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Habitat improvement and effects on brown hare *Lepus europaeus* and roe deer *Capreolus capreolus*: a case study in northern Italy

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After the Common Agricultural Policy reform of 1992 and the application of agro-environmental measures, most EU countries have introduced specific measures for wildlife habitat improvement. The aim of our study was to evaluate the effects of two habitat improvement actions on brown hare *Lepus europaeus* and roe deer *Capreolus capreolus* populations in two study areas in the hills of Emilia-Romagna in Italy. The study was carried out from October 1996 to October 1997. Data on brown hares were collected at night using spotlights. Density was estimated at 26 (area A) and 29 (area B) sampling sites. Data on roe deer were collected at 17 sampling sites (fields observed) during 2-hour periods, before sunset and after sunrise, respectively, using binoculars. We recorded 736 brown hares. Brown hare density was higher in study area A (0.27 individuals/ha) than in study area B (0.23 individuals/ha). We counted 153 roe deer during the diurnal surveys. The highest roe deer density was observed in February-March 1997 (0.306 individuals/ha). We used Bonferroni confidence intervals, Kruskal-Wallis and Mann-Whitney U tests to compare the densities in different habitats. Brown hares avoided uncultivated fields in both study areas, while they selected habitat improvements in area A and forage crops in area B. Roe deer selected habitat improvements and secondarily forage crops, but avoided uncultivated fields. Our study demonstrates that extensive cultivated fields (maintained or reintroduced according to EU agro-environmental regulations) can play an important role in territories with agriculture retirement and abandonment, acting primarily as a source of food (mostly green forage) for several herbivorous wildlife species.

Key words: agro-environmental measures, brown hare, Capreolus capreolus, habitat improvement actions, Lepus europaeus, northern Italy, roe deer

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After World War II, the development of agricultural practices in Italy and Europe can in general be characterised by a concentration of activities in plains and low hills, with an increasing impact on habitat and wildlife (Di Cocco 1991). In upland regions (high hills and mountains), land use change has involved a reduction in arable land and temporary forage crops and an increase in woodlands and uncultivated, abandoned and non-productive land (Table 1).

This has had serious consequences on the economic

Table 1. Development in land use of upland farms (in ha x 1,000 and %) during 1961-2000 in the Emilia-Romagna region and in Italy. Data on arable lands, permanent crops, pastures and permanent meadows, agricultural lands and total upland area concern farmlands in hills and mountains. Source: National Agricultural Census (I.S.T.A.T. 1961, 2000). Data on forest lands, uncultivated lands, non-productive lands and total land area concern farmlands and non-farmlands in upland and lowland areas. Source: I.S.T.A.T. 1963, 1994.

	Emilia-romagna					Italia				
	Area				Var.	Area				Var.
	1961		2000		1961-2000	1961		2000		1961-2000
	ha	%	ha	%	%	ha	%	ha	%	%
Arable lands	483	*41.8*	262	*22.7*	-19.2	6274	*27.1*	4127	*17.8*	-9.3
(forage crops)	301	*26.0*	154	*13.3*	-12.7	2136	*9.2*	1051	*4.5*	-4.7
Permanent crops (e.g. orchards, vineyards)	17	*1.5*	37	*3.2*	1.7	1458	*6.3*	1774	*7.7*	1.4
Pastures and permanent meadows	169	*14.6*	97	*8.4*	-6.2	6161	*26.6*	3135	*13.5*	-13.1
Agricultural lands	669	*57.9*	435	*37.7*	-20.3	13893	*60.0*	8994	*38.8*	-21.2
Forest lands	356	*16.1*	402	*18.2*	2.1	5847	*19.4*	6750	*22.4*	3.0
Uncultivated lands	49	*2.2*	221	*10.0*	7.8	1040	*3.5*	2563	*8.5*	5.1
Non-productive lands	196	*8.9*	292	*13.2*	4.3	2552	*8.5*	3948	*13.1*	4.6
Total upland area	1155	*100*	1155	*100*	-	23151	*100*	23155	*100*	-
Total land area	2212	*100*	2212	*100*	-	30122	*100*	30111	*100*	-

