Published by Associazione Teriologica Italiana
Hystrix, the Italian Journal of Mammalogy
Online first – 2014
OPEN ACCESS
Available online at:
http://www.italian-journal-of-mammalogy.it/article/view/7878/pdf
doi:10.4404/hystrix-25.1-7878

Short Note

Winter habitat selection by the European hare (*Lepus europaeus*) during feeding activity in a farmland area of southern Tuscany (Italy)

Francesco Santilli[a,*], Gisella Paci[b], Marco Bagliacca[b]

[a] *Via F. Dini 3, Campiglia Marittima, Italy*
[b] *Dipartimento di Scienze Veterinarie, Università degli Studi di Pisa, Via delle Piagge 2, Pisa, Italy*

Keywords:
European hare
Lepus europaeus
arable crops
habitat use
over winter cereal stubbles

Article history:
Received: 19 September 2012
Accepted: 5 November 2013

Abstract

We investigated the winter habitat use by the European hare (*Lepus europaeus*) at the macro-habitat level in a farmland area of southern Tuscany during feeding activity using spot-light counts.

Olive tree groves, cereal stubbles and winter cereals were used more than their availability, whereas ploughed fields, alfalfa and fallow fields were used less than their availability. Olive tree groves were the most used, followed by cereal stubbles. Since approximately 50% of over-wintering cereal stubbles were the result of economic agreements between the hunting district and local farmers, the study confirms the importance of this kind of agro-environmental measure for hare conservation.

Introduction

The number of European hares (*Lepus europaeus*) has drastically decreased in Italy (Santilli and Galardi, 2006), as well as in the whole of Europe since the 1960's (Marboutin and Péroux, 1995; Hutchings and Harris, 1996; Slamečka et al., 1997; Edwards et al., 2000; Marboutin er al., 2003; Vaughan et al., 2003; Schmidt et al., 2004; Smith et al., 2005).

It has been widely accepted that habitat changes caused by the intensification of agriculture are a key factor in driving the long-term decline of the species (Edwards et al., 2000; Smith et al., 2005; Santilli and Galardi, 2006; Zellweger-Fischer et al., 2011). Agriculture intensification resulting in loss of biodiversity, can significantly affect the habitat diversity of ecosystems inhabited by hares. Habitat diversity is considered a key factor for the European hare conservation (Tapper and Barnes, 1986; Meriggi and Alieri, 1989; Smith et al., 2004). Hares are best sustained by agricultural habitats which provide them with a diversity of crops at different growth stage in order to ensure food and shelter throughout the year, (i.e., herbaceous crops, hayfields, and meadows) (Tapper and Barnes, 1986; Meriggi and Verri, 1990; Santilli et al., 2004; Cardarelli et al., 2011; Kamieniarz et al., 2013). The structure of agricultural landscape can also influence the rate of predation (Slamečka, 1991; Smith et al., 2005), in particular by red fox, which is documented to negatively affect hare densities (Knauer et al., 2010; Reynolds and Tapper, 1995; Schmidt et al., 2004; Panek et al., 2006; Panek, 2009).

However, other factors such as diseases (Lamarque et al., 1996; Paci et al., 2011), landscape fragmentation (Roedenbeck and Voser, 2008) climatic conditions (Kilias and Ackermann, 2001; Jennings et al., 2006; Santilli and Galardi, 2006; Spittler, 1997) and kind of soil (Santilli and Ferretti, 2008) are also reported to play a role in shaping European hare abundance.

Although the habitat use by hares in arable farmlands is generally known, the need to study in depth habitat selection and preference by hares still persists in intensive agro-ecosystems and during limiting seasons. For these reasons spot-light counts were carried out in a farmland area of southern Tuscany (Italy) from 2008 to 2011, with the aim of investigating habitat use by the European hare during winter (December) and obtaining useful information about hare habitat requirements for management purposes.

