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Does postfire management affect the recovery of Mediterranean communities? The case study of terrestrial gastropods

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ABSTRACT

In fire-prone regions, understanding the response of species to fire is a major goal in order to predict the effects on biodiversity. Furthermore, postfire management can also model this response through the manipulation of environmental characteristics of the burnt habitat. We have examined the taxonomic and functional response to fire and postfire management of a Mediterranean snail community affected by a summer fire in 2003. After the fire, the area was logged, leaving wood debris on the ground, and three alternative practices were implemented in several plots within the burnt area: subsoiling, removal of trunks having branches, total removal of trunks and branches, as well as one area not logged. Our results indicated that fire exerted a major impact on the snail community, strongly reducing diversity and species richness, particularly for forest species living in the humus and having European distribution ranges. By contrast, we found slight differences within the postfire practices, presumably because of the strong initial impact of fire and subsequent xerophilous postfire conditions. However, the area with only trunk removal showed a positive response of generalist snail species, probably due to moist microhabitats provided by the accumulation of wood debris on the ground. The effects of postfire management should be further explored due to the expected increase of fire risk associated with climate change and land-use histories.

1. Introduction

In the Mediterranean region, wildfire has been a common natural disturbance that has modelled landscapes and hence has acted as a fundamental element on ecosystem functioning (Trabaud and Prodon, 1993; Moreno and Oechel, 1994; Piñol et al., 1998; Keeley and Fotheringham, 2003; Gillson, 2009). Fire expands open areas during the early ecological succession, favouring a shift in dominant species, which lead to different species assemblages in burnt areas compared with unburnt ones (Herrando et al., 2003; Moretti et al., 2004; Brotons et al., 2005; Apigian et al., 2006; Rugiero and Luiselli, 2006; Santos et al., 2009). This, in turn, increases gamma diversity (at the landscape level), and thus fire may contribute to maintain habitat heterogeneity and biological diversity in the Mediterranean region (Moreira et al., 2001; Blondel et al., 2010). However, species responses to alterations in habitats caused by fire vary greatly, depending on life histories and functional traits of taxonomic groups (Whelan, 1995; Caturla et al., 2000; Pausas and Verdú, 2005; Moretti et al., 2009), and there are often specific responses among species of a single taxon (e.g. amphibians [Pilliod et al., 2003], reptiles [Driscoll and Henderson, 2008; Santos and Poquet, 2010], molluscs [Santos et al., 2009], and arthropods [Moretti et al., 2004]).

In addition to this variation, recent studies have demonstrated that the response of organisms to fire can be modelled by postfire management (e.g. Izhaki and Adar, 1997; Haim and Izhaki, 2000; Eun-Jae et al., 2008; Puerta-Piñero et al., 2010). Logging (i.e. removal of the burnt tree trunks) has been practiced routinely by forest managers worldwide (Beschta et al., 2004; Lindenmayer et al., 2004), but there is controversy concerning its impact on ecosystems (Donato et al., 2006; Lindenmayer and Noss, 2006). For example, logging reduces bird-species abundance and has selective impact on certain species (e.g. seed dispersers, cavity-nesting birds), finally hampering the natural regeneration of the forest through its impact on some bird assemblages (Hutto and Gallo, 2006; Herrando et al., 2009; Castro et al., 2010a,b). The responses of organisms to postfire practices are expected to vary widely according to species-specific differences in habitat requirements (Herrando et al., 2009). Unfortunately, the effects of postfire management have been scarcely addressed in animals other than birds. For this reason, there is an urgent need to test how postfire man-

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agement affects wildlife responses in terms of abundance, diversity, and dominance of species.

In this light, the present study evaluates how postfire management affects the response of a Mediterranean terrestrial gastropod community. Due to the strict dependence of gastropods on soil structure, we have analysed the response to post-fire management by examining some functional traits of gastropod species, in order to understand the mechanisms that drive community responses to environmental changes, such as those prompted by fire and post-fire management (functional approach; Moretti and Legg, 2009; Moretti et al., 2009). Terrestrial gastropods are important elements in ecosystems, with a fundamental role in the decomposition of the leaf litter and soil formation (Mason, 1970; Shachak et al., 1987; Dallinger et al., 2001), and are a source of essential nutrients for other animals (Graveland et al., 1994). Because of their small home ranges and low mobility, terrestrial gastropods are adequate organisms to evaluate fire survival and postfire recolonization of burnt areas (Nekola, 2002; Kiss and Magnin, 2003). Snails are also sensible to forest type and coarse wood debris in the ground (Kappes et al., 2006), two variables that can greatly change after fire. Previous studies have demonstrated that fire inflicts severe initial impact on the snail community, which becomes dominated by xerophilous species (Kiss et al., 2004; Kiss and Magnin, 2006; Santos et al., 2009). However, in some Mediterranean landscapes, quick recovery of the preburnt community has been reported, depending on the number of existing shelters (Kiss and Magnin, 2003, 2006). Nevertheless, little information is available on how the snail community and its recovery capacity are affected by postfire management. An impact of postfire management on terrestrial gastropods is predicted, given that other management practices such as intense grazing and the amount of wood debris alter gastropod diversity (Kappes et al., 2006; Baur et al., 2007; Boschi and Baur, 2007). Moreover, as terrestrial gastropods depend strongly on soil moisture (Cook, 2001; Martin and Sommer, 2004), different levels of wood removal are expected to be correlated with the availability of moist microhabitats, thus influencing snail abundance and/or diversity.

