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VEGETATION STRUCTURE AND COMPOSITION OF ROAD VERGE AND MEADOW SITES COLONIZED BY CABRERA VOLE (*MICROTUS CABRERAE* THOMAS)

ABSTRACT: This paper analyses the floristic composition and vegetation structure in road verge and meadow sites colonized by Cabrera vole (*Microtus cabreræ* Thomas, 1906), a threatened rodent with fragmented distribution in the Iberian Peninsula. Vegetation was sampled in 26 colonized patches in five geographical areas of Southern Portugal. The cover of the herbaceous layer was sampled in 1 × 1 m plots. Several variables related to plant diversity, Raunkiaer life-forms, taxonomic groups, disturbance and soil properties were assessed. Floristic composition of the herbaceous communities of road verge and meadow sites was different. Indicator species of road verges corresponded mainly to annual grasses and forbs, ruderal and nitrophilous species, along with a few perennials. In meadows, perennial grasses and moisture indicative species were more common. Results suggest that road verges are lower quality habitats for Cabrera vole maintenance, due to high disturbance, low moisture availability during summer and reduced patch surface. Nevertheless, they might provide benefits such as extra foraging and refuge, especially in disturbed areas. Potential ecological effects of road verge management are discussed in the light of species conservation goals.

KEY WORDS: floristic composition, *Microtus cabreræ*, linear habitats, Portugal

1. INTRODUCTION

The Cabrera vole (*Microtus cabreræ* Thomas, 1906) is an endemic rodent in the Iberian Peninsula, distributed in the Mediterranean region that is classified as vulnerable in Portugal and Spain (Cabral *et al.* 2005, Palomo and Gisbert 2002). The species occurs locally in small patches, often in areas that are lower than 500 m² (Ayanz 1992, Fernández-Salvador 1998). The main habitat requirements of the species include high values of grass cover and height, associated with meadow areas, rush/sedge communities and grasslands with high moisture conditions during the dry season (Ayanz 1992, Fernández-Salvador 1998, Pita *et al.* 2006a). The major threat to Cabrera vole conservation is habitat loss and destruction as a result of fire and grazing intensification as well as agricultural conversion (Fernández-Salvador 1998, Pita *et al.* 2006a, b, Rosário *et al.* in press), which increase the fragmentation of populations.

During a previous survey of this species distribution in Southern Portugal, an unexpected high frequency of well-established colonies was observed in road verge habitats (Santos *et al.* 2006). Although the issue has

already been highlighted in Spain (Fernández-Salvador 1998), this is new information for Portugal. In the last few decades, several studies have pointed out the ecological value of hedgerows and field margins for biodiversity (e.g. Merriam and Lanoue 1990, Parish *et al.* 1995, Fuller *et al.* 2001, Boutin *et al.* 2002, Tattersall *et al.* 2002). However, few studies have examined the ecological value of road verges for small mammals (Bellamy *et al.* 2000, Brock and Kelt 2004).

Roads can have a significantly negative impact on the environment by traversing areas of suitable wildlife habitat: hence, they are among the most relevant structures involved in the habitat fragmentation process. For some species, however, road verges can

function as corridors or ecological refuges, thus playing an important ecological role (e.g. Bennett 1991, Bellamy *et al.* 2000). This may be the case for the Cabrera vole. Therefore, detailed information on the role of road verges as a suitable habitat for this species is a critical in order to develop and implement appropriate management techniques for conservation. Moreover, some of the main resources on which herbivorous rodents depend (e.g. food, shelter, and nesting sites) are related to vegetation structure and species composition (e.g. Doyle 1990, Lin and Batzli 2001).

In this context, our study addresses the following questions: 1) Are vegetation structures and compositions different in road verge and meadow sites colonized by Cabrera

