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HABITAT USE BY THE EUROPEAN WILD RABBIT (*ORYCTOLAGUS CUNICULUS)* IN A COASTAL SANDY DUNE ECOSYSTEM OF CENTRAL ITALY

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ABSTRACT - The European wild rabbit (*Oryctolagus cuniculus*) has been recurrently introduced into Italy since the Roman times. Some populations occur along sandy coastal dunes (Central Italy). There is no information about the ecology and habitat preferences of wild rabbits in this particular ecosystem. During May and June 2009, we assessed the distribution of wild rabbits in a 120 ha protected area (province of Livorno, Tuscany), by faecal pellet counts in 170 circular plots (d = 1 m). Range size defined by Kernel Analysis was 27.3 ha (95%) and 13.2 ha (50%). Habitat selection was assessed through Jacobs' index of selection. Rabbits selected the first dunes that offer both food (psammophilous grasses) and the cover of tamarisk shrubs. Holm oak woods and pinewoods were avoided, probably because of the lack of undergrowth.

Key words: wild rabbit, coastal dunes, habitat selection, Italy

RIASSUNTO - ***Uso del habitat da parte del coniglio selvatico (*Oryctolagus cuniculus*) in un ecosistema dunale costiero dell'Italia centrale***. In Italia sono presenti diverse popolazioni di coniglio selvatico (*Oryctolagus cuniculus*) derivanti da introduzioni effettuate in epoche diverse. Alcune di queste sono localizzate lungo le coste sabbiose della Toscana. Le informazioni sull'ecologia e sulle preferenze ambientali delle popolazioni che vivono in questi particolari ecosistemi sono molto carenti. In questo studio è stato analizzato l'uso del habitat da parte del coniglio selvatico in un area costiera protetta della provincia di Livorno delle dimensioni di 120 ha. La distribuzione di questo lagomorfo è stata stimata nel periodo maggio - giugno 2009 in base alla presenza/assenza delle feci in 170 cerchi campione di 1 m di diametro. L'areale occupato dalla specie è stato definito tramite *Kernel Analysis* al 95% (27,3 ha) e 50% (13,2 ha). La selezione di habitat è stata stimata tramite l'indice di Jacobs. Il coniglio selvatico seleziona la prima fascia di dune, dove la vegetazione erbacea psammofila ed i cespugliati formati dalle tamerici offrono contemporaneamente cibo e riparo dai predatori. Al contrario, i boschi di leccio e pini sono evitati, probabilmente in seguito alla scarsa presenza di sottobosco.

Parole chiave: coniglio selvatico, aree costiere, preferenze ambientali, Italia

INTRODUCTION

The European wild rabbit (*Oryctolagus cuniculus*) is a mammal native to the Iberian Peninsula, where it is considered a keystone species of Mediterranean ecosystems (Calvete *et al*., 2004; Delibes *et al*., 2007), being the

most important prey for many predators, including the both threatened Iberian lynx (*Lynx pardinus*) and Spanish eagle (*Aquila aldalbertii*) (Lees and Bell, 2008).

The introduction of the wild rabbit into Italy probably occurred during the Roman time, although many populations have originated by recent introductions carried out for hunting purposes (Masseti, 2004).

Nevertheless, information about the ecology of wild rabbits in both natural and agricultural habitats of introduction areas is quite scarce (Meriggi, 1998).

In central Italy, the wild rabbit is widespread in agricultural areas and along coastal stripes (Masseti, 2004).

In several regions of the world, ecological plasticity and colonizing ability have led European rabbits to reach the pest status. Nonetheless, in resource-limited ecosystems of the Mediterranean basin, rabbits act as food source for more than 20 predators and may represent more than 40% of consumed biomass (Delibes and Hiraldo, 1981). Latrines have already been typified as an important niche for endemic dung beetles (Verdu and Galante, 2004) and warrens can be used as den sites or temporary refuges by other vertebrates (Blazqued and Villafuerte, 1990; Calzolai and Chelazzi, 1991). For these reasons, rabbits can potentially increase biodiversity at different scales (Galvez *et al*., 2008).