Study area

The study area (42°56′50″N, 10°48′29″E) is located in the Grosseto province (south-western Tuscany, Italy) at a distance of about 3.5 km from the coast line. It is a protected area (7.6 km^2) established more than thirty years ago to conserve small game species (only predator control is allowed). The climate is Mediterranean warm-temperate, with mild winters. The annual mean temperature is 15.7°Cwith a maximum of 30°Cin July and a minimum of 3°Cin January. Rainfall is quite scarce (655 mm per year). Land use included, arable crops (winter wheat, winter beans, sunflowers, and alfalfa *Medicago sativa*, 89.3%), olive tree groves (5.2%), horse pastures (1.1%), woodlands (mainly pine-woods, 2.1%), ditches with grassy banks (1.8%) and human settlements (1.0%) (Fig. 1). On average 15% of arable lands were devolved to over winter cereal stubble.

During the study period hare density estimated by spot-light counts (Langbein et al., 1999) averaged 40.0 hares/km^2 (S.D.=7.82), with a minimum of 31.6 hares/km^2 in 2010 and a maximum of 47.0 hares/km^2 in 2011.

In the study area hooded crows (*Corvus coronae cornix*) and magpies (*Pica pica*) were controlled using Larsen traps and foxes (*Vulpes vulpes*) by shooting. Average fox density estimated by spot-light counts (Heydon et al., 2000) was 0.9 fox/km^2 (S.D.=0.38).

Methods

Habitat use was evaluated using spot-light counts carried out from a moving car (maximum speed: 5 km/h) along 4 transects for a total length of 14.5 km, lighting up both sides of the transects by a handle lamp (1 million candle power) and mapping the lighted belt on aerial photographs (Langbein et al., 1999). The transect route was selected from the existing fields road network so as to survey each habitat type in proportion to its relative extension; in this way the distribution of hares within the sampled area did not differ from that of the whole study area

*Corresponding author
Email address: perdix@teletu.it (Francesco Santilli)

Table 1 – Results of Bonferroni simultaneous confidence interval analysis for the use of habitat types by European hares during winter (pooled years, Province of Grosseto (south-western Tuscany, Italy).

Habitat	Proportion availability	Hares observed	Hares expected	Manly's index	Bonferroni confidence interval
Winter cereals	0.305	181	148	0.13	$0.330 \leq P_1 \leq 0.416$ **
Ploughed fields	0.303	103	147	0.08	$0.176 \leq P_2 \leq 0.249$ **
Alfalfa fields	0.070	22	34	0.07	$0.027 \leq P_3 \leq 0.064$ *
Olive tree groves	0.017	18	8	0.24	$0.020 \leq P_4 \leq 0.054$ *
Horse pasture	0.024	12	12	0.11	$0.011 \leq P_5 \leq 0.039$
Cereal stubbles	0.144	117	70	0.18	$0.203 \leq P_6 \leq 0.279$ **
Fallow fields	0.114	18	55	0.04	$0.020 \leq P_7 \leq 0.054$ **
Winter beans	0.023	14	11	0.14	$0.014 \leq P_8 \leq 0.044$
Total	3.15 km^2	485	485		
		$\chi^2 = 94.53$	$p<0.0001$		

* $p<0.05$, ** $p< 0.01$, preferred habitats in bold.

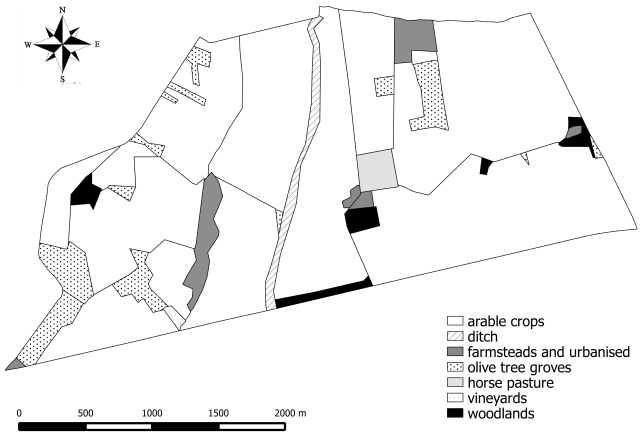

Figure 1 – Land use of the study area.

