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HABITAT-RELATED DIFFERENCES IN RABBIT (*ORYCTOLAGUS CUNICULUS*) ABUNDANCE, DISTRIBUTION, AND ACTIVITY

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The European rabbit (*Oryctolagus cuniculus*) is a key prey species in Mediterranean ecosystems and is ecologically plastic. However, ecological responses of rabbits to different habitats are poorly understood. We present data on abundance, distribution, activity, and survival in 3 neighboring habitats in southwestern Spain differing in refuge and forage availability. Scrubland presents dense cover but low forage abundance; grassland offers little protective vegetation but high food availability; the ecotone provides intermediate levels of both resources. Rabbits reached the highest abundance in ecotone, whereas low food and refuge availability seemed to limit their abundance in scrubland and grassland, respectively. In scrubland, rabbits were dispersed among the cover. In grassland, rabbits were linked to aggregated burrows. In ecotone, rabbits dug burrows in the bordering bushes that abutted grassy feeding pasture. Predation by raptors was low in scrubland, and mortality due to mammalian carnivores was higher in spite of more diurnal rabbit activity. Carnivore predation also caused higher mortality in grassland, where rabbits were more nocturnal. In ecotone, the effect of both mammalian carnivores and raptors on rabbits was similar. Mortality by disease seemed to be linked to level of rabbit aggregation.

Key words: abundance, activity, habitat structure, Mediterranean ecosystem, *Oryctolagus cuniculus*, predation exposure

The selection of a habitat in which to live affects the fitness of an animal by influencing its foraging opportunities and its exposure to predators and competitors (Bergerud and Page 1987; Myserud and Ims 1998; Rangeley and Kramer 1998; Wywiałowski 1987). For prey animals, the characteristics of their habitats, such as shelter possibilities and food availability, have been related largely to their distribution, abundance, and habitat use by individuals (Lagory 1986; Lima 1990; Watts 1991). Therefore, a given prey species exhibits a particular way of living to survive in different habitats, and some species are able to modify their hab-

itat use and behavior to adapt their requirements to habitat conditions. This is the case with the European rabbit (*Oryctolagus cuniculus*), a key mammal prey species in the food webs of Mediterranean ecosystems (Valverde 1958).

The worldwide distribution of rabbits demonstrates their capacity for colonizing many different habitats (Thompson and King 1994) and highlights the ecological plasticity and ability of rabbits to change behavior to increase fitness (Gibb 1993; Kolb 1994). European rabbits have been described as solitary or gregarious (Cowan 1987; Wheeler et al. 1981), cooperating or not regarding vigilance (Burnett and Hosey 1987; Roberts 1988), living in warrens or

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aboveground (Wheeler et al. 1981), and selecting the open or avoiding it (Jaksic and Soriguer 1981; Villafuerte and Moreno 1997). Certain advantages and disadvantages to rabbits of living in habitats with different availability of refuge and food have been discussed (Jaksic et al. 1979; Palomares and Delibes 1997). In costs and benefits, rabbits in open pastures would benefit from abundant food, but scarcity of sheltering vegetation might involve a high cost because of fewer opportunities to escape from predators. By contrast, in protected, covered habitats, food for rabbits is usually scarce, limiting their population density (Beltrán 1991; Moreno and Villafuerte 1995). However, in these cases differences were explained by the obvious differences in predator communities (i.e., Spain and Chile) or the difficulties involved in digging burrows in hard soils (Parer and Libke 1985).

But what is the most favorable situation and how do rabbits behave to minimize the disadvantages of living in a given habitat? Moreno et al. (1996) postulated that rabbits living in an ecotone between open and covered habitats select feeding and sheltering strategies that allow them to feed and to avoid predators by moving from 1 habitat to the other in different periods of the day. Palomares and Delibes (1997) demonstrated that rabbits in grasslands are favored when burrows are available as refuges. Villafuerte and Moreno (1997) showed that in open habitats rabbits form larger groups to exploit food further from cover. Numerous studies have shown that both food and cover may affect habitat selection by individuals (Lagory 1986; Rangeley and Kramer 1998), but very little is known regarding demographic consequences for mammals living in habitats with different amounts of food and cover.