and social activities of these territories, e.g. rural exodus, land retirement, hydro-geological problems, but also on natural landscapes and wildlife resources. The increase in wilderness has been favourable to some wildlife species (mostly ungulates, some large carnivores and in general the 'interior species', i.e. species that take advantage of a large and homogeneous ecosystem; Payne & Bryant 1994). However, the increased homogeneity of the environment and wildlife habitats has had negative effects on other wild species (brown hares *Lepus europaeus*, grey partridges *Perdix perdix*, pheasants *Phasianus colchicus*, grouse and in general 'edge species', i.e. species that benefit from a heterogeneous ecosystem consisting of small patches of different habitats; Payne & Bryant 1994) and on biodiversity in general (Schröpfer & Nyenhuis 1982, Zürcher 1998, Baldock 1999, OECD 2003). In addition, the spread of ungulates into these areas has led to increasing conflict with the remaining cultivation and the declining intensive agricultural activities (Spagnesi & Toso 1991, Toso et al. 1999)

The changes in agriculture and landscapes have prompted a modification of the Common Agricultural Policy (CAP) and the development of agro-environmental measures to deal with the situation. In particular, EEC regulation 2078/92 provides European countries with several types of action to reduce the impact of agricultural practices on natural habitats or to develop different forms of sustainable management of natural resources. Thus, several European countries have introduced specific measures for wildlife habitat improvement (Boatman 1995, Havet 1995, 1998, Genghini 1997, 2001).

Among the measures applied in Italy (Table 2), our study deals with actions F1 (areas of pasture, meadows and hedgerow plantations) and B2 (areas of extensive permanent sown grasses) which were implemented in the Emilia-Romagna region (see Habitat and field data

Table 2. Agro-environmental measures (with reference to EEC regulation 2078/92) realised in Italy for the benefit of wildlife during 1993-2000. Sources: INEA 1999, Genghini 2004.

Actions	Description	Wildlife benefits	Surface (1000) ha	% of agricultural lands
A1+A2	Maintenance and improvement of integrated agriculture	+	1085	8.3
A3+A4	Maintenance and improvement of organic agriculture	++	697	5.3
B1	Extensive cultivation: meadows, pasture and arable crops	+	173	1.3
B2	Maintenance and improvement of meadows and pastures	++	44	0.3
B/D1	Maintenance of pastures and livestock breeding on uplands	++	507	3.9
D1	Plantation and maintenance of e.g. hedgerows and woodlots	+++	24	0.2
D2	Genetic preservation	+	1	0.0
E1	Restoration and maintenance of agricultural fields on uplands	++	16	0.1
E2	Forestry management and restoration	+	60	0.5
F	20-years environmental set-aside	+++	46	0.4
G	Public outdoor recreation	+	8	0.1

section for details). The general agro-environmental goals of these actions are: (i) to reduce intensive crop production in semi-natural habitats, (ii) to maintain extensive and sustainable forms of agricultural production, and (iii) to reduce agriculture retirement and abandonment of upland territories. In the northern Apennines, as in many comparable Italian and other European upland areas, the interventions may benefit wildlife because they can be oriented more strictly towards wildlife management, with the maintenance of open and low-intensity cultivated fields of pasture and forage within forests and abandoned land (Genghini 1994, 2004).

The aim of our study is to compare the densities of brown hare and roe deer *Capreolus capreolus* during periods of maximal foraging activity in the residual open areas (cultivated and non-cultivated) typical of the northern Apennine uplands. In particular, we intended to evaluate the importance of some habitat improvement areas established for the benefit of wildlife species, in particular the brown hare and the roe deer.

Several studies have documented the importance to hare populations of extensive areas of arable land or pastures and meadows within forests and uncultivated land in upland regions of Europe (Barnes & Tapper 1985, Lewandowski & Nowakowski 1993, Hutching & Harris 1996, Mclaren et al. 1997, Paniek & Kamieniarz 1999) and of Italy (Meriggi & Alieri 1989, Rosa et al. 1993). However, little is known about habitat use by hares in upland territories where agricultural activities have almost disappeared and the landscape is dominated by uncultivated and wooded areas.

Many studies of ungulates have shown that heterogeneous habitats in which open fields of pasture and forage crops alternate with forest have a higher carrying capacity than homogeneous habitats dominated by forests (Perco & Perco 1979, Boisaubert & Boutin 1988, Danilkin 1996). Heterogeneous habitats may also prevent the dispersion of ungulate populations from upland territories toward the more intensive and 'high revenue' agricultural crops in the valley.