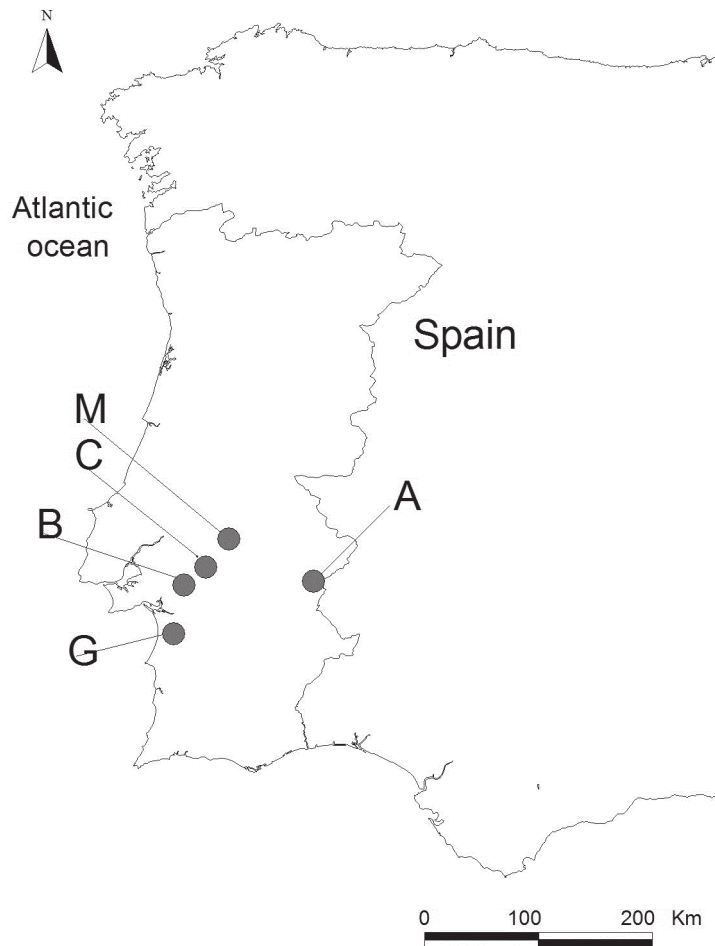


Fig. 1. Outline of Portugal and location of the study areas: Grândola (G), Cabrela (B), Ciborro (C), Mora (M), Alandroal (A).

vole? 2) Are there any indicator plant species in road verges? 3) How do vegetation differences between road verges and meadows correlate with other environmental descriptors? and 4) Can road verges act as refuges for the voles when adjacent areas are disturbed?

2. STUDY AREA

The study was carried out in five geographical areas of Southern Portugal (Alandroal, Mora, Caborro, Cabrela and Grândola; 38°08'N–38°55'N; 7°25'W–8°25'W; up to 300 m a.s.l.). These areas lie on a 120 km east-west longitudinal belt that runs from the Spanish border to the Atlantic coast (Fig. 1). All areas have the typical Mediterranean climate patterns of wet winters and dry summers. The mean annual rainfall is 500 to 800 mm; the mean annual temperature is 15 to 17.5°C; and insolation is 2800 to 3100 h per year. Soils in all of these areas are mainly acidic (Environmental Institute 1995). The main landscape corresponds to the Iberian open woodland of Cork and Holm oak (*Quercus suber* L. and *Q. rotundifolia* Lam.), called “montado” (Pinto-Correia and Mascarenhas 1999). Dominant land uses are extensive agriculture (cereal, fodder), cattle and sheep grazing, hunting and forestry (Pinto-Correia and Mascarenhas 1999).

3. MATERIAL AND METHODS

3.1. Identification of colonies

Cabrera vole colonies were surveyed between February and March 2004 in potential habitat areas, according to Fernández-Salvador (1998), Santos *et al.* (2005) and Pita *et al.* (2006a). Colonized patches were identified by vole presence signs: runways, fresh droppings and grass clippings (e.g. Fernández-Salvador 1998). A vole abundance class (according to Ayanz 1992) was attributed to each colony on the basis of the presence signs, as follows:

1 – ‘Rare’ – few tunnels, presence of scattered old faeces, latrines rare or difficult to find, and no nibbled grass;

2 – ‘Common’ – few or abundant tunnels, faeces and latrines easy to find, few fresh faeces or fresh nibbled grass;

3 – ‘Abundant’ – abundant tunnels, latrines and faeces very easy to find, abundant fresh nibbled grass and fresh faeces;

4 – ‘Very abundant’ – very abundant tunnels, latrines, fresh faeces, fresh nibbled grass, all very easy to find.

A “colony” or “colonized patch” was defined as a local aggregation of the above presence signs, according to Pita *et al.* (2006a). The areas occupied by tunnels were used to assess patch width and surface areas. In each study area, only occupied patches with a minimum surface of 100 m² were selected for sampling. Non-colonized road verge or meadow sites were not studied.

3.2. Vegetation and soil sampling

Vegetation sampling was conducted from March to July 2004 at 26 sites colonized by Cabrera vole: 5 sites each in Grândola, Cabrela, Caborro and Alandroal, and 6 sites in Mora. Road verge sites (n = 13) were located marginally to paved roads (less than 30 m), 12 of which were secondary roads with low traffic volume and one of which was a national road with high traffic volume. Meadow sites (n = 13) were at least 80 m away from any road.