We analyzed the effect of habitat characteristics on survival and behavior of European rabbits in the Iberian Peninsula, where they are native (Flux 1994). Our goal was to examine possible differences in pat-

terns of rabbit abundance and distribution, response to predators, and risk of death under different scenarios of food availability and vegetation structure within the same rabbit population. We attempted to answer the following questions. Is food availability the factor influencing the abundance of rabbits? Is rabbit aggregation dependent on their abundance or on refuge availability (or both)? Given that raptors hunt more effectively in open areas (Janes 1985) and mammalian carnivores are specialized for hunting inside dense vegetation (Murray et al. 1995), does the risk of being preyed on by mammalian carnivores and raptors vary as a function of vegetation structure? Do rabbits adapt their activity rhythms to avoid the most effective predator type in each habitat?

The European rabbit in the Iberian Peninsula is the main prey for almost 30 raptors and mammalian carnivores (Delibes and Hiraldo 1981), including several endangered species such as the Spanish imperial eagle (*Aquila adalberti*—King 1979) and the Iberian lynx (*Lynx pardinus*—Nowell and Jackson 1996). Paradoxically, although rabbits are still considered a pest in some ecosystems, in Spain their scarcity is a serious problem for the conservation of autochthonous predators.

MATERIALS AND METHODS

Study area.—The study was carried out north of Doñana National Park (SW Spain; 37°9'N, 6°26'W), locally called Coto del Rey. The study area is flat (the difference between the highest and the lowest point is <5 m elevation) and sandy (easy to dig by rabbits). It is situated approximately 10 m above sea level. Climate is Mediterranean subhumid with marked seasons; monthly average rainfalls during the last 15 years varied between 116 mm in December and <1 mm in July. Three main ecosystems can be distinguished in Coto del Rey: Mediterranean scrubland, a degradation stage of a cork oak (*Quercus suber*) forest; marsh to the south of the scrubland; and Dehesa, also called Mediterranean savannah, grassland with isolated, old trees (*Q. suber* and *Olea europaea*). Additional de-

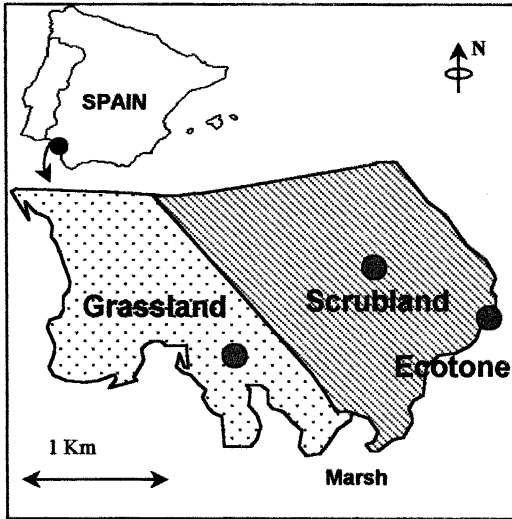


FIG. 1.—Area of study. Circles represent locations of subpopulations of *Oryctolagus cuniculus*.

descriptions of the area and its management can be found in Fernández-Delgado (1997).

We studied 3 areas situated in 3 different habitats in Coto del Rey, located 1.5–2 km from each other (Fig. 1). Scrubland is dominated by Mediterranean bush and scrub formations. Among bushes, *Pistacia lentiscus* is dominant, and most abundant scrubs are *Halimium halimifolium*, *Ulex*, and *Stauracanthus genistoides*. Grassland is open land in the Dehesa dominated by short herbaceous vegetation, with very scarce and scattered scrub formations. Ecotone is an edge biotope between Mediterranean scrubland and nonflooded prairies adjacent to the marsh. This area is also dominated by bush and scrub formations although less abundantly than in scrubland.

