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INFLUENCE OF SMALL-SCALE FIRES ON THE POPULATIONS OF THREE LIZARD SPECIES IN ROME

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The effect of small summer fires on three species of Mediterranean lizards (the lacertids *Podarcis muralis* and *Lacerta bilineata*, and the scincid *Chalcides chalcides*) were studied at five burnt transects and eight unburnt control transects in urban green areas of Rome. Overall, the fire had different effects on the three species at the local level of the single transects. *Lacerta bilineata* was not affected by fire treatment. *Podarcis muralis* showed a significant increase in numbers in two of five burnt transects. *Chalcides chalcides* declined after fire in all transects. The potential ecological causes for the observed patterns are discussed.

Key words: fire ecology, habitat disturbance, Rome, central Italy

INTRODUCTION

Fire may strongly influence the structure of habitats and of plant and animal communities (Thirgood, 1981; Whelan, 1995). In several ecosystems, including the Mediterranean evergreen chaparral (= macchia), fire is a natural regulator of the phytocenosis structure, as it occurs regularly during the dry summer (e.g. Marchand, 1990; Pantis & Mardiris, 1992). However, the effects of fire on a particular ecosystem will depend on their frequency, intensity, and season (Gill, 1975; Lemckert *et al.*, 2003). The effects of fire on vertebrates (e.g. reptiles) can be direct, i.e. by immediate killing of animals (Heinrich & Kaufman, 1985; Wilson, 1994; Whelan, 1995; Duck *et al.*, 1997; Homer *et al.*, 1998; Esque *et al.*, 2002), or indirect, i.e. by their modifications to the vegetation structure (Wilson, 1994; Brooks & Esque, 2002), with eventual ecological consequences for the animals, i.e. on their thermal attributes, microclimate (Hurlbert, 1969; Rice & Parenti, 1978), exposure to predators, food resource availability (Evans, 1984; Kaufman *et al.*, 1990), and timing of reproduction (Lillywhite & North, 1974; Withgott, 1996; Duck *et al.*, 1997; Cavitt, 2000). Although the effects of local fires on herpetofauna have received some attention (e.g. Lemckert *et al.*, 2003; and for a review see Russell *et al.*, 1999), unfortunately the studies on the effects of local fires on the population ecologies of Mediterranean reptiles are extremely scarce. Indeed, it is even hard to find any data on the fluctuations in the apparent numbers of reptiles in areas subjected to burning (but see Pinto *et al.*, 2006).

In this paper, we present data on the effects of small-scale fires on three sympatric lizard species (the lacertids *Podarcis muralis* and *Lacerta bilineata,* and the scincid *Chalcides chalcides*) along some line transects affected by fire, situated in urban green areas in the city of Rome (Central Italy).

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MATERIALS AND METHODS

The data were collected by one of the authors (L. Rugiero) during surveys of the reptile communities of five nature reserves of Rome (Rugiero, 2004). Field surveys were carried out from March 2001 to May 2002. During the process of Rugiero's (2004) research, four out of five nature reserves were affected by small-scale fires. In two of these four areas ('Tenuta dei Massimi' and 'Insugherata' nature reserves; both with identical climate and vegetation characteristics), the fire only affected the transects which were already subjected to investigation. Hence, the data given in this paper were collected in the two above-mentioned nature reserves. The other two burnt nature reserves were not considered for this study because there were no transects which were directly affected by fire. All these fires, which affected an average area of about 3 to 5 ha surface in each study area, occurred during the summer months (August and September) of 2001.

Pooling the two nature reserves, five burnt line-transects (treatment in the following text; named A to E) were surveyed, both before and after fire, and eight unburnt transects at the same nature reserves were surveyed as controls (named (i) to (viii)). Both treatment and control transects were situated in the same nature reserves, i.e. they were under identical climatic characteristics. The minimum linear distance between transects ranged from 250 to 1600 m, and a habitat unsuitable for lizards was always present between two transects. Hence, all the transects were certainly independent of each other in terms of the lizard movements. All the treatment transects were affected by fire for their entire length, i.e. there was no portion of them which was not destroyed by fire. Three of the treatment transects (A, B, and D) were in the middle of the total burnt surface, whereas two transects (C and E) had one of the extremities which was near (< 15 m) the external limit of the burnt surface.

Each 300 m transect was surveyed once each research day (see Table 1 for exact dates of the field days at each transect) by walking very slowly in one direction, and recording all the reptile sightings. Counts of all individuals of each species seen were recorded but lizards were not individually marked. Therefore individual lizards were counted only once per day but some individuals may have been counted on different days. Field surveys of the study transects were carried out during the same weeks in both treatment and control transects (Table 1), hence the eventual differences could not be caused by temporal oscillations of lizard population numbers. Moreover, all the transects were surveyed during sunny days, i.e. under nearly identical weather conditions.

