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ORIGINAL ARTICLE

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Uncovering the environmental factors that influence diversity patterns of Mediterranean terrestrial Gastropod communities: a useful tool for conservation

Abstract Land snails are an important component of biodiversity but the information regarding the factors that influence their distribution is very incomplete or anecdotal in most geographic areas. In this article our aim was to uncover environmental factors that influence the distribution and diversity of a Gastropoda community in a Mediterranean Reserve (Collserola Natural Park, Barcelona). Fieldwork was conducted from 2001 to 2003, and we systematically sampled all 1 km^2 UTM squares throughout the park by randomly selecting at least one 200 m^2 plot within each square. We used a community-based approach to analyse the relationships between 61 Gastropod species distributions and environmental predictors by means of Redundancy Analysis (RDA). Our results highlighted that the land snail community was affected by the environmental predictors (even for short gradients), but their influence was low according to the explained variance (30 %). Climate and habitat predictors were more important than the spatial variables in determining the community composition and diversity. 48 out of 61 (78.7 %) land snail species showed significant responses to the environmental gradients with an association of specialist species with particular habitat types. Collserola is a reserve surrounded by urbanised areas and affected by multiple anthropogenic threats mostly related to habitat transformation. The high degree of specialisation within the Gastropoda community suggests that the restoration of heterogeneous landscapes would be useful to conserve and restore terrestrial mollusc diversity in Collserola. This study can help stakeholders to make decisions related to landscape planning and habitat transformation.

Keywords Biodiversity · Environmental factors · Terrestrial mollusc · Land snails · Mediterranean basin

Introduction

Knowledge on the distribution patterns of species is a key to identifying biodiversity hotspots and prioritising management planning for conservation (Sarkar et al. 2006; Millspaugh and Thompson 2009; Naro-Maciel et al. 2009). In parallel, the environmental factors that influence species distribution are key indicators for understanding the processes that govern their distribution and for anticipating changes linked to natural or anthropological disturbances (Kimberling et al. 2001; Andersen et al. 2004; Douglas et al. 2013). For terrestrial ecosystems, this knowledge is unfortunately biased towards Vertebrate taxa and some Hexapoda groups (Solem 1984; Ward and Larivière 2004; McGeoch et al. 2011). For other taxa such as terrestrial molluscs, even though they are important components of biodiversity (Cameron and Killeen 2003; Holland and Cowie 2009), the information is very incomplete or anecdotal in most geographic areas (Triantis et al. 2008). It is probably for this reason that many terrestrial invertebrates are scarcely evaluated in local and global conservation Red Lists (IUCN 2013).

Land snails and slugs are organisms with a low active mobility adapted to very specialised ecological niches (Kappes 2005) and represent a significant fraction of the edaphic invertebrate community (Coleman et al. 2004; Harris 2008). Patterns of species richness and biogeography in this taxon respond to a wide variety of envi-

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ronmental factors (Hoffmann et al. 2011; Baur et al. 2014) with clear implications for the spatial distribution of populations (Snegin 2005; Menez 2007). For example, edaphic properties of the soil influence Gastropoda community composition (e.g.: Martin and Sommer 2004a, b; Kappes et al. 2006; Berg 2010). Although acid substrates are likely to support a lower species diversity and abundance of individuals than limestone areas, acidophilic communities can also have a varied and interesting wildlife (Nekola 2010). Likewise, landscape composition and heterogeneity (i.e., the number of different vegetation units) are amongst the most frequently referred environmental factors that influence the composition of Gastropoda communities (Ondina and Mato 2001; Torre et al. 2014). Elevation gradients also drive the distribution and composition of Gastropoda communities at a local scale, since these gradients can be considered as surrogates for many environmental variables that have covariates with elevation (e.g. temperature, rainfall, productivity, and habitat type; Liew et al. 2010; Baur et al. 2014).

Uncovering which environmental parameters drive the distribution of Gastropoda species at small spatial scales is important in terms of conservation management. This is more critical still when parameters other than those that are strictly environmental play a role to drive community composition and species distribution. For example, human-induced landscape changes (i.e. land abandonment and urbanisation) may be responsible for species extinction and the decline of diversity (Torre et al. 2014). In such cases, a correct assessment of the factors driving species diversity and composition of Gastropoda communities may be a necessary tool in terms of proceeding with active landscape conservation planning and management.