Rabbits constitute a large part of the diet of predators inhabiting Coto del Rey. Among mammals, these include Iberian lynx, red fox (*Vulpes vulpes*), Egyptian mongoose (*Herpestes ichneumon*), and Eurasian badger (*Meles meles*). Raptors include Spanish imperial eagle, booted eagle (*Hieraetus pennatus*), short-toed eagle (*Circus gallicus*), buzzard (*Buteo buteo*), black kite (*Milvus migrans*), and red kite (*M. milvus*). In Coto del Rey, rabbits represent 98% of the biomass consumed by Iberian lynx, 80% of that ingested by Egyptian mongoose, about 60% of that consumed by Eurasian badger, and 54% of

the consumption of red fox (Fedriani et al. 1999; Palomares and Delibes 1991; Revilla and Palomares 2001). They also represent about 70% of the diet of black kite (Viñuela and Veiga 1992) and 55% of that of booted eagle (E. Casado, in litt.).

Procedure.—We captured rabbits by chasing them out of warrens using muzzled domestic ferrets (*Mustela furo*) and netting the rabbits. We fitted them with 20-g radiocollars with posture-activity sensors (Biotrack, Wareham, United Kingdom). Fifty-one adult European rabbits (12 in scrubland, 19 in grassland, and 20 in ecotone) were radiocollared between April 1997 and June 1998. We took 3 radiolocations/week from each rabbit during regular monitoring periods and 7–14 locations/week during intensive monitoring periods (30 days every 3 months). We checked the radiocollar posture signal during each radiofix and approached the rabbit when we suspected it was dead. We determined causes of mortality by examining carcasses. Raptors and mammalian carnivores leave different signs with their prey and eat them differently; thus, predator was determined by examination of signs (bite or claw marks [or both] on the body or radiocollar), uneaten remains, etc. Raptors also frequently leave long bones and head and characteristic rabbit-hair tufts, but carnivores consume the head, break long bones, and sometimes bury the prey or its remains (Calvete et al. 1997; Calzada and Palomares 1996). Also, we accounted for other signs such as feathers, footprints, and place where remains were found. Whenever possible, tissues or blood samples (or both) were taken from carcasses for analysis of disease.

To examine the relationship between rabbit abundance and habitat structure, we measured local rabbit abundance in each habitat, vegetation coverage (as a measure of shelter), and food availability. These variables were measured inside the 95% minimum convex polygon (Kenward and Hodder 1996) encompassing radiolocations of all marked rabbits in each habitat.

We estimated monthly local rabbit abundance by counts of fecal pellets conducted in 50 random circles (area of 0.5 m²) within each polygon. Pellet counts are reliable indirect estimators of rabbit abundance (Palomares 2001). To avoid errors in estimation of abundance due to differences in the persistence of pellets, we corrected the count data with the daily persistence of pellet rates obtained by Palomares (2001) for the same

study area and habitats. Monthly counts were grouped into 4 seasons and normalized with $\log(x + 1)$ to comply with multivariate normal distribution and equal variance assumptions in statistical analysis. We analyzed differences between habitats with repeated-measures generalized linear model (GLM—Von Ende 1993) in which season was the within-subject factor and habitat the between-subject factor. We measured coverage as the percentage of bush and scrub cover. We digitized, geo-referenced, and calculated bush cover from aerial photographs (scale 1:2,000), using image analysis software (Sigma Scan Pro 4.0, Jandel Co., San Rafael, California). We estimated scrub and grass covers by the lineal-interception projection method (Kent and Coker 1992), using 20 randomly distributed 20-m-long transects in each area. We sampled grass biomass within 10 randomly distributed squares (0.12 m²—Villafuerte et al. 1997) in each habitat, once per season in 1 year. Biomass was corrected with percentage of grass cover in each habitat. Then, we estimated annual mean food availability in each habitat. Samples were weighed and dried in a hot-air oven at 50°C until constant weight was achieved (Lazo et al. 1992). Corrected biomass data also were transformed using $\log(x)$ to comply with statistical assumptions. Differences among the 3 habitats were analyzed with repeated-measures GLM in which season was the within-subject factor and habitat the between-subject factor. We used Mauchly's criterion to test for sphericity in repeated-measures GLMs (Von Ende 1993).