(Langbein et al., 1999). Spotlights were carried out in December of each year when crops and herbaceous cover were less developed. Each count started at least two hours after sunset. At least two counts where done every years (a third count was always carried out when the number of counted hares differed more then 25% from the average of the first two counts) An average of 3.15 km^2 (42% of the study area) was surveyed every year (S.D.=0.66). Hares sight-ability varied greatly depending on the vegetation structure: it was maximum in open fields with low vegetation (the surveyed belt was 200 meters), and was reduced in fallow fields, where grass has not been not mowed, and in olive tree groves, where trees density prevented lighting over long distances (the surveyed belt was about 50 meters). The use of the maximum distance of hare sight measured by laser range-finder allowed us to reduce the risk of biasing due to the different characteristics of sight-ability.

For every observation (singular or clustered hares), we recorded the habitat type, the position on the transects using a hand held GPS receiver, and the perpendicular distance from the transect with the aid of the laser range-finder. Finally we mapped the cover types of the surveyed belt over an aerial photograph. All information were digitalized by ArcView 3.2.

The observed frequencies and proportion of hare in each habitat type (observed usage proportion) were then calculated and compared with those expected (expected usage proportion) by χ^2 goodness-of-fit test and Bonferroni simultaneous confidence interval analysis (Vidus-Rosin et al., 2008). Habitat preference was measured by Manly index of preference considering only the habitats included in the spotlighted belt (Manly et al., 1993; Vidus-Rosin et al., 2008).

Results

Olive tree groves, cereal stubbles, winter cereals and winter beans resulted used more with respect to their availability, although in the last case the value was not not significant. Ploughed fields, alfalfa and fallow fields resulted used less with respect to their availability. The use of horse pastures did not differ from availability. Use calculated by Manly's index resulted: 0.24 for olive tree groves, 0.18 for over winter cereal stubbles, 0.14 for winter beans, 0.13 for winter cereals, 0.11 for horse pasture, 0.08 for ploughed fields, 0.07 for alfalfa fields, 0.04 for fallow fields. (Tab. 1).

Discussion

Olive tree grooves and over winter cereal stubbles registered the highest uses followed by winter cereals and winter beans. Fallow fields registered the highest avoidance value followed by alfalfa and ploughed fields. Horse pasture was used as its availability.

Olive tree groves in the study area were always grassed and mowed periodically. So they can offer a great variety of suitable weeds. In addiction these crops offer protection from adverse weather and from aerial predators. Over winter stubbles provide essential seed-rich resources for a wide array of species. In particular, they offer a great variety of weeds that make this fields more attractive than winter cereals, where the chemical input and the agricultural processing reduce weeds availability (Tapper, 1987). Frylestam (1986) found that in winter wild plants are generally preferred to agricultural crops indicating the importance of a rich wild flora available to hares. In the study area, approximately 50% of over-winter cereal stubble were the result of economic agreements between the hunting district and local farmers. Our study underlined the importance of this kind of agro-environmental measure for European hare conservation.

Growing winter cereals are usually the most preferred food by hares during winter (Reichlin et al., 2006). This fact probably explain the high use of these crops found in our study. During the surveys in fact winter cereals were in the sprouting stage. Sprouted grain have a high nutritive value due to the activity of hydrolytic enzymes that improve the digestibility of starch and proteins (Chavan et al., 1989).

Fallow fields, set aside and natural vegetation generally play a positive role for the European hare conservation in arable lands, (Frylestam, 1992; Hutchings and Harris, 1996; Vaughan et al., 2003) but hares generally avoid them during the winter (Smith et al., 2004). In addition their use is strongly dependent upon their vegetation structure (Neumann et al., 2011; Pépin and Angibault, 2007). However the low use of fallows in our study might be influenced by the height of vegetation that often reduced the detectability of the hares in these fields.

The avoidance of alfalfa by hares may be surprising, but it is known that this crop during the winter stops its vegetative activity. In this phase the nutritive value tend to be lower than in spring. Lucerne and the other forage legumes as clovers become very important in the spring-summer when cereals start to ripen and their digestibility is reduced. However Reichlin et al. (2006) found that as food item clovers (*Trifolium pratense* and *Trifolium repens*) are more selected then alfalfa in a arable area of Austria.