The objective of this study is to uncover which environmental factors influence the distribution and diversity of a Gastropoda community in a Mediterranean Nature Reserve. The study area is the Collserola Natural Park, where active forestry and land abandonment during the last century, as well as proximity to a very populated area, have had a number of impacts for land snails. Previous studies were carried out in this reserve, aimed at discovering the composition and distribution of terrestrial snails (Bros 2004, 2009; Torre et al. 2014). Uncovering the ecological factors that are responsible for the species composition and distribution will be an important element for planning the conservation of Gastropoda biodiversity in this protected area.

Materials and methods

Study area

This study was conducted at Collserola Natural Park (Barcelona, Catalonia, Spain). This reserve covers 8295 ha (about 17 km long and 6 km wide) and is located in the middle of the metropolitan area of Barcelona. Collserola is dominated by a Palaeozoic base rock consisting essentially of silicates, with some isolated granite outcrops in the western area and some areas with limestone. The park has a mild, subhumid climate with an average yearly temperature of around 15 °C and annual rainfall of 650 mm (Raspall et al. 2004). The altitudinal range is 25–512 m.

Collserola has a rich mosaic of natural environments covering more than 40 habitats of interest for the European Community (Marull and Mallarach 2002). However, the park has undergone drastic modification in terms of land use. One hundred years ago, the park was dominated by a mosaic of vineyards with small forest patches in valleys and on hills and mountain tops (Raspall et al. 2004). Later on, pine plantations and natural reforestation modified the landscape to its present form. Thus, the woodland most commonly found (60 % of the park's area) is a mixed pine forest of Aleppo pine (*Pinus halepensis*) and holm oak (*Quercus ilex*). Holm oak woodlands occupy 6.5 % of the park's surface area. Other types of habitat in the park are scrublands (*Quercus coccifera*) (20 % of the surface area), water bodies and riparian vegetation (0.5 %), meadows and grassland (3 %), rocky spots (0.5 %), and crops and urbanised areas (14 %).

Sampling methodology

Fieldwork was conducted from 2001 to 2003. To cover all of the habitats we systematically sampled all 1 km² UTM squares throughout the park (Fig. 1). Within each square, we randomly sampled at least one 200 m² plot (14 × 14 m). The time taken to collect land snails and slugs in each plot was 90 min. Living terrestrial gastropods were sampled through a visual search for suitable microhabitats (under stones, dead wood, humus and litter, tree bark, scrubland and herbaceous vegetation and the aquatic surroundings). To sample micromolluscs (< 5 mm) in humus and litter, we examined a sample of 20 cm² and 15 cm depth of ground-layer (20 × 20 × 15 cm = 6 L) at each plot. Specimens were identified at species level in the lab. Gastropod taxonomy was based on Bank (2011). To improve the total inventory of species, we also recorded shells of snails that had recently died, despite the inherent risk in including species that were not actually alive at the time of sampling (Cernohorsky et al. 2010). Our sampling approach was qualitative, so species were recorded but individuals were not counted in the field. This approach is useful when combining two species detection methods (timed search, litter/soil samples) of different sensitivity to snail body size (Durkan et al. 2013).