To determine which factors influence the distribution pattern of rabbits, we measured the distribution of rabbit burrows in each habitat (Cowan and Garson 1984; Roberts 1987). We systematically counted and mapped burrows during August 1998 (i.e., outside the rabbit breeding season). We calculated burrow dimensions and number of active entrances compared with total number of entrances. We considered an entrance to be active when it showed signs of regular use, with fresh pellets and trampled runs (Parer and Wood 1986). Number of burrows, total number of entrances, and number of active entrances were compared among habitats by using frequency analyses with the chi-square statistic (Sokal and Rohlf 1995). When a significant difference was obtained, the test was repeated removing 1 habitat each time from the contingency table, i.e., pairs of habitats were confronted

to determine which habitat was causing the significant difference (Zar 1999). In these paired comparisons, we used Bonferroni corrections for multisample hypotheses, which resulted in criteria for statistical significance of $\alpha = 0.017$.

To find out whether burrows were randomly distributed, aggregate, or uniform, we divided the 3 polygons into grids 50 m wide and calculated the aggregation index s^2/\bar{X} , where \bar{X} is the observed mean number of burrows within grids and s^2 the variance (Krebs 1989). We used the z -statistic to test whether distributions were significantly different from random.

In each habitat we estimated the annual rabbit survival and mortality rates caused by different factors (raptor and mammal predation, and disease) using Micromort software (Heisey and Fuller 1985). This computes a maximum-likelihood unbiased estimate of cause-specific mortality rate, which is a generalization of the Mayfield method (Heisey and Fuller 1985; Krebs 1989). Comparisons between rate estimates were performed using the z -test (Heisey 1995). Bonferroni corrections for multisample hypotheses resulted in criteria for statistical significance of $\alpha = 0.017$ for 3 survival comparisons and $\alpha = 0.007$ for 7 comparisons of mortality rate (Sokal and Rohlf 1995).

To examine whether differences existed in activity of rabbits in the 3 habitats, we compared percentages of radiofixes for each individual in which it was active during the day (i.e., the period between sunrise and sunset) and during the night. For this, we used data from radiolocations separated from each other by ≥ 6 h and 1 dusk or sunrise; rabbits are most likely to switch their activity in these periods (Villafuerte et al. 1993), and our preliminary analyses showed that number of rabbit activity switches did not differ between locations separated in time by 6–12 h and those separated by >30 h ($\chi^2 = 0.36$; $P = 0.55$; $n = 400$). Only rabbits with ≥ 40 locations were used to calculate percentages. We performed a GLM (Tabachnick and Fidell 1996) to test effect of habitat and period of the day (i.e., day or night) on activity of rabbits, where sampling units were individual rabbits and dependent variable was percentage of active locations. Preliminary analyses also showed that sex or its interactions with all other variables did not influence the models; therefore, it was not included. Percentage values were normalized using the arcsine-square-root transformation.

TABLE 1.—Habitat structure and food availability for *Oryctolagus cuniculus* in 3 study areas in southwestern Spain. Food availability is expressed as availability of herbaceous biomass (mean \pm SE).

	Scrubland	Ecotone	Grassland
Bush cover (%)	18.0	13.0	0.0
Scrub cover (%)	25.0	9.5	10.5
Grass cover (%)	54.0	75.0	88.0
Sand (%)	3.0	2.5	1.5
Food availability (kg/ha)	417 \pm 44	725 \pm 77	1,778 \pm 203

Generalized linear models were performed with the GLM procedure in SAS 6.12 statistical package (SAS Institute Inc. 1990). We used SigmaStat 2.0 software (Jandel Co.) to perform all other statistics. We considered differences statistically significant if $P < 0.05$.

RESULTS

We obtained 3,359 radiotracking days in scrubland, 2,590 in grassland, and 2,552 in ecotone. Minimum convex polygons were 9.5 ha in scrubland ($n = 1,491$ rabbit locations), 7.8 ha in ecotone ($n = 1,058$), and 13.7 ha in grassland ($n = 1,007$).