Two complementary methods were used to survey plant communities of each site. Woody species composition was determined by the identification of each individual growing in the colonized patches. Tree and shrub canopy cover and height were assessed using visual estimation and averaged to an overall percentage in the patch (e.g. Boutin *et al.* 2002). Herbaceous vegetation was surveyed in 1×1 m plots, by stratified random sampling (e.g. Kent and Coker 1992). Three to six plots were distributed within each patch, according to the number of strata and the patch surface area. The percentage of ground cover and the height of all herbaceous species were recorded within each plot. The percentages of ground cover of herbaceous layer and percent bare ground were visually assessed (0–100%).

A total of 191 plots were sampled in two visits to confirm some late flowering grasses. Nomenclature of plant taxa followed “Nova Flora de Portugal” (Franco 1971, 1984,

Franco and Rocha-Afonso 1994, 1998, 2003). Species were divided into five categories: lifespan, Raunkiaer life-form (e.g. geophyte, hemicryptophyte, therophyte), moisture affinity, ruderality and nitrophily (according to “Nova Flora de Portugal” and Valdés *et al.* (1987), and Duarte *et al.* (2002) for moisture indicators). Soil sampling was carried out at 15–20 cm depth in all sites, during August 2004 to assess soil texture (sand and clay content), pH, organic matter content and water retention capacity (field capacity).

3.3. Data analysis

Floristic composition matrices were built with herbaceous species data only. Shrub and tree data were considered as explanatory variables for analysis. To evaluate the dissimilarities in plant species composition between meadow and road verge sites, data were subjected to multi-response permutation procedure (MRPP; McCune and Mefford 1999). Detrended correspondence analysis (DCA) was performed to evaluate grouping of the two colony types according to their floristic composition, with downweight of rare species and detrending by segments options (Jongman *et al.* 1995).

Plant species characterising either the road verge or the meadow sites were determined by indicator species analysis (ISA; Dufrêne and Legendre 1997). This method combines information on species abundance and frequency to produce indicator values ranging from zero (no indication) to 100 (perfect indication) for each species in the group. Both MRPP and ISA methods were tested for statistical significance using a Monte Carlo test with 499 permutations (Dufrêne and Legendre 1997, McCune and Mefford 1999). Each colonized patch was characterised by 25 explanatory variables concerning topography, plant diversity, Raunkiaer life-forms, taxonomic groups, disturbance and soil properties (Table 1).

Explanatory variables were compared between the two types of colonies using the Mann-Whitney test (Zar 1999). PC-ORD Version 4 (McCune and Mefford 1999) was used for MRPP, Species Indicator Analy-

sis and DCA. SPSS 10.0 (SPSS Inc. 1999) was used for the Mann-Whitney tests. Significance is reported at $\alpha = 0.05$ level, unless otherwise noted.

4. RESULTS

4.1. Vegetation structure and composition

In both colony types, 56% of the total number of plant species was observed in both colony types (2 trees, 12 shrubs and 90 herbs and grasses) and 22% of all species were exclusive to each of the two colony types (1 tree, 6 shrubs and 34 herbs and grasses for road verges, and 2 trees, 6 shrubs and 33 herbs and grasses for meadow sites). The herbaceous floristic composition of the two colony types was significantly different (MRPP test: $T = -2.655$, $P < 0.05$). The DCA ordination eigenvalues were 0.448 for the first axis and 0.322 for the second. There was a tendency for road verge sites to be positioned on the right side of the first axis, while meadows were on the left side (figure not shown).

According to the Indicator Species Analysis (ISA), road verge sites were characterised by the presence of *Bromus madritensis* L., *Sonchus oleraceus* L., *Galactites tomentosa* Moench, *Andryala integrifolia* L., *Bromus diandrus* Roth, *Sherardia arvensis* L., *Holcus lanatus* L., *Cerastium glomeratum* Thuill., *Cynara humilis* L., *Convolvus arvensis* L., *Geranium molle* L., *Parentucelia viscosa* (L.) Caruel and *Gynandrisis sisyrrinchium* (L.) Parl. (see Appendix). Nevertheless, only *Bromus madritensis*, *B. diandrus* and *Holcus lanatus* reached maximum local percentage cover greater than 5%. Seven of these 13 road verge indicator species have annual life cycles, while five of them are ruderal and two are nitrophilous species. The ecological indicators for the meadow sites were *Agrostis castellana* Boiss & Reuter, *Festuca ampla* Hackel, *Holcus mollis* L., *Scilla ramburei* Boiss and *Juncus acutiflorus* Hoffm, although their indicator values were smaller than those observed for the road verges (see Appendix). Only the first two species were important in terms of cover area (more than 10%), all five were perennial species and all indicate moisture conditions that are typical of meadows, except for *A. castellana*.

Table 1. Explanatory variables, median and range values in meadow and road verge sites, and results of Mann-Whitney U tests (^aPhy test for binary variables) and *P*-values.