Statistical procedures

An incidence matrix (presence/absence) of 61 land snail species on 108 sampling plots was created. The associ-
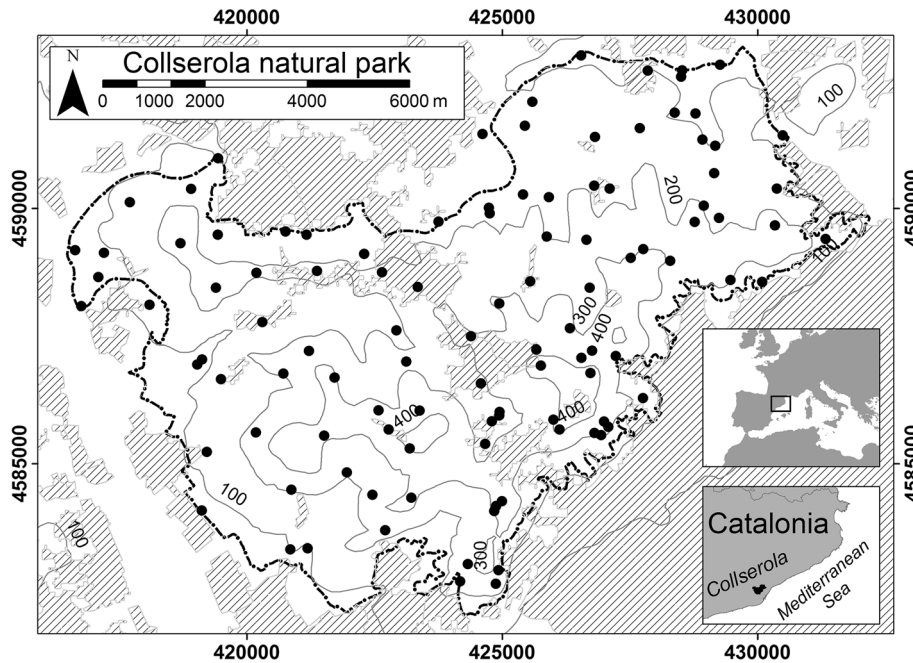
Fig. 1 Distribution of the 108 sampling sites at Collserola Natural Park (Barcelona, Spain). *Shaded areas* are urban landscapes

ation between the species matrix and the environmental variables (13 variables) was tested with the software CANOCO, version 4.5 for Windows (Ter Braak and Šmilauer 2002; Lepš and Šmilauer 2003). To explore which environmental factors determine land snail distribution at Collserola Natural Park, we used two types of variables: five continuous physical variables, namely elevation, mean maximum temperatures, mean minimum temperatures, radiation, and precipitation, and two categorical habitat variables (dummy variables): habitat type, divided into seven classes (anthropogenic, riparian, meadow, rocky, scrubland, holm oak forest, and pine-oak forest), and habitat heterogeneity, counting the number of habitats present within the sampling plots. The continuous variables were extracted from the environmental databases available in the mapping servers (Government of Catalonia: http://mediambient. gencat.cat/ca/05_ambits_dactuacio/patrimoni_natural/), while the habitat variables present at each location were recorded during fieldwork.

Firstly, a detrended correspondence analysis (DCA) was performed with the species incidence matrix. The result of this analysis is expressed in the length of gradients measuring beta diversity, i.e. the turnover or rate of change of the species. When gradient lengths were less than four (as in our case), we used linear instead of unimodal ordination methods (Lepš and Šmilauer 2003). We used redundancy analysis (RDA) to assess whether changes in community composition in plots could be explained by a matrix of environmental variables. Associations of each species with the environmental axes extracted were calculated after fitting Generalized Linear Models with the logit link function for binomial

data. The log link function for Poisson distributed data was used to fit the environmental axes to the species density, that is, the number of species recorded by sampling unit disregarding the number of individuals (Gotelli and Colwell 2001).

Apart from these environmental variables, we included a set of nine spatial predictors, i.e. a third-degree polynomial function of the geographic coordinates (cubic trend surface regression), to control spatial auto-correlation in the community composition of the sampled plots (Borcard et al. 1992; Boone and Krohn 2000). The MS-DOS program SpaceMaker2 (Borcard et al. 2004; available at http://www.bio.umontreal.ca/ casgrain/en/labo/spacemaker.html) was used to obtain the polynomial terms from the coordinates of the plots sampled. Then, partial constrained ordination (was used to remove the effects of: 1) spatial structure on species-environment associations by using the geographic coordinates of sampling plots as covariates, and 2) environment on spatial patterns in the species data by using the environmental variables as covariates (see Borcard et al. 1992 for details). With this procedure we were able to partition the variance that every group of variables had on the species matrix, obtaining the non-spatial environmental variation for the species data, the spatial patterns in species data not shared with the environment, the spatial-environmental fraction and the unexplained fraction of the variance (see Borcard et al. 1992 for details). Since some of the species were considered as rare, we used the down-weight algorithm available in CANOCO (see Labaune and Magnin 2001). The significant level for all the statistical tests was set at $P < 0.05$.

