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Biological invasion of a refuge habitat: *Anthriscus caucalis* (Apiaceae) decreases diversity, evenness, and survival of native herbs in the Chilean matorral

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Abstract In central Chile, the bur beak chervil (*Anthriscus caucalis* M. Bieb.; Apiaceae) is an annual naturalized herb introduced from Europe at least 120 years ago. *Anthriscus* is distributed in vegetation formations such as sclerophyllous shrublands (locally known as "matorral") and spiny savannas of *Acacia caven* (locally known as "espinal"). In matorral formations, *Anthriscus* grows at the edge of native woody fragments. Because these fragments are refuges where native herbs recruit, we studied the impact of *Anthriscus* on the diversity and survival of native forbs established in these sheltering microsites. First, we characterized the spatial distribution of *Anthriscus* in the matorral, sampling in different micro-habitat types. We differentiated three micro-habitat types: under the canopy of a fragment, at the edge of the canopy of a fragment, and in open sites outside the fragments. A total of 40 1×1 m quadrates were randomly distributed in each habitat type. Inside each of them, we recorded the number of seedlings and established plants, including *Anthriscus*. Then we evaluated experimentally the effect of *Anthriscus* on diversity and evenness of the local herb assemblages. For this purpose we conducted a field trial using 34 metallic enclosures (0.5×0.5 m) arranged in pairs. In each pair, *Anthriscus* individuals were removed from one plot, the other paired plot acting as control. We periodically recorded the presence and abundance of the remanent species of herbs inside the plots, and then we characterized the species diversity and evenness over time (Shannon's index, H' and Pielou's index, J'). Finally, in a second experiment we measured experimentally the presence or absence of *Anthriscus* against the survival of four native herb species (*Bowlesia incana*, *Bromus berteroanus*, *Pectocarya linearis*, and *Moscharia pinnatifida*). Here we used 20 0.5×0.5 m plots where we randomly transplanted seedlings of native herbs and *Arnthiscus*. Then, for each species and plot we determined their survival (%) according to the

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number of seedlings initially transplanted. The samplings show strong association between the presence of *Anthriscus* on edge habitat in the matorral. The maximum densities were noted in these microhabitat types whereas in open areas and under-fragment sites *Anthriscus* shows very low or null densities. At the end of the first trials, the plots with *Anthriscus* showed a Shannon diversity index $H' = 0.41$ (± 0.11 SE), while in plots without *Anthriscus* this value was 1.19 (± 0.1 SE), both as averages. Pielou's evenness index (J') yielded values of 0.23 (± 0.06 SE) and 0.59 (± 0.04 SE) for treatments with and without *Anthriscus*, respectively. Similarly, the second trials shows that the survival of the four native herbs was drastically decreased in the presence of *Anthriscus*: by 64% for *Bowlesia incana*, 43% for *Bromus berteroanus*, 46% for *Moscharia pinnatifida*, and 76% for *Pectocaria linearis*. Our study shows that the effects of *Anthriscus* include an inhibition of the establishment of native plants and a decrease in their survival in edge habitats, therefore affecting the composition and diversity of the local herb layer. Thus, *Anthriscus* is invading a refuge habitat for native herbs in the Chilean matorral, decreasing the native herb diversity and survival.

Keywords Edge habitat · Refuge · Mediterranean vegetation · Plant invasions · Herb layer

Introduction

Plant invasions can have important effects on the diversity of communities (Myers et al. 2000; Levine et al. 2003; Dukes and Mooney 2004; D'Antonio and Hobbie 2005). Although for most invasions these effects are minimal, some alien species are responsible for dramatic effects, affecting the distribution and abundance of native species (Williamson 1996; Levine et al. 2003). Therefore, some invasive plants may be considered as important drivers of communities and biomes (Vitousek et al. 1996), whose invasibility may depend on the native biodiversity context (Lonsdale 1999).