The aim of this preliminary study was to define the habitat preferences of wild rabbits in the sandy dune ecosystem of west-central Italy, in order to achieve sound information to implement effective management strategies.

STUDY AREA

The study was carried out in the Coastal Park of Rimigliano, a protected area located in the southern part of Livorno province (43° 5' N 10° 32' E, Tuscany, central Italy). It covers an about 6 kilometres long strip of coast, varying between 200 and 240 m in width, for a total area of ca. 120 ha (Fig. 1).

The climate is temperated-warm Mediterranean, with mild winters. Mean annual temperature is 15°C, with a maximum of 28°C in July and a minimum of 5°C in January. Rainfall is quite scarce, less than 600 mm per year.

Starting from the sea shore the following succession of habitats occurs: foredunes colonised by psammophilous grasses, such as *Ammophila arenaria, Anthemis maritima, Cakile maritima, Salsola cali, Euphorbia paralias, E. peplis, Arctium lappa*; mobile dunes characterised by plant species with deeper roots, such *as A. maritima, Helichrysum spp., Eryngium maritimum, Pancratium maritimum, Medicago marina, Glaucium flavum, Sporobulus pungens, Tamarix gallica*; fix dunes characterised by the presence of Mediterranean sclerophyllous scrubs, such as *Phillyrea latifolia, Juniperus oxycedrus, J. phoenicea, Pistacia lentiscus, Myrtus communis*, *Rhamnus alatemus, Quercus ilex*; retrodunal areas characterized by woods of holm oak (*Quercus ilex*) and pine-trees (*Pinus pinaster* and *P. pinea*).

METHODS

To assess habitat availability, we produced by ArcView 3.2 (ESRI, Inc., Redlands, CA, USA) a detailed land use map of the study area, based on both aerial photographs and direct surveys, carried out in May-June 2009 (Tab. 1).

We randomly located 170 0.78 m^2 wide circular plots (diameter = 1 m) in the study area and then determined rabbit distribution