The highest values of bush and scrub

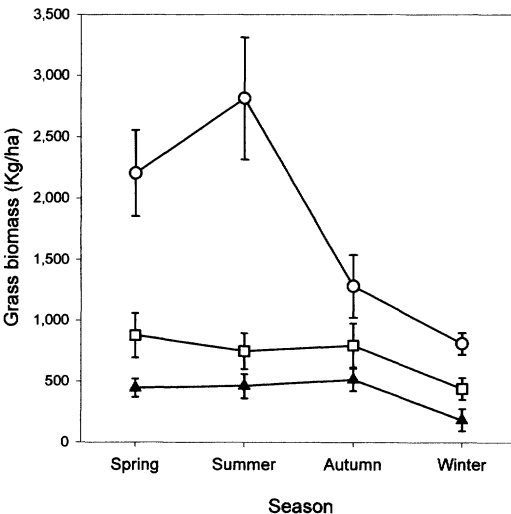


FIG. 2.—Biomass of grass estimated in 3 habitats of *Oryctolagus cuniculus* during 4 seasons in Coto del Rey, Spain. Symbols indicate means: black triangles represent scrubland; open circles, grassland; and open squares, ecotone. Vertical lines indicate 95% confidence intervals.

cover were found in scrubland (Table 1). Grassland contained no bushes, with grass being almost 90% of the land surface. The ecotone was intermediate, with a high proportion of area covered by both bushes and grass. Food availability showed a significant habitat \times season interaction ($F = 3.09$, $d.f. = 6, 81$, $P < 0.01$). Food was more abundant in grassland in all seasons, especially in spring and summer. It tended to be less abundant in scrubland than in ecotone, except in autumn (Fig. 2).

With respect to rabbit abundance, interaction of habitat \times season was also significant ($F = 7.76$, $d.f. = 6, 432$, $P < 0.001$). Mean abundance tended to be higher in the ecotone than in the other 2 habitats in all seasons except winter (Fig. 3). In winter, abundance in grassland was higher than that in scrubland and overlapped with that in ecotone.

Abundance and distribution of rabbit burrows differed among the 3 areas (Table 2; Fig. 4). Frequency analyses revealed differences among habitats in number of warrens ($\chi^2 = 84.9$; $P < 0.001$), total number of entrances ($\chi^2 = 71.9$; $P < 0.001$), and number of active entrances ($\chi^2 = 171.5$; $P < 0.001$). Number of burrows was higher in ecotone, and all paired comparisons between habitats showed significant differences (all $\chi^2 > 10.7$; all $P < 0.01$). Differences in number of entrances were not significant between scrubland and grassland ($\chi^2 = 1.4$; $P = 0.24$), indicating that differences among habitats were due to a higher number of entrances than was expected in eco-

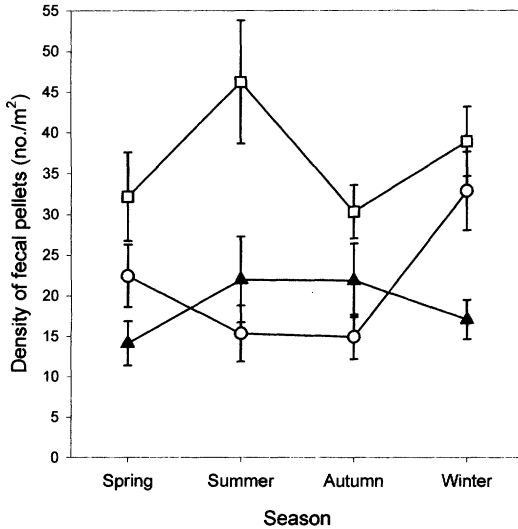


FIG. 3.—Density of fecal pellets as an estimate of abundance of *Oryctolagus cuniculus* during 4 seasons in 3 habitats in Coto del Rey, Spain. Symbols represent mean density: sample size = 50 plots per habitat. Black triangles represent scrubland; open circles, grassland; and open squares, ecotone. Vertical lines indicate 95% confidence intervals.

tone. The difference between ecotone and grassland in number of active entrances ($\chi^2 = 5.9$; $P = 0.018$) was marginally not significant after the Bonferroni correction. These results indicate that, although in ecotone the numbers of burrows and burrow entrances were significantly greater, the use of warrens was comparatively higher in grassland than in the other habitats (Table 2). On the other hand, burrows in scrubland were distributed randomly, but in ecotone

and grassland they were aggregated (Table 2).