Plant invasions in Mediterranean ecosystems have special importance due to their intrinsic diversity and value as biodiversity hotpots. Mediterranean biomes contain near 20% of the vascular taxonomic diversity (Cowling et al. 1996; Myers et al. 2000), and support large and expanding human settlements (di Castri 1981; Rundel 1998; Aronson et al. 1998). Comparative patterns and processes implicated in the invasion of those ecosystems have been attended only recently attended (Arroyo et al. 2006; Holmgren 2002; Sax 2002; Pauchard et al. 2004; Jiménez et al. 2007). A recognized -but scarcely studied- pattern is that alien and native plants tend to occupy different habitats. For example, in mediterranean California it has been documented that serpentine grasslands, characterized by low Ca^{+2}:Mg^{+2} ratio and low macronutrient levels (N and P), contain a large diversity of native herbs, whereas in non-serpentine soils alien herbs are more common (Murphy and Ehrlich 1989; Harrison 1997, 1999; Gelbard and Harrison 2003; Gram et al. 2004).

In mediterranean Chile, early observations of the ecology of alien plants were made by Gulmon (1977) and Keeley and Johnson (1977), who independently documented that native and alien herbs were differentially distributed. They noted that naturalized herbs were mainly established in open microhabitats while native ones were more diverse underneath the canopy or at the edge of woody matorral fragments. Since then, local researchers have shown that the microhabitat of the canopy edge constitutes a refuge for native plants, because in open areas they are displaced by the combined effect of competition with naturalized herbs (Fuentes et al. 1986), grazing by alien herbivorous mammals (Jaksic and Fuentes 1980; Fuentes et al. 1984), and human disturbance (Holmgren 2002).

The bur beak chervil *Anthriscus caucalis* M. Bieb., Apiaceae (hereafter called simply *Anthriscus*) is an annual naturalized herb introduced from Europe in the second half of the nineteenth century. Its original distribution included the Mediterranean Basin and the Caucasus region (Tutin et al. 1968), and it has been introduced into North America, New Zealand, and South America (Randall 2002). In Chile, Reiche (1899) documented its presence (as the synonym *A. vulgaris* Pers., non Bernh.) in 'some localities' around the city of Santiago, indicating that this species was first observed in 1888 and that it was accidentally introduced to the country. Currently, *Anthriscus* is distributed throughout central Chile,

occupying cooler microsites in vegetation formations such as the sclerophyllous matorral and *Acacia caven* espinal (Montenegro et al. 1991). Additionally, it is present in abandoned sites in urban areas and in agricultural lands, where it is considered a weed (Matthei 1995). In the matorral, *Anthriscus* grows at the edge of woody canopy and its presence is associated with low native plant diversity (Figueroa et al. 2004).

Because *Anthriscus* recruits and becomes a dominant plant in a refuge habitat for native herbs, we studied the putative effects of this species on the diversity and survival of native forbs established in that habitat. We first characterized the spatial distribution of *Anthriscus* in the matorral, and by means of two field experiments, assessed the effect of *Anthriscus* on the diversity and evenness of the herb layer (including both native and naturalized herbs), and on the survival of four native herbs.

Materials and methods

Study area

In mediterranean Chile, the evergreen shrub vegetation is called matorral (Rundel 1981), an ecological analogue of the Californian chaparral (di Castri 1981). The actual composition and physiognomy of the matorral are determined by human effects on the originally continuous vegetation (Rundel 1981), which over the centuries have produced a mosaic of secondary fragments or patches of native species of woody flora with variable composition, size and shape (Fuentes et al. 1984). These woody patches are surrounded by a rather continuous matrix of herbaceous vegetation, composed of variable combinations of native and naturalized species (Figueroa et al. 2004), the latter chiefly originated in Eurasia and brought via Europe (Montenegro et al. 1991).