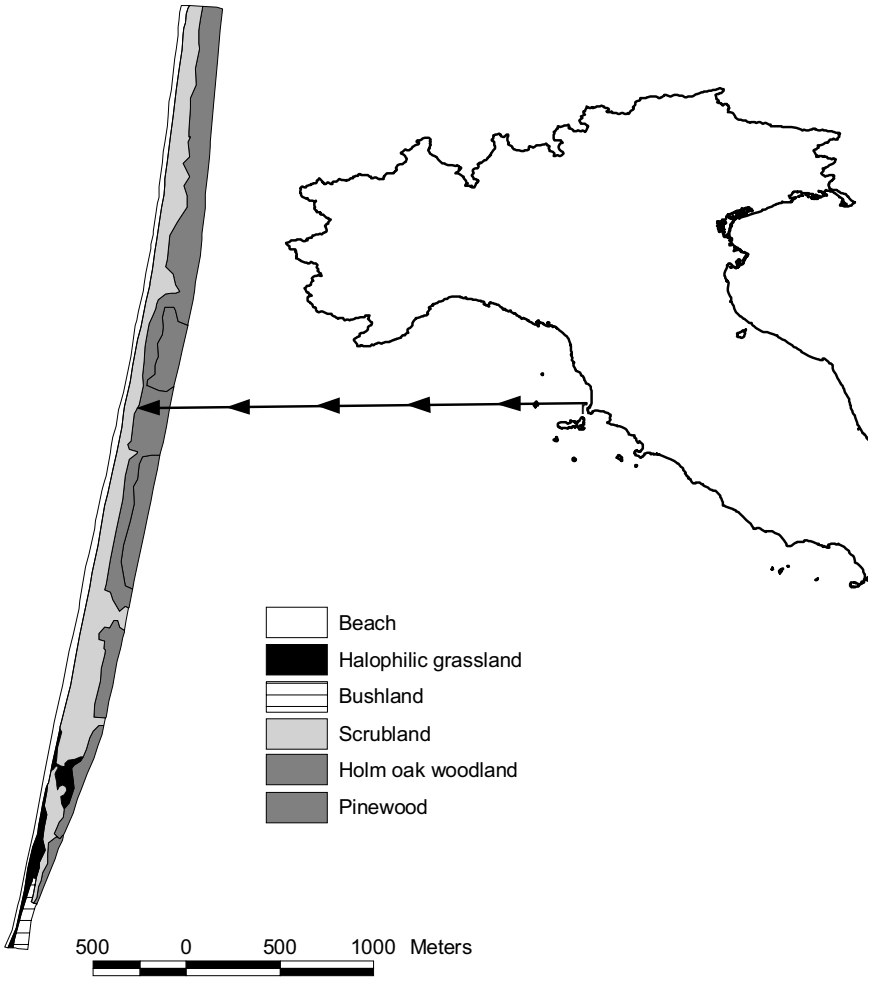


Figure 1 - Study area

Table 1 - Habitat composition of the study area.

Location	Habitat	%	Description
Dunal area	Halophytic grassland	7.7	*Psammophilous* vegetation of mobile sand dunes
	Bushland	5.2	Bush, mainly *Tamarix gallica*
	Scrubland	51.8	Mediterranean scrublands, mainly *Juniperus* spp., *Phillirea latifolia*, *Mirtus communis*, *Q. ilex*
Retrodunal area	Holm oak woodland	23.1	Woods, mainly *Q. ilex* often associated to pine trees
	Pinewood	12.2	Pine woods (*P. pinea*, *P. pinaster*)

based on the presence/absence of faecal pellets (Swihart and Yahner, 1984; Litvaitis *et al.*, 1985; Vidus Rosin *et al.,* 2008). The range of the species in the study area was defined by Kernel Analysis (KA), using both 95% and 50% of the total plots positive for rabbit's presence, the latter contour corresponding to their area of concentrated activity (core area). Kernel contours were defined by the extension "Animal Movement" for Arcview (Seaman and Powell, 1996; Hooge and Eichenlaub, 1997).

Habitat selection by wild rabbits was assessed comparing the proportion of each habitat in the species range to its availability in the whole study area (Johnson, 1980; Serrano Pèrez *et al.*, 2008; Vidus Rosin *et al.,* 2008) by the use of Jacobs' index of selection, JI (Jacobs, 1974):

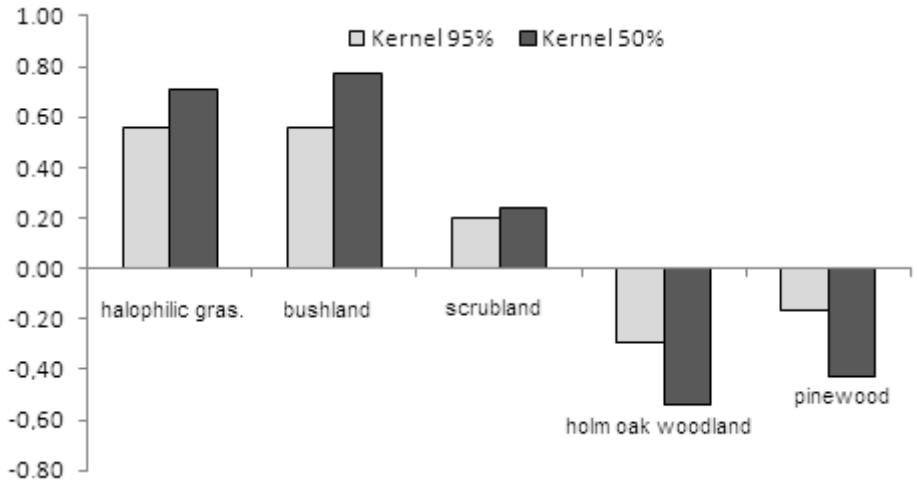
$$JI = (o_i - p_i)/(o_i + p_i)$$

where o_i is the proportion of use for the habitat i and p_i its proportion of availability. JI ranges between +1 for maximum preference and -1 for maximum avoidance. The chi-squared (χ^2) test was used to verify whether habitat use differed significantly from expected use (availability), with respect to both the whole range and its core area.