Variables	Description	Meadow sites	Road verge sites	Univariate tests	<i>P</i> value
DIM	Colony surface dimensions (m ²)	450 (200–2450)	240 (100–744)	28.0	< 0.01
WIDTH	Colony width (m)	14 (7–35)	4 (2–10)	4.5	< 0.001
ABUND	Vole abundance class (1–4)	3 (1–4)	2 (1–3)	70.0	ns
H'	Shannon's diversity measure	2.5 (1.5–3.1)	2.8 (2.0–3.2)	50.5	ns
EVEN	Evenness of H' diversity	0.7 (0.4–0.8)	0.7 (0.6–0.8)	58.0	ns
SG_m2	Number of grass species per m ²	2.2 (1.4–3.4)	3.7 (1.7–4.7)	22.5	< 0.01
BAR	Bare ground in the colony (%)	9 (3–16)	6 (4–16)	73.5	ns
TREE	Tree cover in the colony (%)	4 (0–15)	4 (0–70)	73.5	ns
SHRU	Shrub cover in the colony (%)	25 (10–60)	35 (1–60)	67.0	ns
MD_HH	Mean herbaceous height (m)	39 (32–48)	40 (32–56)	63.0	ns
RUDER	Proportion of ruderal species in the colony (%)	15 (6–22)	19 (14–29)	44.5	< 0.05
NITRO	Proportion of nitrophilous species in the colony (%)	3 (0–8)	7 (2–9)	35.0	< 0.05
MOIST	Proportion of moisture indicator species in the colony (%)	34 (15–50)	17 (12–38)	33.0	< 0.01
HMG	Hemicryptophyte or perennial grass cover (%)	42 (0–71)	22 (11–29)	25.5	< 0.01
TG	Therophyte or annual grass cover (%)	8 (1–28)	17 (2–53)	43.0	< 0.05
SHR_100	Number of shrub species per 100 m ²	1 (0–2)	2 (1–8)	31.5	< 0.01
S_RAUN	Number of Raunkiaer life-forms	8 (4–10)	9 (4–10)	75.5	ns
H_RAUN	Shannon's diversity of Raunkiaer life-forms	1.3 (0.8–2.0)	1.8 (1.0–2.0)	40.0	< 0.05
GRAZ	Presence of grazing signs inside the colony (0/1)	0 (0–1)	0 (0–0)	–0.426 ^a	< 0.05
N	North exposure of the colony (0/1)	0 (0–1)	1 (0–1)	0.234 ^a	ns
PH	Soil pH	5.8 (5.4–6.4)	5.8 (5.3–6.9)	73.0	ns
ORGM	Soil organic matter content (%)	2.4 (1–4)	1.8 (1–4)	66.0	ns
PF2	Soil water retention capacity at 2.54 pF (field capacity)	20 (6–35)	11 (8–31)	64.5	ns
SAND	Soil sand content (%)	46 (14–86)	69 (24–79)	67.0	ns
CLAY	Soil clay content (%)	17 (5–46)	18 (8–33)	84.0	ns

4.2. Explanatory variables

The surface and width of the road verge sites (240 m² and 4 m, respectively) were significantly smaller ($P < 0.01$ and $P < 0.001$; see Table 1) than those of the meadows (450 m² and 7 m). Grazing was associated only with the latter ($P < 0.05$). Road verge sites had a greater number of grass species per m² ($P < 0.01$) and shrub species per 100 m² ($P < 0.01$) than the meadow sites. The diversity of Raunkiaer life-forms and the proportions for ruderal and nitrophilous species were also greater ($P < 0.05$) in the former. Moreover, ground cover by annual grasses ($P < 0.05$) was greater in the road verge sites. On the contrary, proportions of moisture indicator species ($P < 0.01$) and percentage cover by perennials were smaller ($P < 0.01$) in this colony type than in the meadow sites (Table 1).

5. DISCUSSION

Road verge and meadow sites of Cabrera vole had distinct herbaceous floristic compositions. Indicator species for the road verge sites corresponded mainly to annual grasses and forbs, as well as ruderal and nitrophilous species. In meadows, perennial grasses and moisture indicative species were more common. Road verge sites showed greater annual grass cover, greater cover of ruderal and nitrophilous species, greater richness of grass and shrub species, greater Raunkiaer life-forms diversity, smaller cover of perennial grasses, and smaller abundance of moisture indicator species. Other environmental traits of verges that are potentially meaningful for vole's occupancy are smaller patch surface and width, as well as the absence of grazing.