We conducted our study at the Estación de Investigaciones Ecológicas Mediterráneas (EDIEM; 33°23′S, 70°31′W) located ca. 20 km east of Santiago on the Andean foothills. This protected area occupies 835 ha, with elevations ranging from 1050 to 1915 m. The climate is mediterranean (di Castri and Hajek 1976) with an annual mean rainfall of 370 mm, mainly concentrated during the austral winter months (June to August). The mean temperature is highest from December to March (corresponding to the austral summer) and lowest from June to August (the austral winter). Details of the climate, weather, and habitat conditions at our study site are found in www.bio.puc.cl/sca/.

The study site is covered by sclerophyllous vegetation (Jaksic 2001), which physiognomically may be described as a mosaic of evergreen shrubland patches. Trees and shrubs of *Lithrea caustica* are dominant in these fragments, with cover ranging from 12% to 42% depending on slope orientation. Other shrubs such as *Kageneckia oblonga* (Rosaceae), *Colliguaja odorifera* (Euphorbiaceae), *Baccharis rosmarinifolia* (Asteraceae), *Quillaja saponaria* (Rosaceae), *Podanthus mitique* (Asteraceae), *Acacia caven* (Fabaceae), and *Azara dentata* (Flacourtiaceae) are also present in the fragments. These patches are surrounded by a herb layer with mixed native and alien herbs, which is distributed mainly between matorral fragments.

Spatial distribution of *Anthriscus*

During 2004 and 2005 we studied the spatial distribution of *Anthriscus* in different habitat types in our study site. We differentiated basically three microhabitat types: under the canopy of a fragment, at the edge of the canopy of a fragment, and in open sites outside fragments. These three sites were recognized because previous reports indicate that they are micro-climatically differentiated (temperature, humidity, solar insulation; del Pozo et al. 1989; Rozzi et al. 1989). The under-fragment sites (called hereafter under habitat) were areas located inside woody fragments of continuous canopy cover, >3 m from the fragment's edge. Open sites (hereafter open habitat) were >3 m outside neighboring fragments, in the herb layer. Finally, the fragment's edge sites (hereafter edge habitat) were areas below the shrub canopy projection, up to 2 m toward the fragment's core.

A total of 40 1 × 1 m quadrates separated by at least 50 m from each other were randomly distributed in each habitat type, with a total of 120 quadrates. In each of them, we recorded the number of seedlings and established plants, including *Anthriscus*. To this end, each quadrate was subdivided into 100 10 × 10 cm cells. Thus, we determined the relative cover (%) for each species by counting the number of

cells occupied. The sampling took place between July and October of both 2004 and 2005, during late winter and early spring, the season with highest diversity of emerged herbs, and encompassing the entire phenology of *Anthriscus*.

Effect of *Anthriscus* on herb diversity

To determine the putative effects of *Anthriscus* on the diversity of the herb layer, a field trial was conducted in 2006. We used 34 metallic enclosures (0.5×0.5 m) arranged in pairs 10–20 cm apart. Each pair of plots was distanced 20 m or more from others, all of them located in edge habitat. In each pair, *Anthriscus* individuals were removed from one plot, the other plot acting as control.

From August to November 2006 (spanning 9 weeks) we periodically recorded the presence and abundance of species of herbs inside the plots. Then each plot was characterized by its species diversity and evenness through time. Species diversity was calculated by Shannon's index, computed as $H' = \Sigma (p_i \times \mathrm{Ln}(p_i))$, where p_i corresponds to the relative abundance of each species in the plot. To compare plots differing in their diversity, we standardized the diversity indices obtained over time with respect to the initial one, using the following algorithm $\Delta H' = (H_f - H_i)/H_i$, where $\Delta H'$ is the change in diversity, H_f is the diversity recorded in each plot at different times, and H_i is the diversity recorded at the onset of the experiment. Additionally, the evenness was calculated by Pielou's index, computed as $J' = H'/H_{\max}$, where H' is Shannon's index, $H_{\max}$ equals $\mathrm{Ln}(S)$, and S is the maximum number of species counted in the plots.