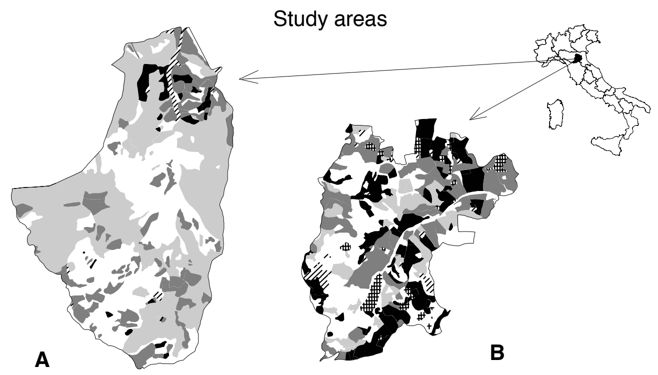
Material and methods

Study areas

Our study was carried out in two game farms in the northern Apennines in Italy (Fig. 1).

Study area A covers 1,200 ha and is elevated 200-570 m a.s.l. It represents the typical habitat of marginal hills, where most pastures or arable fields have been abandoned for 10-15 years. The territory is dominated by uncultivated fields, woods and shrublands. In the rare, cultivated fields forage crops and winter cereals are grown.

Study area B covers 800 ha at elevations of 100-450 m a.s.l. Cultivated fields are more abundant than in area



	Area A				Area B			
	Total (ha)	Survey areas(ha)	% of total	% of s. areas	Total (ha)	Survey areas(ha)	% of total	% of s. areas
Woodlands and shurbs	380,2		31,7		251,3		31,5	
Forage crops and pastures	173,2	(65)	14,4	(71,1)	196,4	(52,7)	24,6	(42,5)
(Habitat improvement fields)	97,2	(45)	8,1	(47,5)	32,5	(14,9)	4,1	(11,8)
Uncultivated fields	575,4	(23,5)	47,9	(25,4)	101,3	(9,6)	12,7	(7,7)
Unvegetated areas	16,8		1,3		19,6		2,5	
Orchards, vineyards, etc.	0,0		0,0		30,7		3,9	
Arable lands (winter cereals)	55,7	(3,2)	4,6	(3,5)	198,0	(61,8)	24,8	(49,8)
Total	1200,3	(92,4)	100	(100)	797,3	(124,1)	100	(100)

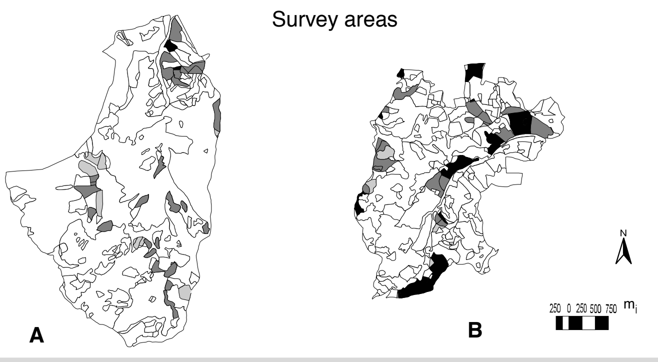


Figure 1. Geographic location, main categories of land use and natural surveyed fields in study areas A and B.

A, representing about 50% of the territory. However, the cultivated fields are interspersed within woods, shrublands and uncultivated fields (see Fig. 1), and consist mainly of arable land, forage crops, vineyards and orchards. This area represents the typical environment of medium and low hills, where agricultural activities are dominant, but woods, shrublands and uncultivated fields are also present.

In study area A, roe deer hunting was strictly regulated, whereas in study area B the deer population was fairly unstable. In both areas there had been no hare hunting for the previous five years.

Habitat and field data

Land use data were recorded on the basis of a photo survey done in 1994 (Volo Italia 1994). Detailed updating (1996 and 1997) of the land use was carried out by means of field surveys. Land use maps were based on the Corine classification, adapted and improved for the cultivated areas. Field types selected for habitat use and feeding preference analyses were grouped into five main categories: 1) open uncultivated fields, 2) habitat improvement fields, 3) forage crops, 4) winter cereals and 5) non-surveyed habitat.

The open uncultivated fields are areas of herbaceous vegetation dominated by cock's foot *Dactylis glomerata*, the remnants of pastures or arable fields abandoned at least 8-10 ago, or calanques mostly covered by a type of sagebrush *Artemisia cretacea*, bird's foot trefoil *Lotus corniculatus*, cock's foot and tall fescue *Festuca arundinacea*. The general appearance of the open uncultivated fields is dry grassland dominated by degraded herbaceous cover.