Results

Land community level

We recorded 61 species of terrestrial gastropods in the 108 plots sampled (Table 1).

The DCA performed with the species matrix explained 27.8 % of the variance in the land snail community, and the first axis explained 12.6 %. The gradient length along the axis was lower than 4, so linear ordination methods were used in further analyses. The first RDA with the species matrix constrained by environmental variables showed that these variables explained 26.3 % of the variance of the land snail community, and the first axis was significant (F ratio = 13.58, P = 0.002), as well as the four axes altogether (F ratio = 2.70, P = 0.002). The first axis can be considered as a gradient for elevation and climate, with negative values associated with holm oak and pine-oak forests located at the highest elevations, and positive values associated with open habitats in the temperate lowlands. The second axis was mainly a gradient from higher elevation and areas with more precipitation to areas situated at low elevation and covered by streams, ponds and lakes (Fig. 2).

The stepwise procedure for selecting environmental variables after the first RDA (Table 2) showed that the mean maximum temperature was the most important variable influencing the land snail community (6 %), followed by annual radiation (3 %), the mean minimum temperature and rainfall (1 % for both). The presence of meadow (4 %), anthropogenic (3 %), riparian, rocky and shrubby habitats (2 % each) also influenced the land snail community. Climate and habitat had similar influences on the community (11 vs. 13 %, respectively).

Species density (number of species recorded at every sampling plot) showed a strong and positive association with the first axis (F = 111.9, P < 0.0001, Fig. 3). The habitats with the lowest mean species density were pine-oak forests (7–8 species), and holm oak forests (8–9 species), whereas rocky, meadow (grasslands/crops) and anthropogenic habitats contained the richest communities at the sampling plot level, with 11–13 species (Fig. 3). The highest species densities were found in the peripheral areas of the Natural Park (covered by open and anthropogenic habitats), with there being lower densities in central areas almost covered by continuous forests.

The second RDA with species constrained by the spatial variables showed that these variables only explained 4.5 % of the variance of the land snail community. Nonetheless, the first axis was significant (F ratio = 2.55, P = 0.04), as well as the four axes altogether (F ratio = 1.62, P = 0.03). Only the linear terms (bx and by) were selected in the stepwise procedure, explaining 3 % of the variance altogether, a fact which meant that there was low spatial autocorrelation and the nearest plots did not have similar gastropod communities.

Lastly, we performed two partial constrained RDA, the first one with species data constrained using the environmental data, adding the spatial variables as covariates (22.0 % of variance), and the second one with species data constrained using the spatial variables, adding the environmental variables as covariates (3.7 % of variance). In both cases, the four axes extracted were significant (P = 0.002 for both). Our results indicated that the non-spatial environmental fraction of the variance was the most important in determining the land snail community (22.0 %), followed by spatial structuring in species data shared by the environment (4.3 %) and spatial patterns not shared with the environment (3.7 %), with a high fraction of unexplained variance (70 %).

Gastropod species level

48 out of 61 (78.7 %) land snail species showed significant responses to the environmental gradients extracted from RDA. From the total land snails recorded in the park, 57.3 % of the species showed significant associations with axis 1, and 40.9 % of them showed significant associations with axis 2. Twelve species showed a negative association with axis 1 (Table 1), but only two showed negative associations with both axes. These species were associated with holm oak woodland on mountain tops; in contrast, almost none of the species were associated with pine-oak forests (Fig. 3) despite their extensive presence throughout the park. 23 species showed positive associations with axis 1, and five showed positive associations with both axes (Table 1).

Specific land snail species responses varied according to their biogeographic affinity: species with European distribution such as *Cepaea nemoralis* selected forest (holm oak and pine-oak) habitats, whereas species with Mediterranean distribution such as *Cernuella virgata* and *Cornu aspersum* showed their preference for open lowland habitats (Fig. 3). Iberian endemics such as *Montserratina martorelli* showed a negative association with axis 2 and a preference for highland forests (Fig. 3). Lastly, species with a wide distribution range in Europe and the Palaearctic, such as *Deroceras laeve*, although relatively scarce in the study area, showed a positive association with axis 2 and were associated with riparian environments (Fig. 3).