The Cabrera vole is considered a specialist herbivore, consuming mostly grasses and other monocotyledons (Soriguer and Amat 1988, Costa *et al.* 2005). The plant species mostly consumed by this small mammal are: *Vulpia* spp. C. C. Gmelin, *Agrostis castellana*, *Bromus* spp., *Briza maxima* L., *Holcus lanatus* and *Avena barbata* Link, according to Soriguer and Amat (1988), Ayanz (1992) and Costa *et al.* (in press). Therefore, the presence and abundance of these species may indicate the occurrence of favourable habitat conditions. Five of them

were more common ($n \geq 7$ patches) and abundant (1 to 5% cover) in road verges than in meadow sites ($n \geq 4$ patches and 1 to 3%; see Table 2). *Agrostis castellana* reached 22% cover in meadow sites and only 10% in road verges, despite the same frequency occurrence ($n = 12$) in both colony types.

According to these results, road verges did not seem to present serious limitations in diet items availability, during the study period. In fact, there was a greater diversity of consumed grasses in the road verges. However, some disadvantages of road verge sites for the Cabrera vole population persistence and establishment might be expected, including higher habitat disturbance (grass mowing), lower moisture in the dry season and smaller patch size. High abundance of annuals indicate high frequency of disturbance (e.g. Lavorel *et al.* 1997, Dupré and Diekmann 2001), while perennial grasslands are associated with extensive agriculture and high habitat quality (Burel *et al.* 2004). According to White *et al.* (2004), high grassland diversity on low fertility soils is associated with low plant growth rates and low dry matter digestibility. Therefore, although road verges can provide a high diversity of food items, their nutritional quality (protein, fibre and water content) is probably less than that of perennials in meadow sites. Moreover, the communities dominated by annuals with low moisture conditions offer no guarantee of green food during the hot and dry Mediterranean summer.

Traditional land uses of the study areas include grazing and extensive agricultural practices such as ploughing (Pinto-Correia and Mascarenhas 1999). Although grazing was observed in meadow sites, its past incidence could not be determined, but the actual incidence seems to be low. In fact, the high cover of perennial species registered in these places is not compatible with high levels of grazing (Noy-Meir *et al.* 1989). This clearly suggests that the grazed sites in the present study were, in fact, areas with very occasional presence of grazers. More than half of the road verge colonies were separated from surrounding areas by fences that protect herbaceous communities (Burke *et al.* 2003, O'Farrell and Milton 2005) and allow the establishment of taller grasses

Table 2. Frequency of occurrence and mean percentage cover of plant species referred to as food items for Cabrera vole in the studied sites. *Vulpia* spp., *A. castellana*, *Bromus* spp., *B. maxima*, *H. lanatus* and *A. barbata* are considered the most consumed species (1: Soriguer and Amat 1988, 2: Ayanz 1992, 3: Costa *et al.* in press).

Species	No of sites (n = 13)		Cover %		Reference
	Verges	Meadows	Verges	Meadows	
<i>Vulpia</i> spp.	12	12	5	3	1
<i>Agrostis castellana</i>	12	12	10	22	1, 3
<i>Bromus</i> spp.	11	9	3	1	1, 2, 3
<i>Briza maxima</i>	10	12	1	1	1
<i>Holcus lanatus</i>	7	4	3	<1	2, 3
<i>Avena barbata</i>	11	9	3	1	2,3
<i>Phalaris</i> sp.	9	4	4	7	3
<i>Scirpoides</i> sp.	5	7	5	11	1, 2
<i>Corynephorus</i> sp.	0	0	0	0	3
<i>Carex</i> spp	2	3	1	2	2, 3
<i>Cynosurus</i> sp.	8	1	1	<1	3
<i>Poa</i> spp.	2	3	5	3	1, 2, 3
<i>Brachypodium phoenicoides</i>	3	3	6	12	2
<i>Phleum pratense</i>	0	0	0	0	2
<i>Hypochaeris radicata</i>	4	9	1	1	2
<i>Plantago lanceolata</i>	4	6	1	1	2
<i>Calendula arvensis</i>	3	2	1	<1	2
<i>Scorpiurus vermiculatus</i>	6	3	1	1	pers obs

(Bellamy *et al.* 2000) by preventing grazing. When crossing highly grazed areas, the fenced road verges, aside from their lower quality plant species composition, can be structurally suitable for voles. They maintain a tall, dense herbaceous layer that provides food and shelter (Fernández-Salvador 1998, Pita *et al.* 2006b).