A methodological limitation of this research study was that, using only visual observations of individuals, there may be some uncontrolled sources of bias for the results, as, for example, reptiles in burned areas may be more easily detected than those from unburned sites. This might artificially inflate the numbers of observed specimens. Unfortunately, this limitation is widespread in studies estimating population 'abundance' by visual sightings, not only in herpetology (e.g. Schmidt, 2004) but also in mammalogy and ornithology (Lebreton *et al.*, 1982; Nichols & Pollock, 1983; Link & Nichols, 1994). However, the use of control transects and the high visibility of the study species led us to suppose that this potential problem had not seriously compromised the validity of our conclusions.

Treatment Transects

Transect (A) was laid along the edge of a *Quercus suber* woodland, and was characterised by ecotonal scrub vegetation (*Spartium junceum*, *Prunus spinosa*, *Rubus ulmifolius*) and grassy vegetation. During the post-fire research period, there was no re-growth of the scrub vegetation, whereas the grass was slowly re-growing. Transect (B) was laid along a thick wood (*Quercus suber*). Underbrush (*Hedera helix*, *R. ulmifolius*, *Pteridium aquilinum*, and *Ruscus aculeatus*) was dense. The fire caused a strong reduction of the underbrush cover, but trees survived. Re-growth of the underbrush was mainly due to *P. aquilinum.* Transect (C) was laid along the edge of a bushland (*S. junceum*), with a continuous and well developed grassy cover. Fire occurred at the end of August 2001 and destroyed completely the

TABLE 1. Distribution of the dates for the field days of survey of each transect (both treatment and control), both before and after fire. Asterisks indicate dates of survey; F indicates dates of fire. For the transect symbols, see the text.

	Transect												
	A	B	C	D	E	i	ii	iii	iv	v	vi	vii	viii
Year 2001 (before fire)													
10 March				*	*								
22 March	*	*						*	*				
24 March			*	*	*					*	*	*	*
03 April	*	*				*	*	*	*				
09 April			*	*	*					*	*	*	*
18 April	*	*				*	*	*	*				
26 April			*	*	*					*	*	*	*
28 April	*	*				*	*	*	*				
04 May	*	*				*	*	*	*				
10 May			*	*	*					*	*	*	*
15 May	*	*				*	*	*	*				
28 May			*	*	*					*	*	*	*
Aug-Sep	F	F	F	F	F								
Year 2002 (after fire)													
20 March	*	*				*	*	*	*				
22 March			*	*	*					*	*	*	*
06 April	*	*				*	*	*	*				
07 April			*	*	*					*	*		*
21 April						*	*	*	*				
22 April	*	*											
25 April			*	*	*					*	*	*	*
01 May	*	*				*	*	*	*				
06 May			*	*	*					*	*	*	*
15 May	*	*				*	*	*	*				
21 May			*	*	*					*	*	*	*

TABLE 2. Means (±SD), and *t*-tests of the numbers of lizards observed along line-transects in Rome, before and after fire.

Species	Transect	Mean (± SD) Before fire	Mean (± SD) After fire	Change in abundance	*t* (df) mean	*P*
Lacerta bilineata						
TREATMENT TRANSECTS	A	6.33±2.2	4.40±1.9	1.93	1.50 (9)	0.167
	B	1.67±1.4	1.00±1.0	0.67	0.90 (9)	0.389
	C	3.0±3.24	0.6±0.9	2.40	1.60 (8)	0.149
	D	1.33±1.03	1.20±1.3	0.13	0.19 (9)	0.853
	E	3.67±1.7	2.20±1.6	1.47	1.42 (9)	0.189
CONTROL TRANSECTS	i	5.80±3.4	5.20±3.4	0.60	0.28 (9)	0.788
	ii	3.80±1.9	3.40±1.8	0.40	0.34 (8)	0.744
	iii	1.33±0.5	1.40±1.7	-0.07	-0.09 (9)	0.928
	iv	0.83±1.2	1.40±1.5	-0.57	-0.70 (9)	0.501
	v	2.80±1.8	5.40±4.9	-2.60	-1.12 (8)	0.296
	vi	3.60±2.9	1.39±0.9	2.21	1.63 (8)	0.141
	vii	5.00±2.9	5.00±2.3	0.00	0 (7)	1.000
	viii					
Overall comparison before vs. after fire		3.20±2.0	1.88±1.5	1.32	1.17 (8)	0.274
Overall comparison control transects		3.39±1.7	3.24±1.8	0.15	0.17 (14)	0.868
Podarcis muralis						
TREATMENT TRANSECTS	A	0.67±5.4	6.40±0.5	-5.73	-2.61 (9)	0.028
	B	3.00±2.1	9.20±3.9	-6.20	-3.38 (9)	0.008
	C	0.40±0.6	0.80±1.8	-0.4	-0.48 (8)	0.645
	D	3.67±3.0	6.80±3.3	-3.13	-1.63 (9)	0.136
	E	0.67±0.8	0.20±0.4	0.47	1.14 (9)	0.285
CONTROL TRANSECTS	i	1.60±2.1	3.60±2.1	-2.00	-1.52 (8)	0.166
	ii	0.40±0.5	0.80±0.8	-0.40	-0.89 (8)	0.397
	iii	3.00±1.8	2.80±2.3	0.20	0.16 (9)	0.874
	iv	8.67±4.7	9.00±6.6	-0.33	-0.10 (9)	0.924
	v	2.80±2.4	1.75±1.2	1.05	0.79 (7)	0.456
	vi	0.83±0.9	0.20±0.4	0.63	1.32 (9)	0.219
	vii	6.60±3.2	5.50±2.6	1.10	0.55 (7)	0.599
	viii	4.00±3.7	2.80±2.2	1.20	0.62 (8)	0.552
Overall comparison before vs. after fire		1.68±1.5	4.68±4.0	-3.00	-1.57 (8)	0.154
Overall comparison control transects		3.48±2.9	3.30±2.8	0.18	0.13 (14)	0.901
Chalcides chalcides						
TREATMENT TRANSECTS	A	3.17±2.0	0.40±0.9	2.77	2.8 (9)	0.021
	B					
	C	7.00±3.7	3.40±3.4	3.60	1.58 (8)	0.151
	D					
	E	2.33±2.6	0.20±0.4	2.13	1.81 (9)	0.103
CONTROL TRANSECTS	i	0.40±0.5	0.20±0.4	0.20	0.63 (8)	0.545
	ii					
	iii	3.40±3.2	2.80±1.1	0.60	0.39 (8)	0.703
	iv					
	v					
	vi	1.67±1.4	1.20±0.4	0.47	0.73 (9)	0.486
	vii					
	viii					
Overall comparison before vs. after fire		4.17±2.5	1.33±1.8	2.84	1.60 (4)	0.184
Overall comparison control transects		1.82±1.5	1.40±1.3	0.42	0.37 (4)	0.732