Discussion

Our results suggested that environmental variables (climate and habitat) were more important than spatial variables in determining the composition of the land snail communities of Collserola Natural Park. Spatial structure may affect the distribution of communities

Table 1 Checklist of species found in the 108 sites sampled within Collserola Natural Park

Species	Codes	Localities	Frequency (%)	Axis 1	Axis 2
Abida polyodon	ABPO	16	14.81		
Acanthinula aculeata	ACAC	5	4.63	N	
Arion intermedius	ARIN	2	1.85		P
Arion lusitanicus	ARLU	11	10.19	N	
Caracollina lenticula	CALE	6	5.56	P	
Carychium sp	CASP	4	3.70		P
Cecilioides acicula	CEAC	1	0.93		
Cepaea nemoralis	CENE	53	49.07	N	
Cernuella virgata	CEVI	40	37.04	P	
Clausilia rugosa	CLRU	27	25.00		
Cochlicella acuta	COAC	9	8.33	P	P
Cochlicella barbara	COBA	13	12.04	P	P
Cochlicopa lubrica	COLU	7	6.48	P	P
Cornu aspersum	COAS	71	65.74	P	
Deroceras altimirai	DEAL	28	25.93	N	
Deroceras laeve	DELA	20	18.52		P
Deroceras reticulatum	DERE	1	0.93	N	
Discus rotundatus	DIRO	22	20.37	N	P
Eobania vermiculata	EOVE	37	34.26	P	
Euconulus fulvus	EUFU	5	4.63		
Euomphalia strigella	EUST	57	52.78		
Ferussacia folliculus	FEFO	17	15.74	P	N
Granopupa granum	GRGR	5	4.63	P	N
Helicigona lapicida	HELA	23	21.30		P
Hygromia cinctella	HYCI	1	0.93		P
Hypnophila boissii	HYBO	28	25.93	N	
Jaminia quadridens	JAQU	9	8.33	P	N
Lauria cylindracea	LACY	3	2.78	P	
Lehmannia valentiana	LEVA	4	3.70		
Limacus flavus	LIFL	3	2.78		
Limax maximus	LIMA	5	4.63		
Merdigera obscura	MEOB	3	2.78		N
Microxeromagna lowei	MILO	8	7.41	P	
Milax gagates	MIGA	2	1.85		
Monacha cartusiana	MOCA	56	51.85	P	
Montserratina martorelli	MOMA	25	23.15	N	N
Morlina glabra	MOGL	2	1.85		P
Otala punctata	OTPU	43	39.81	P	
Oxychilus cf. *cellarius*	OXCE	3	2.78	N	
Oxychilus courquini	OXCO	8	7.41		N
Oxychilus draparnaudi	OXDR	19	17.59	P	
Oxyloma elegans	OXEL	5	4.63		P
Paralaoma servilis	PASE	49	45.37	N	N
Pomatias elegans	POEL	84	77.78	P	P
Pseudotachea splendida	PSSP	56	51.85	P	N
Punctum pygmaeum	PUPY	3	2.78		
Rumina decollata	RUDE	45	41.67	P	
Testacella haliotidea	TEHA	4	3.70	N	
Testacella scutulum	TESC	1	0.93		P
Theba pisana	THPI	35	32.41	P	
Trochoidea elegans	TREL	12	11.11	P	P
Truncatellina callicratis	TRCA	5	4.63	P	
Truncatellina cylindrica	TRCY	1	0.93		
Vallonia costata	VACO	19	17.59	P	
Vallonia pulchella	VAPU	1	0.93		
Vitrea contracta	VICO	5	4.63	N	
Vitrina pellucida cf.	VIPE	1	0.93		N
Xerocrassa penchinati	XEPE	9	8.33		N
Xerosecta arigonis	XEAR	10	9.26	P	
Xerotricha conspurcata	XECO	2	1.85		
Zonitoides nitidus	ZONI	6	5.56		P

