1985. Group foraging in wild brown hares: effects of resource of distribution and social status. *Anim. Behav.*, 53: 993-999.

Panek M. and Kamieniarz R.1999. Relationship between density of Brown hare (*Lepus europaeus*) and landscape structure in Poland in the years 1981-1995. *Acta Theriol.*, 44:(1) 65-67.

Partridge L. 1978. Habitat selection. In: Krebs J.R. and Davies, N.B. (eds), Behavioural Ecology. An evolutionary approach. Blackwell Scientific Publications, Oxford, 351-376.

Pépin D. and Angibault J.M. 2007. Selection of resting sites by the European hare as related to habitat characteristics during agricultural changes. *Eur. J. Wildl. Res.*, 53: 183-189.

Pimm S.L. and Rosenzweig M.L. 1981. Competitors and habitat use. *Oikos*, 37: 1-6.

Reichlin T., Klansek E. and Hacklander K. 2006. Diet selection by hares (*Lepus europaeus*) in arable land and its implications for habitat management. *Eur. J. Wildl. Res.*,52: 109-118.

Reitz F. and Leonard Y. 1994. Characteristics of European hare *Lepus europaeus* use of space in a French agricultural region of intensive farming. *Acta Theriol.*, 39: 143- 157.

Roedenbeck I.A. and Voser P. 2008. Effects of roads on spatial distribution, abundance and mortality of brown hare (*Lepus europaeus*) in Switzerland. *Eur. J. of Wildl. Res.*, 54: 425-437.

Rosenzweig M.L. 1981. A Theory of habitat selection. *Ecology*, 62: 327-335.

Rosenzweig M.L. 1991. Habitat selection and population interactions: the search for mechanism. *Am. Nat.*, 137: S5-S28.

Santilli F. and Galardi L. 2006. Factors affecting Brown hare (*Lepus europaeus*) hunting bags in Tuscany region (central Italy). *Hystrix It. J. Mamm.*, 17: 143-153.

Schneider M.F. 2001. Habitat loss, fragmentation and predator impact: spatial implications for prey conservation. *J. Appl. Ecol.*, 38: 720- 735.

Smith R.K., Jennings N.V., Robinson A. and Harris S. 2004. Conservation of European hares *Lepus europaeus* in Britain: is increasing habitat heterogeneity in farmland the answer? *J. Appl. Ecol.*, 41: 1092-1102.

Smith R.K., Jennings N.V. and 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. *Mammal Rev.*, 35: 1-24.

Spagnesi M. 2002. Silvilago, *Sylvilagus floridanus*. In: Spagnesi M. and De Marinis A.M. (eds), Mammiferi d'Italia. Quaderni di Conservazione della Natura, Ministero ambiente-Istituto Nazionale per la fauna Selvatica, Bologna, 144-146.

Swihart R.K. and Yahner R.H. 1982. Eastern cottontails use of fragmented farmland habitat. *Acta Theriol.*, 27: 257-275.

Swihart R.K. and Yahner R.H. 1984. Winter use of insular habitat patches by eastern cottontail. *Acta Theriol.*, 29, 4: 45-56.

Tapper S.C. and Barnes R.F.W. 1986. Influence of farming practice on the ecology of the brown hare (*Lepus europaeus*). J. *Appl. Ecol.*, 23: 39-52.

Vance R.D.1976. Changes in land use and wildlife populations in south-eastern Illinois. *Wildl. Soc. Bull.*, 4: 11-15

Vaughan N., Lucas E., Harris S. and White P.C.L. 2003. Habitat associations of European hares *Lepus europaeus* in England and Wales: implications for farmland management. *J. Appl. Ecol.*, 40: 163-175.

Vidus Rosin A., Gilio N. and Meriggi A. 2008.

Introduced lagomorphs as a threat to "native" lagomorphs: The case of the Eastern cottontail (*Sylvilagus floridanus*) in northern Italy. In: Alves P.C., Ferrand N. and Hacklander K. (eds), Lagomorph biology, evolution, ecology and eonservation. Springer, Eidenberg, 153-165.