The habitat improvement fields are mainly characterised by the creation of extensive permanent pastures and meadows. Two grass mixtures were sown in the two areas 2-3 years ago. The first mixture (action F1) of which 50 kg/ha was used contained 26% tall fescue, 20% perennial ryegrass *Lolium perenne*, 40% red fescue *Festuca rubra*, 4% white clover *Trifolium repens*, 5% bird's foot trefoil and 5% sulla sweetvetch *Hedysarum coronarium*. The second mixture (action B2) of which 40 kg/ha was used contained 17% cock's foot, 20% tall fescue, 7% timothy *Phleum pratense*, 15% red fescue, 3% white clover, 4% bird's foot trefoil, 6% sulla sweetvetch and 10% lucerne *Medicago sativa*. The management contract imposes one late cut per year (after 20 July). Action F1 also provides for the planting of hedgerows of different shrubs and trees. However, the study and observations were carried out in the second and third year of hedgerow planting and grass growth, respectively. Thus, the hedges were too small to have a great influence on habitat use by hares and roe deer, and the effects of habitat improvement fields were mostly due to the presence of the extensive forage mixtures.

The forage crops of the two areas are dominated by lucerne. In area B, ⅓ of the forage crop fields are dominated by sulla sweetvetch. All the fairly young cultivated meadows or pastures (< 7-8 years old) are included in this category. The cultivation and cutting regimes of forage crops are particularly extensive in the two areas, with usually two or three harvesting periods (June, July and August). The one- or two-year-old uncultivated fields are also included in this group.

The winter cereals include winter wheat and winter barley. Observations were suspended from the growing phase until harvesting, and ploughed fields were not surveyed. This habitat category was excluded from the analysis of area A because the few fields present were concentrated in a non-comparable part of the game farm in terms of human disturbance.

The non-surveyed habitat (where hares and roe deer were not surveyed) included woods and shrublands, row crops (e.g. sunflower *Helianthus annus*, maize *Zea maize*, sorghum *Sorghum vulgare*), orchards, vineyards, water bodies, bare habitats, private gardens, urban areas and other artificial surfaces.

Sampling periods

The study was carried out between October 1996 and October 1997. Counts were possible only when most of the vegetation or crops were low. In study area A, nocturnal surveys were carried out in four periods: October-November 1996, January-February, March-April, and September-October 1997. In study area B, they were carried out in October-December 1996, January-February, March-April, and June-July 1997.

Nocturnal surveys of brown hares

Data on the brown hare were collected using spotlights (Frylestam 1981, Barnes & Tapper 1985) in 26 (area A) and 29 (area B) sampling sites to which good views across the fields could be obtained from farm tracks, and for which comparisons between different habitat categories were possible. The light beam of a 1,000,000 candle-power spotlight was swept around to count the hares. Since this method is highly affected by changes in visibility, foggy and very misty conditions were avoided. We carried out 3-5 observation sessions in each seasonal period.

Diurnal surveys of roe deer

Data on the roe deer were collected in 2-hour periods,

Table 3. Chi-square goodness-of-fit test and Bonferroni confidence interval test for habitat preferences by hares in the study areas A and B during 1996-1997. The symbols used in the table are: +: preference, -: avoidance, =: indifference, according to the fact that the observed frequency values are greater, lower or included in the confidence interval values of the expected frequencies.*: totals do not include data from June and July. **: in this period habitat preference was not significantly different (χ^2 test)

	October-November 1996	January-February 1997	March-April 1997	September-October 1997	Total
Habitat types in area A					
χ^2 (P <0.0001)	19.9	34.8	22.8	19.6	61.5
Improvements	=	+	=	=	+
Forage crops	=	-	+	=	=
Uncultivated	-	-	-	-	-
	October-December 1996	January-February 1997	March-April 1997**	June-July 1997	Total*
Habitat types in area B					
χ^2 (P <0.0001)	43.9	25.7	4.5	28.0	61.3
Improvements	=	=	=	=	=
Forage crops	+	+	+	+	+
Uncultivated	-	-	-	-	-
Winter cereals	-	-	=	=	-

before sunset and after sunrise, using binoculars (Zeiss 8x56) from three panoramic viewpoints in study area A (Ratcliffe & Mayle 1992). We selected 17 sampling sites (fields observed) on the basis of comparable visibility within the four habitat categories (excluding winter cereals). In total, 15 observation sessions were carried out during three seasons (February-March, May-June and September-October) in 1997. Roe deer foraging activity for at least 10 minutes in the same field was considered an indicator of habitat use. An extended presence of the same deer in the same field within the same 2-hour observation period was not double counted.