For each species, the number of sites and the frequency of occurrence is displayed. Significant associations of species with both environmental axes extracted from the RDA were calculated after fitting Generalized Linear Models with logit link function for binomial data (*P* positive association; *N* negative association; *empty* no association)
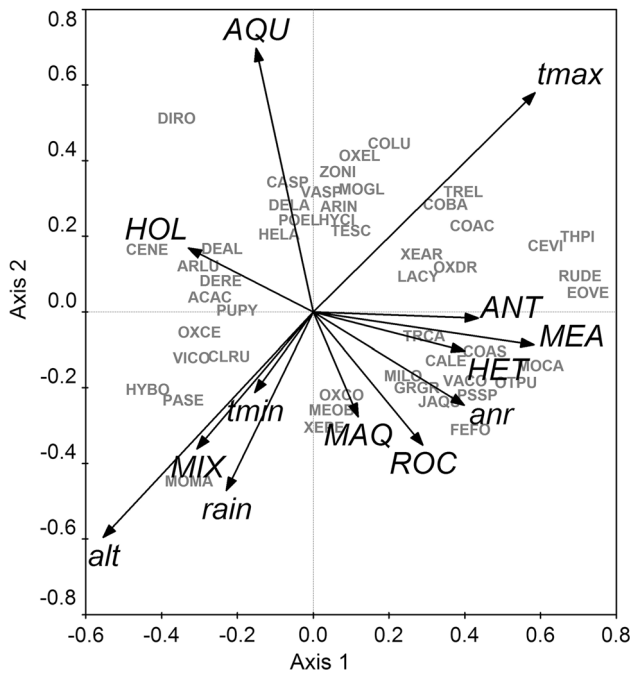
Fig. 2 Species responses to the environmental variables in the space generated by the two first axes extracted from the redundancy analysis with the species matrix constrained by the environmental variables in Collserola Natural Park. Codes of species as in Table 1, and codes of environmental variables as in Table 2. Only species showing axis coordinates larger than ±0.2 are plotted

Table 2 Results of the stepwise procedure for selecting environmental and spatial variables after the two redundancy analyses (RDA) performed with land snail species and environmental and spatial variables

Type of variables	Code	F-ratio	P	% var.
Environment				
Maximum temperature	tmax	6.76	0.002	6
Meadows	MEA	4.76	0.002	4
Anthropogenic	ANT	3.41	0.002	3
Annual radiation	anr	3.27	0.002	3
Aquatic	AQU	2.72	0.002	2
Rocky	ROC	2.33	0.002	2
Minimum temperature	tmin	1.94	0.002	2
Scrubland	MAQ	1.93	0.006	2
Rainfall	rain	1.43	0.048	1
Pine-Oak forest	MIX	1.32	0.11	1
Altitude	alt	1.19	0.2	1
Holm oak forest	HOL	0.78	0.79	1
Habitat heterogeneity	HET	–	–	–
Space				
Polynomial2		2.11	0.004	2
Polynomial3		1.49	0.03	1

from local to continental scales (Borcard et al. 1992; Diniz-Filho et al. 2003), as confirmed for land snail communities along elevation gradients (Labaune and Magnin 2001). However, the lower values of the length gradients extracted from the RDA suggested a low turnover rate and high species similarity at sampling stations (Diniz-Filho et al. 2003), without evidence of

relevant spatial structure influences on land snail communities.

The explained variance of environmental and spatial variables on land snail communities was low (30 %). This result suggests that other important factors acting at the microhabitat level such as edaphic conditions, chemical composition, and microhabitat structure may influence land snail species composition and richness (Kappes et al. 2006; Cejka et al. 2008; Moreno-Rueda et al. 2009). Nonetheless, our results highlighted that several physical variables influenced the distribution of land snail species, and hence, the composition and diversity of gastropod communities in the park. In fact, 75 % of species showed significant linear responses to the environmental gradients extracted from RDA. For example, species density decreased with elevation (range 43–463 m.a.s.l.), as observed for land snail communities in other mountain ranges (Aubry et al. 2005; Liew et al. 2010), even in short elevation gradients (Labaune and Magnin 2002). Maximum temperature was the variable with the highest explained variance on Collserola land snail community structure (see Aubry et al. 2005; Hoffmann et al. 2011 for similar results), and this variable showed a negative association with elevation. Nonetheless, and owing to the short elevation gradient studied, we might expect there to be an influence of other variables that are correlated with temperature in relation to elevation. As such, the decreasing pattern could also be interpreted in terms of changes in landscape composition and structure in relation to elevation, bearing in mind that patterns of covariation between climatic and habitat variables prevented detailed interpretations of causal factors (Liew et al. 2010).