According to a recent study on plant diversity in road verges (O'Farrell and Milton 2005), road construction and maintenance activities like vegetation removal are the main factors controlling community composition. Mowing and ploughing are the major management strategies in road verges. In some of the studied road verges, the entire verge vegetation was mowed; in others, the fences constrained road maintenance works, and a shrubby patch remained af-

ter mowing/ ploughing. These patches have a structure similar to a typical hedgerow: present a high shrub richness and high diversity of life-forms with low abundance of annual grasses, and few ruderal or nitrophilous species, which are associated with smaller disturbance frequency. This kind of verge is particularly important for voles as refuges, allowing population persistence, because mowing and ploughing often takes place in late spring or in early summer, when the dry season is beginning and few grassy areas are available. In verges where all vegetation was mowed, colonies disappeared (personal observations).

The mean density of Cabrera vole populations varies from 12 to 93 individuals per ha (Fernández-Salvador 1998). The corresponding number of individuals in our

surveys would range from 1 to 2 in smaller colonies and 1 to 4 in meadow colonies, according to the different patch surfaces (240 m² in road verges and 450 m² in meadow colonies). Rosário *et al.* (2004) observed 2 to 3 individuals per meadow site in the area of Grândola. These numbers are typical of rare species occurring in fragmented areas, such as *Microtus tatricus* Kratochvíl of the Carpathian Mountains, where densities range from 0.2 to 28.6 individuals per ha (Martínková and Dudich 2003).

The smaller dimensions of road verge sites can result in even greater vole vulnerability, due to the smaller number of individuals and the stronger edge effect. Depending on connectivity with other suitable patches, the local extinction risk is greater for small road verge colonies than for meadows (e.g. Bennett 1991, Saunders *et al.* 1991, Pita *et al.* 2006b). Moreover, a greater edge to area ratio can increase predation risk (Soulé and Gilpin 1991, Jacob and Hempel 2003). Bellamy *et al.* (2000) suggest that 4 m might be the minimum habitat width for *Microtus agrestis* L. in road verges. According to the range (2–10 m) and median (4 m) estimated in the occupied verge sites, we suggest that minimum habitat width for Cabrera vole is slightly less than observed for *M. agrestis*. Our findings are in accordance with the results obtained in a study on *Microtus pennsylvanicus* Ord by La Polla and Barrett (1993), who observed that 1 m wide corridors were enough for sink dispersion.

Overall, our results suggest that linear habitats, like road verges, can play an important role for Cabrera vole's persistence, providing extra foraging and refuge sites when adjacent areas are disturbed, as reported for other small mammals, like *Clethrionomys glareolus* Schreber (Tattersall *et al.* 2002) or *Peromyscus leucopus* Rafinesque and *Microtus pennsylvanicus* (La Polla and Barrett 1993, Merriam and Lanoue 1990). However, further research is needed to determine whether road verges function as corridors or sink habitats for Cabrera vole and in what circumstances. Future studies should focus on differences in the fitness of individuals inhabiting these two habitat types, including rates of mortality due to road-killings. This information is crucial to include small mam-

mal conservation goals in road verge management plans.

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APPENDIX

Plant species identified in the road verge and meadow sites colonized by Cabrera vole (*Microtus cabreræ*) in Southern Portugal (sites: number of sites with presence of each plant species; cover %: mean cover percentage where it occurs; IV: Indicator value for each colony type and significance of Monte Carlo test; * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, nc: not calculated; ISA methodology (see Methods) was applied only to herbaceous species; species occurring in less than three sites were excluded from the list).