Of 51 radiotagged rabbits, 4 disappeared during the study period and their fate was unknown, so these were not considered in mortality analyses. The fate of 11 individuals radiotracked in scrubland, 19 in ecotone, and 17 in grassland was known. Annual survival rate in scrubland was 0.53, which was significantly higher than that in ecotone ($z = 2.51$, $P = 0.006$) and that in grassland ($z = 2.30$, $P = 0.010$), but the difference between ecotone and grassland was not significant ($z = 0.23$, $P = 0.40$). In scrubland and grassland the main cause of mortality was predation by mammals, which was especially high in grassland (Table 3). However, this cause of mortality did not differ between ecotone and grassland ($z = 1.74$, $P = 0.04$), scrubland and ecotone ($z = 0.54$, $P = 0.29$), or scrubland and grassland ($z = 1.02$, $P = 0.15$). Rates of mortality due to predation by raptors did not differ among the 3 habitats (scrubland–ecotone, $z = 1.22$, $P = 0.11$; scrubland–grassland, $z = 0.19$, $P = 0.40$; grassland–ecotone, $z = 1.49$, $P = 0.06$). Mortality by disease was detected only in ecotone and in grassland, and the difference between the 2 habitats was not significant ($z = 0.76$, $P = 0.22$).

Percentage of locations at which rabbits were active showed a significant interaction between habitat and period of day ($F = 4.96$, $d.f. = 2, 54$, $P = 0.01$). Rabbits were more active at night than during the day in

TABLE 2.—Abundance and distribution of burrows of *Oryctolagus cuniculus* in 3 habitats in southwestern Spain.

	Scrubland	Ecotone	Grassland
Number of burrows per hectare	9.1	14.5	3.1
Number of entrances per hectare	20.7	51.3	22.9
Number of entrances per burrow	2.3	3.5	7.5
Percentage of entrances active	17.2	23.4	37.3
Aggregation index (s^2/\bar{X})	0.7	3.5	2.1
Distribution	Random ($Z = -1.46$)	Aggregated ($Z = 6.19^*$)	Aggregated ($Z = 4.43^*$)

* $P < 0.05$.

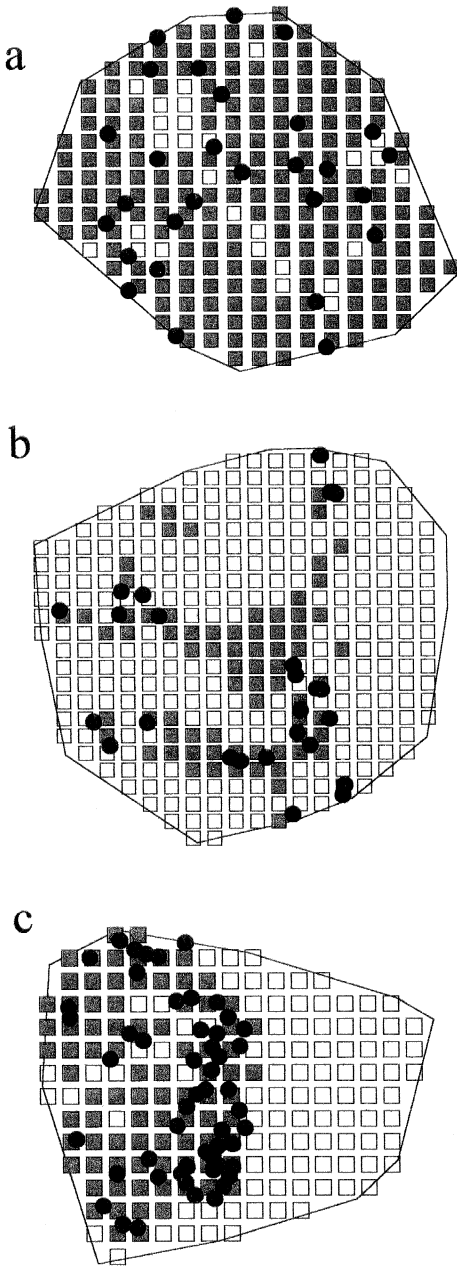


FIG. 4.—Vegetative coverage and distribution of burrows of *Oryctolagus cuniculus* at Coto del Rey, Spain, in a) scrubland, b) grassland, and c) ecotone. Circles represent burrows; squares represent 50-by-50 areas of open land (white) and shrubland (dark).

ecotone and in grassland (Fig. 5). Nocturnal activity was greater in covered (scrubland) than in open (grassland) habitat.