Data analyses

The exact surface areas covered by the nocturnal and diurnal observations were calculated using geographic information systems (ArcInfo 7.0 and ArcView 3.1). Estimated densities of brown hares and roe deer were calculated as the ratio of the number of animals seen divided by the exact area covered by the nocturnal or diurnal survey. Statistical analyses were performed using SPSS for Windows (version 6.1; Norusis 1993); all tests were 2-tailed and alpha was set at 0.05. The procedures used are described in Sokal & Rohlf (1969) and Zar (1984). The selection or avoidance of a given habitat type was determined by the expected and observed frequency of observations, applying first the chi-square goodness-of-fit test and then the Bonferroni confidence intervals test following the method described in Neu et al. (1974), Byers et al. (1984) and Litvaitis et al. (1994). Brown hare and roe deer densities in the various field types were compared using the Kruskal-Wallis test. Differences between pairs of categories were then analysed using the Mann-Whitney U-test (Glantz 1987).

Results

Brown hare

In total, 736 brown hares were observed by spotlight of which 380 (51.6%) were observed in study area A and 356 (48.4%) in study area B. The average density in the surveyed fields was higher in study area A (0.27 ± 0.07 (SE) hares/ha) than in study area B (0.23 ± 0.04 (SE) hares/ha), but the difference was not statistically significant (Kruskal-Wallis, H = 0.48, df = 1, P = 0.47). The mean hare density was highest in spring in study area A (0.28 ± 0.08 (SE) hares/ha) and in summer in study area B (0.31 ± 0.10 (SE) hares/ha). Significant differences among seasons were found in study area A (H = 12.36, df = 3, P = 0.006), but not in study area B (H = 1.10, df = 3, P = 0.78).

Differences in density among field types

In study area A, hares did not use the selected field categories in proportion to their availability. The same was true for study area B, except for the survey period of March-April 1997 when no selection was made (Table 3). Brown hares avoided uncultivated fields in both study areas, and they preferred habitat improvement fields in study area A and forage crops in study area B (see Table 3). Hare densities in study area A (Fig. 2) revealed a significant preference only in one sampling period (Kruskal-Wallis test: March-April: N = 26, H = 8.55, df = 2, P = 0.02) and with all the periods considered together (N = 26, H = 8.42, df = 2, P = 0.01). However, significance was almost reached in all the other periods (October-November 1996: N = 26, H = 5.20, df = 2, P = 0.07; January-February: N = 26, H = 4.44, df = 2, P = 0.10; September-October 1997: N = 26, H = 4.79, df = 2, P =

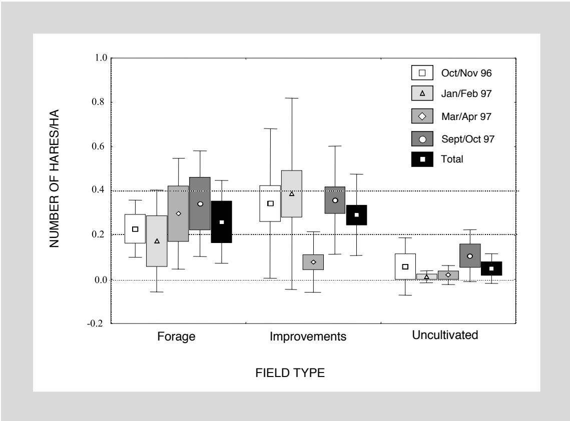


Figure 2. Average densities (in individuals/ha), standard deviation and error of hares in study area A, during the periods surveyed and according to the three types of fields.

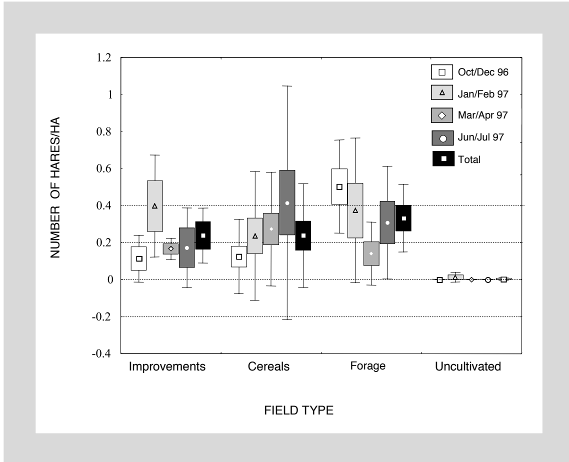


Figure 3. Average densities (in individuals/ha), standard deviation and error of hares in study area B, during the periods surveyed and according to the three types of fields.