As small ectothermic animals, land molluscs are expected to be more directly influenced by abiotic soil and climate gradients rather than indirectly by the effects of climate and soil on vegetation (Tattersfield et al. 2001). Forest canopy, presumably because of solar radiation, moisture and temperature, as well as the proximity to water courses, affect the Gastropoda community composition (Kappes 2006; Bros et al. 2011; Rancka et al. 2015). We also found a clear association between the presence of snails and particular habitat types. This finding suggests that habitat structure, with woodland and open habitats being the two extremes, probably to some extent govern the relationship between species richness and environmental variables (Chiba 2007).

Snails, like other taxonomic groups, show a gradient between generalist and specialist species in habitat selection (Hoffmann et al. 2011). In Collserola, some snails and slugs are considered to be habitat generalists (e.g. *Arion lusitanicus autoct. non Mabille, 1868*, *Cornu aspersum* and *Euomphalia strigella*) and are able to occupy different plant communities in specific geographic areas. In contrast, we found associations between several species and particular habitat types such as holm-oak forests (*Acanthinula aculeata* and *Hypnophila boissii*), open dry habitats (*Caracollina lenticula, Ferussacia folliculus, Jaminia quadridens* and *Xerocrassa penchinati*)
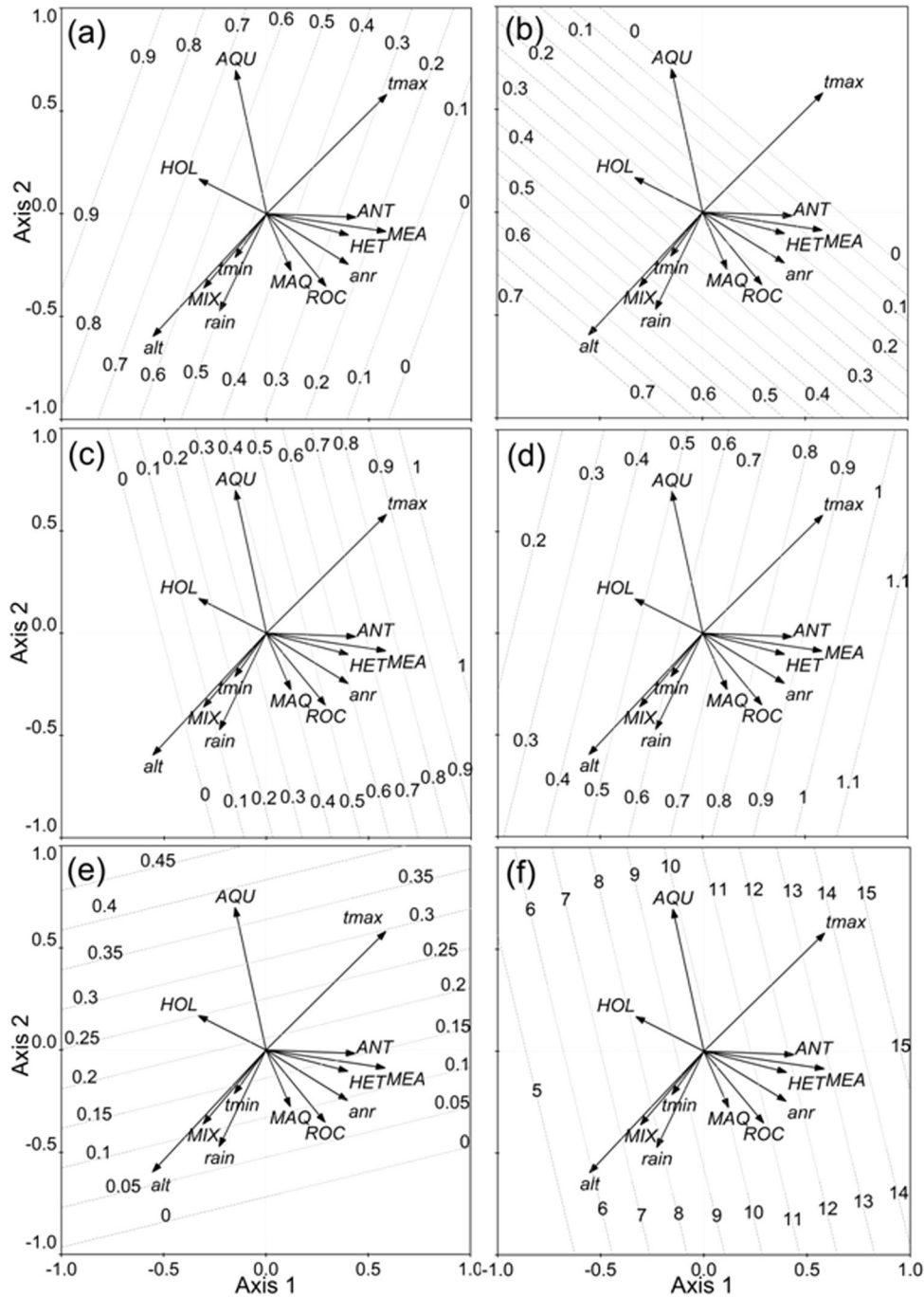
Fig. 3 Specific responses of *Cepaea nemoralis* (**a**), *Montserratina martorelli* (**b**), *Cernuella virgata* (**c**), *Cornu aspersum* (**d**) and *Deroceras leave* (**e**), and species density (**f**) to the environmental variables in the space generated by the two first axes extracted from the redundancy analysis with the species matrix constrained