Effect of *Anthriscus* on native herb survival

To determine the putative effects of *Anthriscus* on the survival of native herbs, a set of trials was carried out during 2005. We used 80 0.5×0.5 m plots located in edge habitat. Into each plot we randomly transplanted ten seedlings of each of the following native plant species: *Bowlesia incana*, *Bromus berteroanus*, *Pectocarya linearis*, and *Moscharia pinnatifida*. These species were chosen because they were the most abundant native plants growing in edge habitat. Then, 10 seedlings of *Anthriscus* were randomly inoculated in half of the plots (i.e., 40 plots). Thus,

we had two experimental treatments: plots transplanted with native herbs growing with or without *Anthriscus*, both replicated 10 times. Inside the plots, the transplanted plants were determined randomly using 5×5 cm cells. Each of the 100 cells was numbered and sorted for each transplant.

All the transplanted plants were marked individually using small plastic stakes for temporal localization and monitoring, and all independently emerged seedlings were removed manually. All plots were enclosed with metal fencing and were monitored periodically, counting the number of plants that survived since the initial transplantation. From July to October 2005 (spanning 14 weeks) we determined if the marked herbs were present and erect; withered herbs were considered as not having survived. For each species and plot their survival (%) according to the number of seedlings initially transplanted.

Statistical analyses

We analyzed the spatial distribution of *Anthriscus* using one-way ANOVA (Sokal and Rohlf 1995). We used habitat as the independent factor with three treatments: under, edge, and open habitats. *Anthriscus* cover (%) was the dependent variable, previously normalized by arcsine transformation (Sokal and Rohlf 1995). Changes in diversity and evenness were analyzed with one-way ANOVA for repeated measures. The independent factor was *Anthriscus* presence (with or without), replicated 17 times. The dependent variables (with repeated measures, 9 times) were values of H', $\Delta H'$ and Js. Finally, we estimated the survival curves for each native species with and without *Anthriscus* using the Kaplan–Meier's method (Kaplan and Meier 1958). Later, to assess the effects of exotic species, survival curves were compared with the two-sample Cox-Mantel test (Lee et al. 1975).

Results

Spatial distribution of *Anthriscus*

Inside the plots we found 15 species of herbs, eight native and seven naturalized species. Seedlings and established plants of herb species were very scarce in the under-habitat, reaching a mean cover of 0.5% per

Table 1 Herb composition and abundance (mean cover $\pm$ standard deviation) of herbs in three microhabitats of the Chilean matorral

Species	Family	Biogeographical origin	Under habitat	Edge habitat	Open habitat
Amsinkia calycina	Boraginaceae	Native	–	0.09 ± 0.1	5.67 ± 6.8
Anthriscus caucalis	Apiaceae	Naturalized	0.23 ± 0.7	81.4 ± 9.0	–
Bowlesia incana	Apiaceae	Native	0.11 ± 0.9	5.12 ± 4.3	0.14 ± 0.7
Bromus berteroanus	Poaceae	Native	–	2.43 ± 4.3	7.54 ± 8.1
Capsella bursa-pastoris	Brassicaceae	Naturalized	–	0.02 ± 0.1	2.67 ± 3.8
Centaurea melitensis	Asteraceae	Naturalized	–	0.3 ± 2.9	27.4 ± 18.1
Cotula australis	Asteraceae	Native	–	–	0.17 ± 0.1
Erodium cicutarium	Geraniaceae	Naturalized	–	0.3 ± 0.9	3.23 ± 3.3
Erodium moschatum	Geraniaceae	Naturalized	–	–	1.02 ± 1.1
Gamochaeta stachydifolia	Asteraceae	Native	–	–	1.72 ± 1.6
Moscharia pinnatifida	Asteraceae	Native	–	0.07 ± 0.1	2.11 ± 3.4
Pasithea coerula	Liliaceae	Native	–	4.07 ± 28.1	12.07 ± 33.1
Pectocaria linearis	Boraginaceae	Native	–	2.26 ± 3.6	0.9 ± 1.56
Trifolium glomeratum	Fabaceae	Naturalized	–	–	$1.\,25 \pm 1.6$
Vulpia bromoides	Poaceae	Naturalized	–	1.72 ± 3.6	7.23 ± 7.5
Spp. unidentified			0.02 ± 0.1	–	–