0.10). The pairwise comparisons (Mann-Whitney U-test) confirmed the significant preference for habitat improvement fields to uncultivated fields (Table 4).

Among the hare densities recorded in study area B during the four sampling periods (Fig. 3), differences between habitats were significant at P = 0.05 only in October-December 1996 (Kruskal-Wallis test: N = 28, H = 11.99, df = 3, P = 0.007). However, in January-February 1997 (N = 28, H = 6.97, df = 3, P = 0.07) and March-April 1997 (N = 28, H = 6.06, df = 3, P = 0.10), the differences were relevant, if not statistically significant (June-July 1997: N = 21, H = 4.34, df = 3, P = 0.23). In addition, the total density (excluding the period of June-July 1997) differed significantly between the three field types (N = 28, df = 3, H = 8.68, P = 0.03). The

Table 4. Results of Mann-Whitney U tests performed on the brown hare densities recorded in study areas A and B. P-level abbreviations are: n.s.: not significant; *: P < 0.05; **: P < 0.01; ***: P < 0.005. The significance levels indicate preference for the type of field in the corresponding row, except for 'Uncultivated fields' where the sign + indicates preference for the type of field in the corresponding column (Winter cereals). Considering the situation of multiple comparisons, as in our case, several authors suggest that P levels be corrected. Usually the Bonferroni correction is applied, dividing the P level by the number of comparisons, but different approaches have been proposed (see Winer et al. 1991). Applying the Bonferroni correction the significative comparisons are marked with #. In study area B the survey period was October/December 1996.

		Area A		Area B		
Type of field	Study periods	Habitat improvements	Uncultivated fields	Habitat improvements	Uncultivated fields	Winter cereals
Forage crops	Oct-Nov 96	n.s.	n.s	*	*	* *#
	Jan-Feb 97	n.s.	n.s.	n.s.	*	n.s.
	Mar-Apr 97	*	*	n.s.	n.s.	n.s.
	Jun-Jul 97	-	-	n.s.	*	n.s.
	Sept-Oct 97	n.s.	n.s.	-	-	-
	Total	n.s.	*	n.s.	* *#	n.s.
Habitat improvements	Oct-Nov 96	-	-	-	n.s.	n.s.
	Jan-Feb 97	-	-	-	*	n.s.
	Mar-Apr 97	-	n.s.	-	*	n.s.
	Jun-Jul 97	-	-	-	-	-
	Sept-Oct 97	-	-	-	n.s.	n.s.
	Total	-	* * *#	-	*	n.s.
Uncultivated fields	Oct-Nov 96	-	-	-	-	n.s.
	Jan-Feb 97	-	-	-	-	n.s.
	Mar-Apr 97	-	-	-	-	+
	Jun-Jul 97	-	-	-	-	n.s.
	Total	-	-	-	-	+

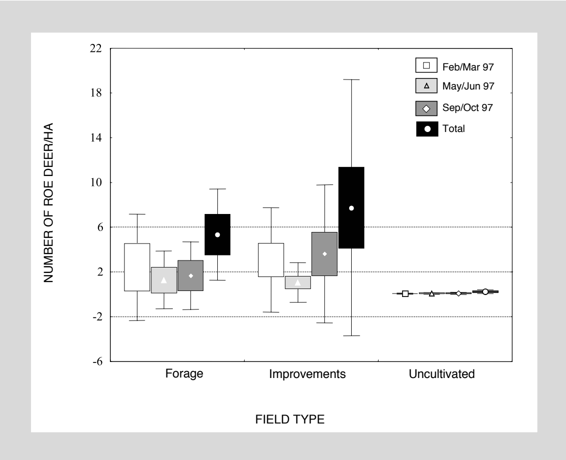


Figure 4. Average densities (in individuals/ha), standard deviation and error of roe deer in study area A, during the periods surveyed and according to the three types of fields.

pairwise comparisons (Mann-Whitney U-test) showed that the strongest preference in this area was for forage crops versus uncultivated fields (see Table 4).