Ploughed fields are important resting site during the winter when the height of vegetation of adjacent crops is generally reduced (Pépin and Angibault, 2007) but tend to be avoided during feeding activity. Pastures are generally considered an unsuitable habitat for hares (McLaren et al., 1997). In our case, the presence of horses, which grazed at low

density, improved a high herbaceous diversity. In addiction equines tend to create a mosaic of short, heavily grazed lawns interspersed with patches of taller, lightly grazed or ungrazed vegetation (Ausden, 2007). This kind of cover is probably quite favourable for hares because can be used both for feeding and resting. Generally pastures grazed by cattle are avoided in winter when other crops are available, whereas pastures grazed by sheep are avoided in all seasons (Smith et al., 2004). The negative effect of the density of grazing sheep on brown hare bag records was confirmed also in Tuscany (Santilli and Galardi, 2006). Smith et al. (2004) clarified that avoidance of pasture is mainly due by the low heterogeneity at the within-habitat scale as a consequence of high grazing pressure. Unimproved grasslands which has a heterogeneous structure, is strongly associated with high hare numbers (Hutchings and Harris, 1996).

Our results suggest that landscapes characterized by heterogeneous vegetation structure and by low horse grazing pressure might provide a suitable habitats for hares. In addition over winter stubbles seem to be a valuable measure for hare conservation within simplified agro-ecosystems probably because they provide a high variety of palatable weeds.

References

Ausden M., 2007. Habitat Management for Conservation. Oxford University Press.

Cardarelli E., Meriggi A., Brangi A., Vidus-Rosin A., 2011. Effects of arboriculture stands on European hare *Lepus europaeus* spring habitat use in an agricultural area of northern Italy. Acta Theriol. 56: 229–238.

Chavan J.K., Kadam S.S., Beuchat L.R., 1989. Nutritional improvement of cereals by sprouting. Cr. Rev. Food Sci. Nutr. 28: 401–437.

Edwards P.J., Fletcher M.R., Berny P., 2000. Review of the factors affecting the decline of the European brown hare, *Lepus europaeus* (Pallas, 1778) and the use of wildlife incident data to evaluate the significance of paraquat. Agric. Ecosyst. Environ. 79: 95–103.

Frylestam B., 1986. Agricultural land use effects on the winter diet of brown hares (*Lepus europaeus* Pallas) in southern Sweden. Mammal Rev. 16: 157–161.

Frylestam B., 1992. Utilization by brown hares *Lepus europaeus*, Pallas of field habitats and complimentary food stripes in southern Sweden. In: Bobek B., Perzanowski K., Regelin W. (Eds.) Global Trends in Wildlife Management. Swiat Press, Krakow-Warszawa. 259–261.

Heydon M.J., Reynolds J.C., Short M.J., 2000. Variation in abundance of foxes (*Vulpes vulpes*) between three regions of rural Britain, in relation to landscape and other variables. J. Zool. Lond. 251: 253–264.

Hutchings M.R., Harris S., 1996. The Current Status of the Brown Hare (*Lepus europaeus*) in Britain. Joint Nature Conservation Committee, Peterborough.

Jennings N., Smith R.K., Hackländer K., Harris S., White P.C.L., 2006. Variation in demography, condition and dietary quality of hares *Lepus europaeus* from high-density and low-density populations. Wildl. Biol. 12: 179–189.

Kamieniarz R., Voigt U., Panek M., Strauss E., Niewęgłowski H., 2012. The effect of landscape structure on the distribution of brown hare *Lepus europaeus* in farmlands of Germany and Poland. Acta. Theriol. 58(1): 39–46. doi:10.1007/s13364-012-0091-z

Kilias H., Ackermann W., 2001. Zur Bestandssituation des Feldhasen (*Lepus europaeus* Pallas) in Bayern. Z. Jagdwissen. 47: 111–124.

Knauer F., Küchenhoff H., Pilz S., 2010. A statistical analysis of the relationship between red fox *Vulpes vulpes* and its prey species (grey partridge *Perdix perdix*, brown hare *Lepus europaeus* and rabbit *Oryctolagus cuniculus*) in Western Germany from 1958 to 1998. Wildl. Biol. 16: 56–65.

Lamarque F., Barrat J., Moutou F., 1996. Principal diagnosis for determining causes of mortality in the European hare (*Lepus europaeus*) found dead in France between 1986 and 1994. Game and Wildife Science 13: 53–72.

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

Manly B.F.J., McDonald L.L., Thomas D.L., 1993. Resource selection by animals. Chapman & Hall. New York.