DISCUSSION

Rabbits in Coto del Rey, Spain, are subject to high predation risk from several Mediterranean predator species, some of which exhibit their highest densities within Doñana National Park. Red foxes reach 3.0 individuals/km²; Iberian lynxes, 1.2 individuals/km²; and black kites, 28 pairs/km² (Calzada 2000; Forero et al. 2002). The spatial scale of movements of these predators is much larger than the distance among the 3 study sites, so sites constitute a single area from the point of view of the predator community (Fedriani et al. 1999; Ferrer 1993; Palomares et al. 2001; E. Casado, in litt; F. Hiraldo, in litt.). Thus, rabbits in the 3 habitats are potentially exposed to the same predators. On the other hand, the possibilities of building warrens are also similar in the habitats studied (Palomares and Delibes 1997). Therefore, differences in abundance and activity of rabbits among habitats are best explained by abundance of food and availability and distribution of shelter.

It is usually assumed that habitat quality for a species is positively correlated with density of the species (but see Van Horne 1983). If true, the ecotone, where rabbits reached the highest density, seems to be the best habitat for the species, with a combination of abundant forage and dense cover (Beltrán 1991; Rogers and Myers 1979). However, survival in this habitat was low as a consequence of high predation and disease incidence. Survival was the highest among the sites studied in scrubland. Food availability may have been the limiting factor for rabbit abundance in this habitat in all seasons. In a similar nearby scrubland area, Moreno and Villafuerte (1995) demonstrated that rabbit abundance increases up to 4 times when food availability is improved through habitat management. However, high availability of food in open grass-

TABLE 3.—Annual rates for cause-specific mortality and survival of *Oryctolagus cuniculus* in southwestern Spain. Values are estimated for each habitat with maximum-likelihood method (Heisey and Fuller 1985). Sample size (*n*) is the number of dead animals or, for last row, the number of survivors. σ^2 is a Taylor-series variance computation.

Cause of mortality	Scrubland			Ecotone			Grassland		
	<i>n</i>	Annual rate	σ^2	<i>n</i>	Annual rate	σ^2	<i>n</i>	Annual rate	σ^2
Carnivores	4	0.37	0.021	4	0.27	0.013	8	0.57	0.016
Raptors	1	0.09	0.007	4	0.27	0.013	1	0.07	0.005
Disease	0	0		5	0.34	0.015	3	0.21	0.012
Survivors	6	0.53	0.023	6	0.12	0.005	5	0.14	0.006

land on its own does not seem to be sufficient to support a high density of rabbits throughout the year. In our study, survival in grassland was low due to high predation and disease mortality. Predation has been postulated as a prime factor in maintaining low densities in this type of habitat (Palomares et al. 1996).

Spatial distribution of rabbits seems to reflect both structure of the habitat (specifically availability of refuges) and popula-

tion density. In other prey species, individuals tend to live aggregated at high population density or in open habitats, but a low density of individuals or covered habitats cause them to disperse (Lagory 1986; Rangeley and Kramer 1998). In the ecotone of high rabbit density, rabbits displayed a gregarious distribution, with burrows clustered along the border between scrubs and marsh. The density-dependence hypothesis seems suitable for explaining distribution in this habitat. Alternatively, the distribution pattern also may be influenced by the advantage to rabbits of digging burrows and living in aggregations in the ecotone so as to have immediate access to food and shelter afforded by vegetation. However, this hypothesis does not seem adequate to explain the distribution of rabbits in low-density areas. Also, like other prey species, rabbits were dispersed in scrubland, where refuge availability was high (Lima and Dill 1990; Rangeley and Kramer 1998). In grassland, where cover was limited, rabbits did not have the opportunity of such a refuge strategy and lived in groups linked to large, aggregated burrows, which was the most important shelter available.