by the environmental variables in Collserola Natural Park. *Contour lines* represent the changes in species abundance/density along the environmental axes. All species presented fitted GLZ models with the environmental axes. Codes of environmental variables as in Table 2

and aquatic environments (*Oxyloma elegans*, *Deroceras laeve* and *Zonitoides nitidus*). In summary, habitat structure, floristic composition and other environmental variables can play key roles in shaping mollusc community composition. As these factors interact, it is difficult to distinguish between the influence of climatic

factors, historical events and/or biotic factors that shape snail spatial composition within environmental gradients (Labaune and Magnin 2001).

In addition to this complexity, historical anthropogenic land uses and disturbance regimes (i.e. fire, Raspall et al. 2004; Sala 2012) can also generate patterns

on a local scale (Labaune and Magnin 2001). For example, human historical buildings may function as refuges for some species of snails, particularly in landscapes with poor limestone substrate (Juricková and Kucera 2005). The effect of fire seems unimportant in Collserola when compared to close natural reserves (Santos et al. 2009, 2014; Santos and Poquet 2010). In contrast, habitat-mediated uses such as pine plantations has negatively affected snail composition and has probably caused local extinction of some mollusc species (Torre et al. 2014).

Conservation implications

Natural parks located near urban areas such as Collserola are strongly influenced by anthropogenic processes that occur outside their limits. In fact, they are islands that consist of natural vegetation and are affected by landscape processes such as habitat uses in the surrounding edges (Pino and Marull 2012). In Collserola, urbanisation and forestry are the main pressures on biodiversity (Basnou et al. 2013) with there being emphasis on the loss of open habitats for the terrestrial mollusc community (Torre et al. 2014). Studies that uncover environmental factors that influence diversity patterns are useful tools for biodiversity conservation, especially for species with low mobility patterns such as snails. In the metropolitan area of Barcelona, landscape processes are transforming agroforestry mosaics in urbanised areas (Basnou et al. 2013) causing a human impact on biodiversity that is particularly negative for wild communities such as Gastropoda, which are very sensitive to land-use changes (Douglas et al. 2013). This trend is even more dangerous for habitat specialists and can even result in local extinction (Dahirel et al. 2014). With regard to a more trivial and simple biocenosis, we propose the re-establishment of heterogeneous landscapes as a measure to restore terrestrial mollusc diversity in Collserola. Studies such as the present can help stakeholders make decisions related to landscape planning and habitat transformation.

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