Road verge sites (n = 13)				Meadow sites (n = 13)			
	Sites	Cover %	IV		Sites	Cover %	IV
<i>Agrostis castellana</i> Boiss. & Reuter	12	10	0	<i>Agrostis castellana</i> Boiss. & Reuter	12	22	62.9*
<i>Vulpia</i> spp. C.C. Gmelin	12	5	53.6	<i>Vulpia</i> spp. C.C. Gmelin	12	3	0
<i>Bromus madritensis</i> L.	11	3	62.9*	<i>Briza maxima</i> L.	12	1	0
<i>Avena barbata</i> Link	11	3	57.9	<i>Tolpis barbata</i> (L.) Gaertner	11	< 1	43.8
<i>Leontodon</i> spp. L.	11	2	51.1	<i>Leontodon</i> spp. L.	10	2	0
<i>Medicago</i> spp. L.	11	2	46.8	<i>Gaudinia fragilis</i> (L.) Beauv.	10	< 1	0
<i>Bromus hordeaceus</i> L.	11	1	51.0	<i>Quercus suber</i> L.	9	7	nc
<i>Sonchus oleraceus</i> L.	11	1	76.1***	<i>Avena barbata</i> Link	9	1	0
<i>Galactites tomentosa</i> Moench	11	< 1	62.8**	<i>Hypochaeris radicata</i> L.	9	< 1	38.2
<i>Gaudinia fragilis</i> (L.) Beauv.	11	< 1	44.1	<i>Anagallis arvensis</i> L.	9	< 1	49.7
<i>Vicia</i> spp. L.	11	< 1	58.3	<i>Bromus hordeaceus</i> L.	9	< 1	0
<i>Briza maxima</i> L.	10	1	42.0	<i>Stachys arvensis</i> (L.) L.	8	< 1	0
<i>Linum bienne</i> Miller	10	< 1	32	<i>Briza minor</i> L.	8	< 1	0
<i>Geranium dissectum</i> L.	10	< 1	31.2	<i>Galium</i> spp. L.	8	< 1	0
<i>Andryala integrifolia</i> L.	10	< 1	60.4**	<i>Rubus ulmifolius</i> Schott	7	20	nc
<i>Phalaris coerulescens</i> Desf.	9	4	30.3	<i>Cistus salviifolius</i> L.	7	20	nc
<i>Bromus diandrus</i> Roth	9	2	57.4**	<i>Scirpoides holoschoenus</i> (L.) Sojak	7	11	nc
<i>Tolpis barbata</i> (L.) Gaertner	9	< 1	0	<i>Cynodon dactylon</i> (L.) Pers.	7	3	31.6
<i>Galium</i> spp. L.	9	< 1	60.0	<i>Mentha pulegium</i> L.	7	1	43.1
<i>Cistus ladanifer</i> L.	8	16	nc	<i>Linum bienne</i> Miller	7	1	0
<i>Sherardia arvensis</i> L.	8	1	53.7*	<i>Daucus</i> spp. L.	7	< 1	0
<i>Stachys arvensis</i> L.	8	< 1	43.2	<i>Vicia</i> spp. L.	7	< 1	0

Road verge sites (n = 13)	Sites	Cover %	IV	Meadow sites (n = 13)	Sites	Cover %	IV
<i>Cynosurus echinatus</i> L.	8	< 1	38.3	<i>Festuca ampla</i> Hackel	6	61	41.9*
<i>Sanguisorba minor</i> Scop.	8	< 1	33.7	<i>Asphodelus</i> spp. L.	6	4	14.0
<i>Briza minor</i> L.	8	< 1	33.7	<i>Coleostephus myconis</i> (L.) Reichenb.	6	3	29.4
<i>Quercus suber</i> L.	7	19	nc	<i>Medicago</i> spp. L.	6	2	0
<i>Holcus lanatus</i> L.	7	3	49.0*	<i>Chamaemelum</i> spp. Miller	6	1.	35.1
<i>Dittrichia viscosa</i> (L.) Greuter	7	3	nc	<i>Geranium dissectum</i> L.	6	1	0
<i>Asparagus aphyllus</i> L.	7	2	nc	<i>Plantago lanceolata</i> L.	6	< 1	19.2
<i>Cynodon dactylon</i> (L.) Pers.	7	2	0	<i>Galactites tomentosa</i> Moench	6	< 1	0
<i>Brachypodium distachyon</i> (L.) Beauv.	7	< 1	22.9	<i>Crepis</i> spp. L.	6	< 1	24.4
<i>Daucus</i> spp. L.	7	< 1	32.2	<i>Dactylis glomerata</i> L.	5	2	0
<i>Cerastium glomeratum</i> Thuill.	7	< 1	41.2*	<i>Lavandula luisieri</i> (Rozeira) Rivas Martínez	5	2	nc
<i>Quercus rotundifolia</i> Lam.	6	10	nc	<i>Hypericum humifusum</i> L.	5	1	28.9
<i>Dactylis glomerata</i> L.	6	4	31.3	<i>Bromus madritensis</i> L.	5	1	0
<i>Lavandula luisieri</i> (Rozeira) Rivas Martínez	6	3	nc	<i>Serapia lingua</i> L.	5	< 1	31.0
<i>Asphodelus</i> spp. L.	6	2	0	<i>Tuberaria guttata</i> (L.) Fourr.	5	< 1	30.6
<i>Scorpiurus vermiculatus</i> L.	6	< 1	23.7	<i>Euphorbia</i> spp. L.	5	< 1	21.9
<i>Chamaemelum</i> spp. Miller	6	< 1	0	<i>Sonchus oleraceus</i> L.	5	< 1	0
<i>Rumex bucephalophorus</i> L.	6	< 1	35.9	<i>Andryala integrifolia</i> L.	5	< 1	0
<i>Senecio</i> spp. L.	6	< 1	26.8	<i>Scilla ramburei</i> Boiss	5	< 1	38.5**
<i>Crepis</i> spp. L.	6	< 1	0	<i>Phalaris coerulescens</i> Desf.	4	7	0
<i>Tuberaria guttata</i> (L.) Fourr.	6	< 1	0	<i>Cyperus longus</i> L.	4	5	22.7
<i>Scirpoides holoschoenus</i> (L.) Sojak	5	5	nc	<i>Dittrichia viscosa</i> (L.) Greuter	4	3	nc
<i>Carlina</i> spp. L.	5	2	0	<i>Ulex parviflorus</i>	4	3	nc
<i>Echium plantagineum</i> L.	5	1	31.7	<i>Carlina</i> spp. L.	4	3	17.8
<i>Cynara humilis</i> L.	5	< 1	37.1*	<i>Brachypodium distachyon</i> (L.) Beauv.	4	< 1	0
<i>Torilis</i> spp. Adanson	5	< 1	38.5	<i>Rumex angiocarpus</i> Murb.	4	< 1	20.8
<i>Convolvus arvensis</i> L.	5	< 1	31.5*	<i>Asparagus aphyllus</i> L.	4	< 1	nc
<i>Agrostis pourretii</i> Willd.	5	< 1	23.9	<i>Holcus annuus</i> C.A. Meyer	4	< 1	0
<i>Geranium molle</i>	5	< 1	38.5**	<i>Holcus lanatus</i> L.	4	< 1	0
<i>Anagallis arvensis</i> L.	5	< 1	0	<i>Bromus diandrus</i> Roth	4	< 1	0
<i>Parentucelia viscosa</i> (L.) Caruel	5	< 1	38.5**	<i>Sherardia arvensis</i> L.	4	< 1	0