Marboutin E., Bray Y., Péroux R., Mauvy B., Lartiges A., 2003. Population dynamics in European hares: breeding parameters and sustainable harvest rates. J. App. Ecol. 40: 580–591

Marboutin E., Péroux R., 1995. Survival pattern of European hares in a decreasing population. J. App. Ecol. 32: 809–816.

McLaren G.W., Hutchings M.R., Harris S., 1997. Why are brown hares (*Lepus europaeus*) rare in pastoral landscapes in Great Britain? Gibier Faune Sauvage 14: 335–348.

Meriggi A., Alieri R., 1989. Factors affecting brown hare density in northern Italy. Ethol. Ecol. Evol. 1: 255–264.

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

Neumann F., Schai-Braun S., Weber D., Amhrein W., 2011. European hare select resting place for providing cover. Hystrix 22(2): 291–299. doi:10.4404/hystrix-22.2-4546

Nyenhuis H., 1995. The influence of weather on the population dynamics of European hare (*Lepus europaeus* P.) Eur. J. Wildl. Res. 41: 182–187.

Paci G., Lavazza A., Ferretti M., Santilli F., Bagliacca M., 2011. Relationship between Anti-European Brown Hare Syndrome Serological Titers and Brown Hare (*Lepus europaeus* Pallas) Densities. International Journal of Zoology 2011: 436193. doi:10.1155/2011/436193

Panek M., 2009 Factors affecting predation of red foxes *Vulpes vulpes* on brown hares *Lepus europaeus* during the breeding season in Poland. Wildl. Biol. 15: 345–349.

Panek M.K., Kameniarz 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.

Pépin D., 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.

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

Reynolds J.C., Tapper S.C., 1995 Predation by foxes *Vulpes vulpes* on brown hares *Lepus europaeus* in central southern England, and its potential impact on annual population growth. Wildl. Biol. 1: 145–158.

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

Santilli F., Galardi L., 2006. Factors affecting brown hare (*Lepus europaeus*) hunting bags in Tuscany region (central Italy). Hystrix It. J. Mamm. 17(2): 143–153. doi:10.4404/hystrix-17.2-4372

Santilli F., Ferretti M., 2008. Do Soils affect Brown Hare (*Lepus europaeus* abundance in agricultural habitats? Hystrix 19(1): 39–45. doi10.4404/hystrix-19.1-4413

Santilli F., Mazzoni della Stella R., Guerrini L., Mori L., Bisogno G., Bagliacca M., 2004. Factors affecting brown hare (*Lepus europaeus*) production in large enclosure. Game and Wildlife Science 21: 471–480.

Schimdt N., Asferg T., Forchhammer M., 2004. Long term pattern in European brown hare population dynamics in Denmark: effects of agriculture, predation and climate. BMC Ecology 4: 15.

Serrano Pèrez S., Jacksic D., Meriggi A., Vidus Rosin A., 2009. Density and habitat use by the European wild rabbit (*Oryctolagus cuniculus*) in an agricultural area of northern Italy. Hystrix 19(2): 143–156. doi:10.4404/hystrix-19.2-4424

Slamečka J., 1991. The influence of ecological arrangements on brown hare population. In: Csànyi S, Erhaf J., (Eds.) XXth Congress of the International Union of Game Biologist. Brno, Hungary. 340–344.

Slamečka J., Hell P., Jurcík R., 1997. Brown hare in the west Slovak lowland. Acta Scientarum Natura Brno 31: 1–115.

Smith K.R., Jennings N.V., 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: 1–14.

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

Spittler H., 1997 The cause of the dramatic decline in numbers of the brown hare (*Lepus europaeus* Pallas 1778) in the years 1978 and 1979. Z. Jagdwiss. 33: 175–184.

Tapper S.C., 1987 The Brown hare. Shire Natural History.

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

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

Vidus-Rosin A., Gilio N., 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., Hacklander K. (Eds.) Lagomorph biology. Evolution, Ecology and conservation. Springer, Eidenberg. 153–165.

Zellweger-Fischer J., Kéry M., Pasinelli G., 2011 Population trends of brown hares in Switzerland: the role of land-use and ecological compensation areas. Biol. Cons. 144: 1364–1373

Associate Editor: N. Ferrari