m² (Table 1). In contrast, the other two habitats showed higher richness of herb species, reaching mean covers of 98% and 73% per m² for edge and open habitats, respectively (Table 1).

Anthriscus exhibited a spatial distribution and dominance clearly associated with the edge habitat (ANOVA, $F = 12.4$; $df = 2$; $P < 0.05$), was very scarce in the under-habitat, and was absent in the open areas (Table 1). In fact, in the edge habitat *Anthriscus* was the dominant species, reaching a mean cover of 81%, followed only by *B. incana* and *B. berteroanus* whose respective covers were 5 and 3% (Table 1). The open habitat was more diverse, with *Centaurea melitensis* and *Pasithea coerulea* reaching covers of 27 and 12%, respectively (Fig. 1).

Effect of *Anthriscus* on herb diversity

Plots with *Anthriscus* showed a mean diversity of $H = 0.76$ (± 0.09 SE) at the beginning of the experiments, and of $H = 0.41$ (± 0.11 SE) at the end of the trials (Fig. 2; open squares). Plots without *Anthriscus* showed values ranging between $H = 0.66$ (± 0.27 SE) and $H = 1.19$ (± 0.1 SE) at the beginning and end of the experiments, respectively (Fig. 2; solid squares). These treatments were significantly different in their diversity indices (Fig. 2; ANOVA,
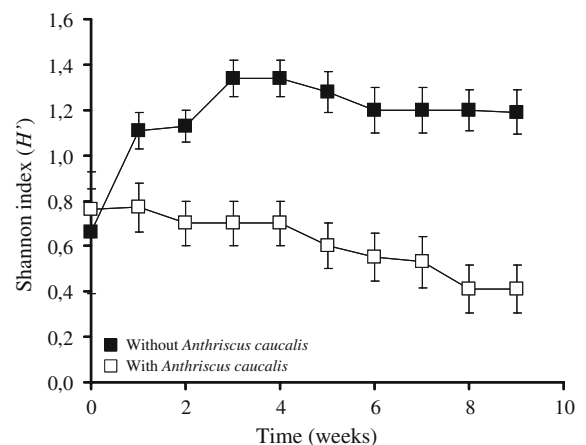

Fig. 1 Herb diversity (Shannon's index, H'; mean $\pm$ SE) recorded in 0.5×0.5 m plots in the matorral of central Chile. The *curves* correspond to two different treatments: with and without *Anthriscus*