Road verge sites (n = 13)	Sites	Cover %	IV	Meadow sites (n = 13)	Sites	Cover %	IV
<i>Gynandris sisyrinchium</i> (L.) Parl.	5	< 1	38.5**	<i>Senecio</i> spp. L.	4	< 1	0
<i>Holcus annuus</i> C.A. Meyer	4	3	26.4	<i>Rumex bucephalophorus</i> L.	4	< 1	0
<i>Coleostephus myconis</i> (L.) Reichenb.	4	1	0	<i>Genista triacanthos</i> Brot.	4	< 1	nc
<i>Trifolium angustifolium</i> L.	4	< 1	21.8	<i>Holcus mollis</i> L.	4	< 1	30.8*
<i>Bromus rigidus</i> Roth	4	< 1	19.7	<i>Juncus acutiflorus</i> Hoffm.	4	< 1	30.8*
<i>Plantago lanceolata</i> L.	4	< 1	0	<i>Brachypodium phoenicoides</i> (L.) Roemer & Schultes	3	12	16.7
<i>Hypochaeris radicata</i> L.	4	< 1	0	<i>Poa</i> spp. L.	3	3	0
<i>Lolium rigidum</i> Gaudin	4	< 1	0	<i>Daphne gnidium</i> L.	3	2	nc
<i>Rumex angiocarpus</i> Murb.	4	< 1	0	<i>Cistus ladanifer</i> L.	3	2	nc
<i>Taeniatherum caput-medusae</i> (L.) Nevski	4	< 1	30.8	<i>Scorpiurus vermiculatus</i> L.	3	1	0
<i>Mentha pulegium</i> L.	4	< 1	0	<i>Pulicaria paludosa</i> Link	3	< 1	0
<i>Raphanus raphanistrum</i> L.	4	< 1	16.4	<i>Ornithopus compressus</i> L.	3	< 1	17.8
<i>Lathyrus angulatus</i> L.	4	< 1	28.9	<i>Lotus</i> spp. L.	3	< 1	0
<i>Cistus salvifolius</i> L.	3	8	nc	<i>Trifolium angustifolium</i> L.	3	< 1	0
<i>Brachypodium phoenicoides</i> (L.) Roemer & Schultes	3	6	0	<i>Sanguisorba minor</i> Scop.	3	< 1	0
<i>Ulex parviflorus</i> Pourret	3	5	nc	<i>Agrostis pourretii</i> Willd.	3	< 1	0
<i>Plantago lagopus</i> L.	3	5	18.4	<i>Carex</i> spp. L.	3	2	0
<i>Bromus tectorum</i> L.	3	3	23.1				
<i>Hedypnois cretica</i> (L.) Dumont-Courset	3	2	11.3				
<i>Myrtus communis</i> L.	3	2	nc				
<i>Lotus</i> spp. L.	3	1	18.3				
<i>Silene gallica</i> L.	3	< 1	15.7				
<i>Calendula arvensis</i> L.	3	< 1	13.6				
<i>Aristolochia longa</i> L.	3	< 1	20.4				
<i>Euphorbia</i> spp. L.	3	< 1	0				
<i>Ornithopus compressus</i> L.	3	< 1	0				
<i>Serapias lingua</i> L.	3	< 1	0				
<i>Campanula lusitanica</i> L.	3	< 1	14				