Roe deer

As the species was very rare in study area B (three observations), we only considered data from study area A, in which 153 roe deer were counted.

Seasonal effects

Roe deer densities (Fig. 4) were higher during the first study period (February-March 1997: 0.306 ± 0.571 (SD) deer/ha) than during late spring (May-June: 0.107 ± 0.236 (SD) deer/ha) and fall (September-October: 0.179 ± 0.336 (SD) deer/ha). However, the differences among the three study periods were not significant (Kruskal-Wallis test: N = 51, H = 4.24, df = 2, P = 0.12).

Differences in density among field types

The chi-square goodness-of-fit test was significant in each survey period and the Bonferroni confidence intervals test (Table 5) showed a clear roe deer preference for habitat improvement fields, avoidance of uncultivated fields and indifference to forage crops during all the periods. The Kruskal-Wallis test showed higher roe deer densities in habitat improvement fields during all three periods, but the differences did not reach significance. However, the differences among field types were significant when total densities were compared (N = 17, H = 6.34, df = 2, P = 0.04). The pairwise comparisons revealed a significant difference (P < 0.05) between forage crops and uncultivated fields in September-October 1997, and between habitat improvement fields and uncultivated fields in all survey periods.

Table 5. Chi-square goodness-of-fit test and Bonferroni confidence interval tests for habitat preference by roe deer in study area A. See the legend of Table 3 for explanations of the symbols used in the table.

Habitat types	Feb-Mar 1997	May-Jun 1997	Sep-Oct 1997	Total
χ^2 (P <0.0001)	106	33.6	80.1	212.5
Improvements	+	+	+	+
Forage crops	=	=	=	=
Uncultivated	-	-	-	-

Discussion

Habitat use

The most evident result of our study is the rarity of brown hares and roe deer in open uncultivated fields in both study areas in all seasons during the periods of maximal foraging activity (during the night for hares and at sunset and sunrise for roe deer), This suggests a low suitability of these habitats as pasture and feeding patches for both species, as reported from other studies (Frylestam 1981, Barnes & Tapper 1985, Danilkin 1996, Mysterud 1998). Although these results are clear and statistically supported, caution should be taken before making a strict correlation between the numbers of animals observed in a specific habitat and habitat use (Hanley 1990). For example, some roe deer behaviours, such as territoriality and grouping behaviours, strongly affect spatial distribution and habitat use (Zejda 1978, Bresinski 1982, Maublanc 1986, Cibien et al. 1989). In the present study, however, we surveyed time periods when the two species were mainly feeding. Thus, we can expect a stronger correlation between the observed animals and the supposed feeding activity.

The results show a clear and prevalent presence of hares and roe deer in the comprehensive category of 'cultivated fields', which are used mainly as forage resource areas. These results are consistent with other studies showing that hares prefer the micro-climatic, soil and food conditions of cultivated fields rather than uncultivated areas (Schröpfer & Nyenhuis 1982), a preference also shown by roe deer, particularly in late spring and summer (Perco & Perco 1979, Danilkin 1996). In addition, both study areas are characterised by extensive and low-impact cultivations, such as forage crops, habitat improvement fields and winter cereals. Therefore, negative effects due to intensive agriculture are minimised. We should underline, however, that the surveyed areas are located in two game farms in upland territories where agricultural activities tend to be extensive. Thus, we cannot generalise our results to all upland territories, which may also contain intensive or high-revenue agricultural areas (e.g. orchards and vineyards) where the impact of wildlife on cultivated fields is a problem.

With regard to preferences within 'cultivated fields' and the effects of habitat improvement actions, our results show that there are generally no significant differences in the use of forage crops and habitat improvement fields by brown hares and roe deer. This is because the vegetation structure and pasture characteristics of the habitat improvement fields are quite similar to forage crops in most of the surveyed seasons. The appearance of the habitat improvement fields was very different from the forage crops only in summer (from late May to mid-August) when the vegetation was tall. This is because the improvement areas were not subjected to a strict cutting regime. Therefore, our results highlight the positive 'forage' performance of habitat improvement fields, which also have a lesser impact on wildlife than cultivated forage crops because of the single late cut per year rather than three or four cuts per year for forage crops. Thus, the implementation of habitat improvement actions (F1 and B2) in Italian upland areas may provide wild herbivorous species with a good substitute for the declining pastures and forage crops (see Table 1).