$F = 11.3$; $df = 1$; $P < 0.05$), plots without *Anthriscus* having higher diversity than those with *Anthriscus*. Standardizing the changes of H values over time ($\Delta H'$), the previous pattern remained constant (Fig. 3). Plots with *Anthriscus* finished with $\Delta H' = -0.35$ (± 0.11 SE) as mean value, while those without *Anthriscus* finished with $\Delta H' = 0.08$ (± 0.09 SE). Again, these changes in $\Delta H'$ were statistically significant (ANOVA, $F = 17.5$; $df = 1$; $P < 0.05$).
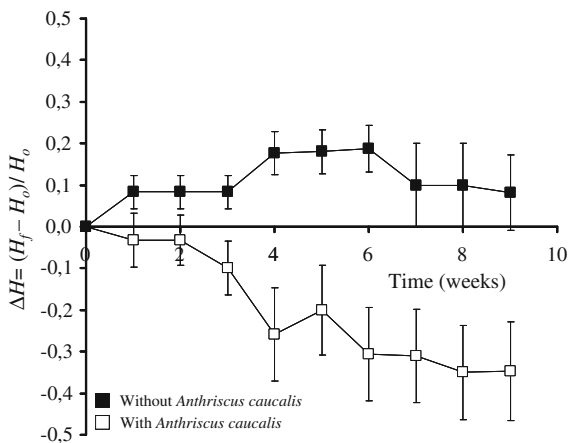
Fig. 2 Standardized Shannon's index ($\Delta H'$; mean $\pm$ SE) recorded in 0.5×0.5 m plots in the matorral of central Chile. The *curves* correspond to two different treatments: with and without *Anthriscus*
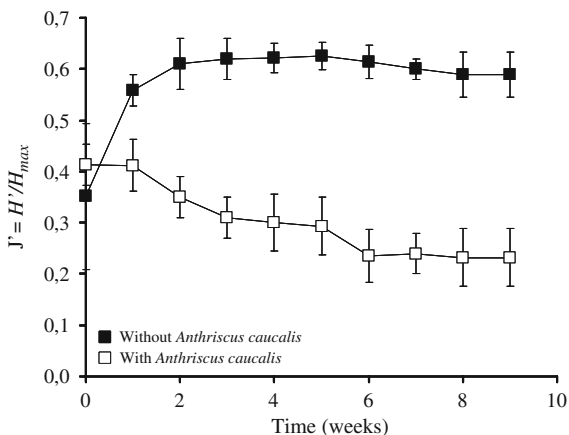

Fig. 3 Herb evenness (J'; mean $\pm$ SE) recorded in 0.5×0.5 m plots in the matorral of central Chile. The *curves* correspond to two different treatments: with and without *Anthriscus*

The evenness index (J') showed similar trends as the previous ones (Fig. 4). Plots with *Anthriscus* had a negative change in evenness throughout the experiments, contrasting with plots without. In the first case, evenness decreased from $J' = 0.41$ ($\pm$0.04 SE) to 0.23 ($\pm$0.06 SE) while in the second case it increased from $J' = 0.35$ ($\pm$0.14 SE) to 0.59 ($\pm$0.04 SE). In combination, these results indicate that the presence and dominance of *Anthriscus* cover in edge habitat affects negatively the richness, diversity, and evenness of the local herb assemblages.

Effects of *Anthriscus* on native herbs survival

The experiments showed that *Anthriscus* was important in determining the survival of native herbs *B. incana*, *B. berteroanus*, *M. pinnatifida* and *P. linearis*. Overall, these four species responded by decreasing their survival when growing together with *Anthriscus*. Comparing the final survival figures for plots without and with *Anthriscus*, these values were 74% and 10% for *B. incana* ($\Delta = 64\%$), 62% and 19% for *B. berteroanus* ($\Delta = 43\%$), 63% and 18% for *M. pinnatifida* ($\Delta = 46\%$), and 77% *versus* 7% for *P. linearis* ($\Delta = 70\%$), respectively, so survival declined more steeply when these species were grown with *Anthriscus* (Fig. 4), and significant differences were indicated in all cases (Cox–Mantel test $P < 0.001$). The strongest effect of *Anthriscus* was detected on *P. linearis* (Fig. 4a). This species showed a final survival of 23% in plots in which the exotic species had been inoculated. Conversely, in the absence of *Anthriscus*, the final survival of *P. linearis* was higher than that of any other native species (72%). A similar pattern was observed for *B. incana* (Fig. 4b), which showed final survival rates of 29% and 71% when it was grown with and without *Anthriscus*, respectively. At the end of the experiment, survival of *B. berteroanus* (Fig. 4c) and *M. pinnatifida* (Fig. 4d) were 41 and 36%, respectively, but their survival rates were higher than 60% when they were grown without *Anthriscus*.