2. Material and methods

2.1. Study area and fire history

The field work was conducted in a 4500 ha burnt area in Sant Llorenç del Munt i l'Obac Natural Park (Barcelona province, NE Spain, Fig. 1A). This reserve is located in the Catalan Pre-coastal Mountain Range and it has a total area of 13,694 ha. The landscape of the park is rugged, with sheer crags and unusual monoliths. The geological substrate is polymictic conglomerates. The climate of the study area is subhumid Mediterranean with annual rainfall of around 600 mm, the highest peaks being more windy, rainy, and cool than lowland areas (Panareda and Pintó, 1997). Rainfall is higher in spring and autumn than in summer. Thus, the area is prone to fast-spreading fires during hot, dry summers. The original forest tree in the Park is Holm oak *Quercus ilex*. Peripheral lowland areas were covered by vineyards during early XX century, and after the Phylloxera plague replaced by pines *Pinus halepensis* and plantations of *Pinus nigra*. The pine forest has Holm oak underbrush. The study area burned in August 2003 during a summer fire that affected 4443 ha on the eastern border of the park, with 1778 ha of this lying inside the park. Impelled by wind, the blaze spread quite quickly and the entire area burned in just one day (10th August 2003). The burnt landscape was previously dominated by a pine forest with Holm oak underbrush. After the fire, charred areas were occupied by dense scrub dominated by Mediterranean shrub species such as *Cistus albidus*, *Rosmarinus officinalis*, *Dorycnium pentaphyllum*, *Rubus ulmifolius* and *Coriaria myrtifolia*.

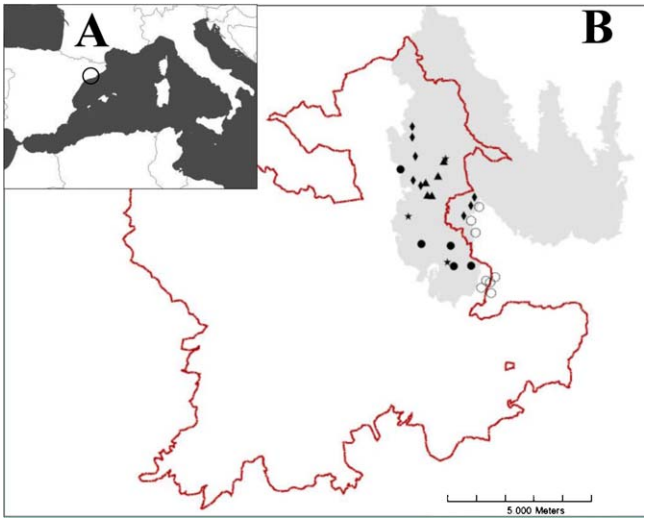

Fig. 1. Geographic location of the study area (A) and the sampling sites (B). The solid line indicates limits of the Sant Llorenç del Munt Natural Park and the grey area the surface of the 2003 fire. Symbols indicate the treatments: unburnt control (empty circles), no management (stars), trunk removal (diamonds), complete removal (solid circles), and trunk removal plus subsoiling (triangles).

2.2. Postfire management and site selection

Timber removal begun soon after the fire in August 2003, and two years later most of the area was almost completely logged, leaving very few or no standing snags. Logging in the study area did not include the elimination of branches and snags, and woody debris remained on the ground. After the logging, a sub-area was also subsoiled in order to plant mainly coniferous stands. However, the Park managers experimentally designed two alternative postfire practices: some areas of approximately 2 ha were maintained without any wood removal, whereas several 1-ha squares were managed with a complete wood removal.

According to the postfire management, we defined four different areas and selected several replicated sites per area (Fig. 1B): (1) No management (NM, 3 replicates); burnt in August of 2003 with no postfire treatment and removal. (2) Trunk removal (TR, 8 replicates); burnt in August 2003, with subsequent complete trunk removal and all the branches spread over the ground. (3) Complete removal (CR, 5 replicates); burnt in August 2003 with the removal of trunk and branches. (4) Trunk removal and subsoiling (SU, 5 replicates); burnt in August 2003 where besides trunk removal, the area had been subsoiled and later replanted with pines. Additionally, we established 8 unburnt control replicates (UN) in the pine forest near the fire edge with the same tree species that had been dominant in the burnt area before the fire.

The study area was relatively small (see geographic scale in Fig. 1) and had low altitudinal variation among sites (range 490–730) this fact precluding differences in precipitation and temperature between burnt and unburnt sites. We have only sampled areas with pine forest that cover peripheral areas of the park to avoid the effect of forest type on snail assemblages (Kappes et al., 2006).

2.3. Snail community and sampling

The gastropod community in Sant Llorenç del Munt i l'Obac Natural Park includes more than 90 terrestrial and freshwater species, with dominance of forest and rupiculous specialist species. The Natural Park stands out for the presence of Iberian endemisms with highly restricted distributions such as *Abida secale bofilli, Chondrina soleri*, *Montserratina bofilliana* and *Xerocrassa montserratensis*. The