In principle, differences in vegetation cover also imply differences in exposure of rabbits to predators, even if predators were the same in all habitats. For example, inside dense vegetation, rabbits are well protected from raptors, but mammalian carnivores are specialized for hunting in such habitats

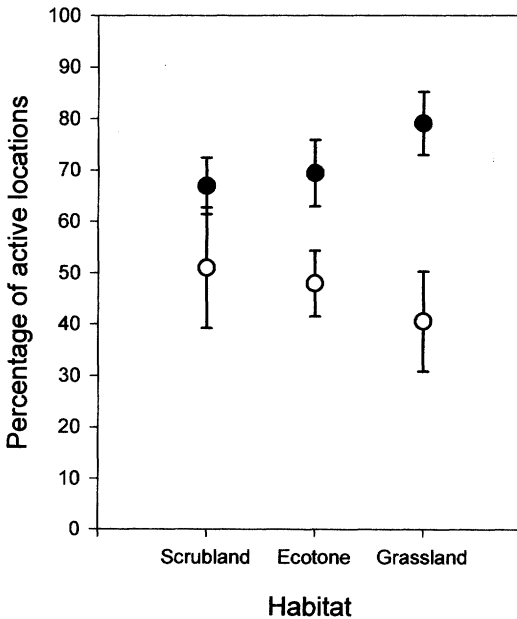


FIG. 5.—Activity of *Oryctolagus cuniculus* during the day (open circles) and at night (closed circles) in 3 habitats in Coto del Rey, Spain. Vertical lines indicate 95% confidence intervals.

(Murray et al. 1995). Although no differences in predator-caused mortality were detected among habitats, we have shown that rabbits exhibit some differences in their activity (being more or less nocturnal) depending on the habitat in which they live. In scrubland, the most covered habitat, average activity at night is lower than in open habitats and not significantly different from that during the day. All mammalian carnivores living in this habitat are mainly nocturnal (Fedriani et al. 1999), so this strategy would allow rabbits to reduce their encounters with these predators. In the open habitat (grassland), rabbits are highly nocturnal. Rabbits may take advantage of grazing in the dark in open areas where diurnal raptors are effective hunters (Janes 1985). In our study, annual mortality due to raptors in grassland was only 7%.

In the ecotone, where shelter and food patches are separated, rabbits stayed under cover during the day, avoiding aerial predators, and foraged in groups in the open at night, probably to better detect stalking carnivores (Moreno et al. 1996). Nevertheless, predation in this area was comparatively high from both mammalian carnivores and predators.

Mortality due to disease was detected only in habitats where rabbits were aggregated. This may be explained by the positive correlation between rabbit aggregation and burrow use and the spread of myxomatosis and rabbit hemorrhagic disease, 2 contagious diseases that have important effects on rabbit populations. Larger warrens, as those in grassland and ecotone habitats, support higher numbers of individuals, favoring transmission of epidemic diseases and prevalence of viruses (Calvete et al. 2002; Parer and Wood 1986; Rogers et al. 1994; Villafuerte et al. 1994). Therefore, availabilities of food and shelter seem to combine to influence rabbit abundance, but the patterns of activity and aggregation that they adopt also may greatly influence the probability of rabbit survival.

RESUMEN

El conejo europeo (*Oryctolagus cuniculus*) es una especie clave de los ecosistemas mediterráneos, sobre la que existe poca información sobre respuestas ecológicas a hábitats distintos. Presentamos datos sobre abundancia, distribución, actividad y supervivencia en tres hábitats colindantes en el SO de España que difieren en disponibilidad de refugio y alimento. El matorral presenta alta cobertura arbustiva y escasa disponibilidad de alimento; la pradera proporciona escasa protección arbustiva y alta disponibilidad de alimento; el ecotono muestra niveles intermedios de ambos recursos. Los conejos alcanzaron la mayor abundancia en el ecotono. La escasez de refugio en la pradera y de alimento en el matorral parecían limitar su abundancia en estos hábitats. En el matorral los conejos se distribuían de manera dispersa. En la pradera estaban ligados a grupos de madrigueras agrupadas. En el ecotono, excavaban madrigueras en arbustos junto a praderas con pasto abundante. La depredación por rapaces fue baja en el matorral, pero por mamíferos carnívoros fue elevada a pesar de que los conejos mostraban mayor actividad diurna. La depredación por carnívoros también causó altas tasas de mortalidad en la pradera, donde los conejos eran más nocturnos. En el ecotono la presión depredadora de carnívoros y rapaces fue parecida. La mortalidad atribuida a enfermedades parecía ligada al nivel de agrupamiento en que vivían los conejos.

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