Discussion

Our results show that *Anthriscus* exhibits a strong spatial zonation, distributing mainly in the edge-habitat of the Chilean matorral. More than 98% of the established plants of *Anthriscus* were recorded in this habitat type, whereas a marginal proportion ($< 2\%$) was observed inside the woody fragments (the under-habitat) and none were recorded in the open-habitat. In the edge-habitat *Anthriscus* reached a mean cover of 81%, becoming the dominant species in both abundance (individuals $\times$ m^{-2}) and cover. Futhermore, *Anthriscus* affected negatively the diversity of the herb assemblage and the survival of four native herb species: *B. incana*, *B. berteroanus*, *M. pinnatifida* and *P. linearis*. Complementarily, inside the experimental plots where *Anthriscus* was excluded

Fig. 4 Kaplan–Meier estimated survival curves for **a** *P. linearis*, **b** *B. incana*, **c** *B. berteroanus*, and **d** *M. pinnatifida*. The *curves* correspond to two different treatments: with (*solid dot*) and without (*open dot*) *Anthriscus*
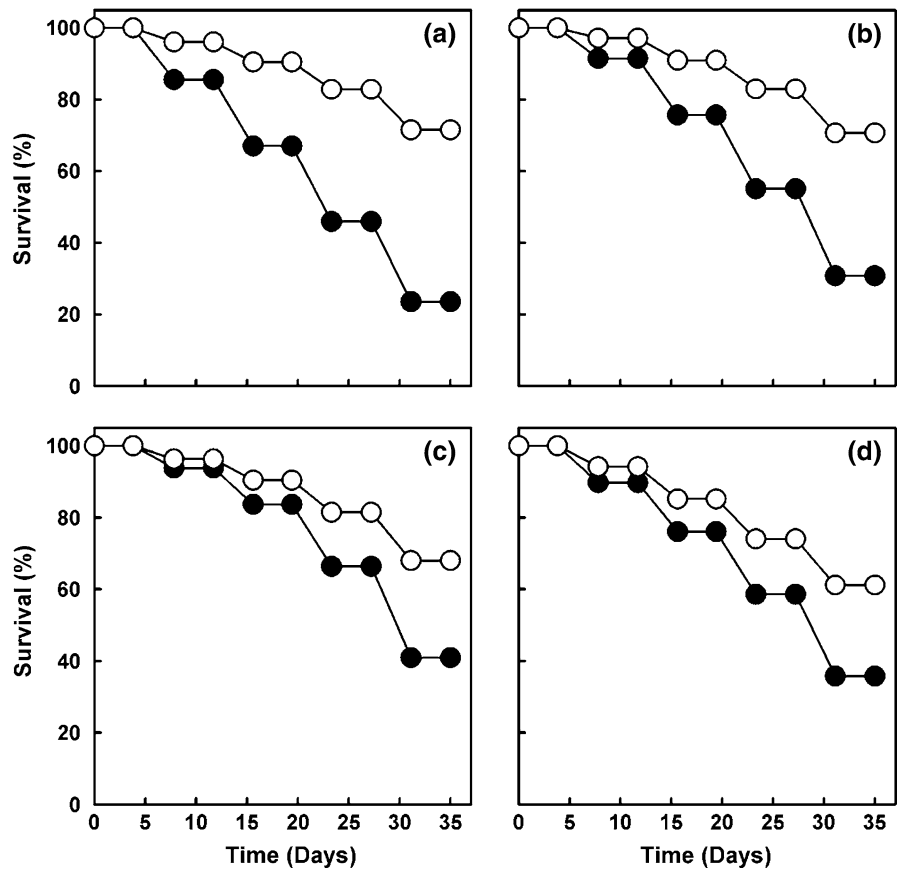
we recorded a higher diversity and evenness of herbs ($H' = 1.2$; $J' = 0.53$) than in those plots where it was not excluded ($H' = 0.4$; $J' = 0.23$).