To explain the differences in use of improved fields and unimproved forage crops by hares, for instance, in terms of grass growth, forage palatability and cutting regime, we need to analyse the two study areas separately. The reduced number of observations, only in one study area, did not permit the same analysis for roe deer.

In study area A, the hares seemed to use habitat improvement fields more in the fall and especially in winter, switching their preference to forage crops in spring. This confirms the empirical observations of different pasture characteristics of the two field types in winter. Forage crops mainly consisted of lucerne, which is less suitable as forage in winter (Baldoni & Giardini 1981, C.R.P.A. 1985). In contrast, the mixed grasses in the habitat improvement fields appeared rich in green biomass and more attractive in winter. In spring, lucerne (genetically selected for forage production) grew earlier and faster than the extensive forage of habitat improvement fields, and the hares seemed to prefer this new and abundant forage, selecting these fields.

In study area B, where only hares were observed, the scenario was somewhat different from study area A due to the lower mean altitude, the relevant abundance of winter cereals and the increased agricultural activities. The avoidance of uncultivated fields was confirmed and was significant in most seasons. Forage crops were selected with respect to habitat improvement fields, particularly in fall. However, the characteristics of the forage crops were partially different from those of study area A; they also covered a greater percentage of the total area, while habitat improvement fields covered a smaller surface area. The importance of winter cereals increased from fall when cereal fields were mostly ploughed and bare, to late winter and spring when they were an important source of green forage. Moreover, after harvesting in summer, cereal stubble still played an important role as a source of spontaneous plants and new growth of cereals. Many studies have highlighted the importance to hares of winter cereals as a source of green forage in winter and of spontaneous plants in the stubble after harvesting (Schröpfer & Nyenhuis 1982, Barnes & Tapper 1985, Zanni et al. 1988, Meriggi & Alieri 1989, Prigioni & Pelizza 1992). Thus, the habitat use analysis of study area B showed a similar use of the different habitats by hares in most seasons, except in fall 1996 when forage crops were significantly selected.

These results demonstrate that in upland areas where extensive agricultural cultivations, such as forage crops and winter cereals, are present or dominant (area B), the landscape is quite heterogeneous, with pastures, shelters and breeding sites. In this case, the creation of habitat improvement areas mainly for feeding purposes does not particularly favour a highly adaptable species like the brown hare, which is able to shift its habitat exploitation according to seasonal variations or local food availability (Frylestam 1992).

Implications for land use management

Our study highlights the importance for hares and roe deer of the presence of 'extensive, cultivated areas' in upland territories and the low suitability of uncultivated and abandoned fields. Extensive, cultivated fields, in some cases reintroduced through agro-environmental measures, play an important role as a food source (mostly of green forage) in territories where the presence of crops and green forage are becoming scarce due to the reduction in agricultural activities. Indeed, the importance of these areas increases as the percentage of agricultural land decreases in favour of forests and uncultivated fields.

In these territories, the implementation of agro-environmental or wildlife habitat improvement measures, such as the actions B2 and F1 of EEC regulation 2078/92 applied in this case, are important not only for hares and roe deer, but also for other small game species (e.g. pheasants, partridges and grouse), ungulates (e.g. red deer *Cervus elaphus* and fallow deer *Dama dama*) and for biodiversity in general (Bernard-Laurent 1994, Tucker & Evans 1997, Commissione UE 1998, Perco 2001, Odasso et al. 2002). In contrast, public subvention of these measures does not appear particularly advantageous in upland territories where agricultural activities are still taking place on most of the land and are characterised by extensive cultivations and crop diversification, as in study area B. Therefore, wildlife habitat improvement interventions in upland areas should be selected on the basis of specific habitat indices, such as, for instance, percentage of arable land or forage crops in the total land area, mixed cultures or habitat heterogeneity.

Our study provides one of the first evaluations of wildlife habitat improvements in Mediterranean upland territories based on agro-environmental measures of 2078/92. Some European and North American countries have a longer tradition of research on habitat improvement actions to benefit wildlife and biodiversity than Mediterranean countries (CTGREF 1975, The Game Conservancy 1981, 1986, 1994, CEMAGREF & ONC 1988, Andrews & Rebane 1994, Payne & Bryant 1994). The continued development of this field of research is important to permit the local application of future agro-environmental policies of the European Union and to support the private management of wildlife resources.

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