RESULTS

Wild rabbits were recorded for 44 out of 170 plots (25.9%). The species range (KA 95%) was 27.3 ha; the core area (KA 50%) was 13.2 ha. Habitat use differed significantly from its availability in the study area (χ^2 = 62.31, P <0.0005, 4 d.f.). Halophilic grassland and bushland showed the highest degree of selection, whereas holm oak woodland was avoided. Results were consistent when considering the core area of rabbit range (χ^2 = 44.1, P <0.0005, 4 d.f.; Fig. 2).

Figure 2 - Jacobs' Index of selection for habitat types (habitat use *vs* availability in the study area) considering both the overall wild rabbit range (95% Kernel contour) and its core area (50%); gras. = grassland.



DISCUSSION

Wild rabbits tend to select those habitats that can provide a favourable combination of food availability and refuge from predators (Beltran, 1991; Moreno *et al*., 1996; Dellafiore *et al.*, 2008; Serrano Pèrez *et al*., 2008; Lopèz-Darias and Lobo, 2009). In our study area, the belt of dunes next to the sea shore could satisfy the habitat requirements of wild rabbits, offering both psammophilous grasses as food and the cover of tamarisk bushes.

The preference showed for these bushes may depend on their structure: tamarisks are relatively sparse at ground level, probably representing a good compromise in terms of protection from aerial and terrestrial predators with respect to sclerophyllous scrubs (Villafuerte and Moreno, 1997; Beja *et al*., 2007). Furthermore grasses are allowed to grow, improving food availability (Ferreira and Alves, 2009).

The negative selection for woods does not agree with other studies. Generally dens tree cover reduces prey detectability and protect from raptors, while dense undergrowth provides refuge from terrestrial predators such as the red fox *Vulpes vulpes* (Gibbs, 1994; Ontiveros *et al*., 2005; Serrano Pèrez *et al*., 2008). In our study area, the undergrowth vegetation of holm oak and pine woods is quite thin as a consequence of both the effect of pine litter and periodical mowing to prevent summer fires. As a consequence the wooded strip, which is also bordered by a road, seems to act as a barrier to the spread of the rabbit in the inner, arable land, where the species could represent a pest. The absence, or unusual presence of flies and mosquitoes (subfamily *Calliphoridae* or *Culicinae*), in the area of the first dunes with respect to the inner wooded strip (pers. obs.) may represent a further explanation of the observed habitat preference of wild rabbits. These insects can spread either myxomatosis or rabbit hemorragic disease (RHD) which can cause the dramatic decline of wild rabbit populations (Asgari *et al.,* 1998; Fenner *et al*., 1956; Gillespie *et al*., 2004). Accordingly, in the San Rossore natural park (central Italy) the colonies which were widespread in the inner part of the park completely disappeared in the 1990s, while wild rabbits still survive in a narrow strip along the sea shore (Bagliacca pers. obs.).

Sand dunes are considered under threat as a consequence of extensive erosion and human pressure (De Lillis, 1998; De Lillis *et al*., 2004). In this contest wild rabbits may interact with the sandy dune habitat enhancing biodiversity. In particular, burrowing can influence plant communities and improve habitat suitability for many *taxa* (Kinlaw, 1999; Gàlvez Bravo *et al*., 2009). Faecal pellets enhance soil fertility (Dixon and Hambler, 1993; Willot *et al*., 2000) and seed dispersion (Malo *et al*., 1995; Malo and Suàrez, 1996), while foraging directly influences the composition of plant communities (Foran, 1996; Crawley, 1990). In these terms, the ecological relationship between wild rabbits and sandy dunes needs to be better understood, at a wider spatial and temporal scale.

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