Considering the spatial distribution of *Anthriscus* in the edge-habitat, several attributes of that species can be associated with its success in this patch type. First, the seeds of *Anthriscus* exhibit morphophysiological latency that is interrupted by low temperatures ($<5°C$), and its optimal temperature for germination is also low, around $8–4°C$ (Baskin and Baskin 1998). During the austral autumn–winter the monthly minimum temperatures drop below $10°C$ in our study site (Jaksic 2001), so the germination and emergence of seedlings of *Anthriscus* occurs earlier than those of other herbs. Interestingly, examining the data documented by Figueroa and Jaksic (2004), who compiled the optimal temperatures for seed germination of 99 species in central Chile, no species showed such a low optimal temperature as *Anthriscus*. Also, a previous study on the matorral seed bank

showed that *Anthriscus* is a super-abundant component of the easily germinating seed bank (Figueroa et al. 2004), outnumbering most native and naturalized species. Moreover, the emerged seedlings usually show a high survival rate in the edge habitat (Guzmán, unpublished data), decreasing towards open areas and inside fragments.

Since the early contributions of Gulmon (1977) and Keeley and Johnson (1973), herb zonation in the Chilean matorral has scarcely been studied. Those authors reported that native and naturalized species show spatial zonation because the former are more common under the woody canopy (i.e. edge-habitat) while the latter are more frequent in open areas. Subsequently, Jaksic and Fuentes (1980) and Fuentes et al. (1983) documented that zonation of some perennial herbs was caused by grazing of introduced European rabbits (*Oryctolagus cuniculus*). Later, Holmgren et al. (2000) and Holmgren (2002) documented that in experimental plots, native grasses

were more sensitive than alien grasses to grazing by rabbits, giving support to grazing as a determinant of herb zonation, but also mentioning human disturbance as an agent. Finally, Figueroa et al. (2004) questioned the generality of that zonation pattern pointing out that six exotic annual herbs can establish underneath woody canopy (edge-habitat) in opposition to the expected spatial segregation. Although plant zonation by biogeographical origin (native *versus* alien species) in the Chilean matorral may need more study (Figueroa et al. 2004), it was partially detected in our study area. At least two (*P. linearis* and *B. incana*) of 18 native forbs showed higher recruitment and establishment in edge-habitat, while six alien forbs were established mainly in open areas.

Levine et al. (2003) and Theoharies and Dukes (2007) recognized that the most prevalent mechanism implicated in the impact of alien plants on native ones is inter-specific competition, and seemingly the case of *Anthriscus* is no exception. This species shows a strong growth rate that usually results in a multi-layer cover of 100%, which strongly limits light availability to other species. For this reasons we proposed that the lower light availability determined by the interference mediated by *Anthriscus* constitute the principal mechanism that excludes the native herbs in the edge habitat of the matorral.

Stohlgren et al. (2001) emphasized the importance for biological conservation of hotspots and rare habitats as refuges for native flora. Although the edge habitats in central Chile are not strictly a hotspot, some proposals of Stholgren et al. (2001) may apply. The edge habitat constitutes an important refuge for the recruitment of shrub and tree species, which contributes strongly to the regeneration of the woody vegetation in central Chile (Fuentes, et al. 1984, 1986; Armesto et al. 1995). Thus, *Anthriscus* may be limiting the natural regeneration of the matorral herb layer by inhibiting plant establishment in edge habitat. Interestingly, seedlings of woody plants were not found in our plots. Also, the importance of the edge habitat as a refuge increases as human disturbance increases; anthropic disturbance usually is concentrated in open areas, thus reducing the survival success of native species in those areas.

Anthriscus is considered a weedy species in agricultural fields (Matthei 1995), but not an invasive species in natural or semi-natural areas. Our study shows that the effects of *Anthriscus* include an inhibition of the establishment of native plants and a decrease in their survival in edge habitats, thus affecting the composition and diversity of the local herb layer. Thus, *Anthriscus* is invading a refuge habitat for native herbs.

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