vegetation. During the post-fire research period, there was partial re-growth of the grassy cover. Transect (D) was laid along the border between a mixed wood (*Castanea sativa* and *Quercus cerris*, with underbrush formed by *P. aquilinum* and *R. ulmifolius*) and cultivated land. Fire occurred at the beginning of September 2001, and destroyed both the wood underbrush and the cultivation, whereas the trees survived. Re-growth of the underbrush, due mainly to *P. aquilinum*, started only after the third of the five post-fire research dates (see Table 1). Transect (E) crossed a Mediterranean bushland, with open grassy habitat dominated by *Asphodelus spp*. and *P. aquilinum*, with some *Cistus salvifolius* and rare *S. junceum* specimens. Fire completely destroyed the vegetation. During the post-fire research period, the re-growth of *Asphodelus* spp. was rapid, whereas that of *P. aquilinum* and of grassy sites were delayed; there was no re-growth of *C. salvifolius* and *S. junceum.*

Control Transects

Transect (i) was laid along the border between a mixed woodland (dominant *Quercus cerris* and *Q. frainetto*, with also *Q. suber* and *Ulmus minor*) with ecotonal vegetation constituted by *R. ulmifolius*. Transect (ii) was laid along the border between a wide spiny bushland (*R. ulmifolius*) and a cultivated field. Transect (iii) was laid along the bank of a small stream, with some trees of *Populus nigra* and *Robinia pseudoacacia,* and bushy and grassy vegetation of *R. ulmifolius*, *Sambucus* spp. and *Urtica dioica*. Transect (iv) was laid along the wooded bank of a stream (trees were *Salix alba*, *R. pseudoacacia* and *P. nigra*), with a well developed cane-bed and with populations of *U. dioica*, *Conium maculatum* and *Silybum marianum*. Transect (v) was laid between the border of a mixed oak wood (*Q. pubescens*, *Q. suber*, *Q. ilex*, *Ulmus minor)* and a cultivated field; the ecotonal vegetation consisted mainly of *R. ulmifolius*, *U. dioica*, *Sambucus nigra, S. marianum* and *C. maculatum*. Transect (vi) was laid along a south-facing edge of a mixed oak wood (*Q. suber*, *Q. frainetto*, *U. minor*) with ecotonal scrub vegetation (*S. junceum, Prunus spinosa* and *Asphodelus microcarpus*). Transect (vii) was laid along the bank of a small and shady stream; the bank vegetation consisted of *Salix alba*, *S. nigra*, *U. dioica*, *R. ulmifolius*, *Equisetum telmateja, S. marianum*, and *C. maculatum*. Transect (viii) crossed a thick wood (*C. sativa, Q. robur, Carpinus betulus*, *Fraxinus ornus*), with relatively dense underbrush (*Ilex aquifolium*, *Ruscus aculeatus* and *Hedera helix)*.

Statistical tests were done with a Statistica (version 6.4) PC package, with all test being two-tailed. The design of this study (choosing independent systems, i.e. the various transects; collecting data on each of them and then assigning them to a treatment and a control because of random events – fire) is normally adequate for a deductive experiment and minimises potential biases due to data pseudoreplication (despite the fact that lizards were not individually marked; see Oksanen, 2001 for a discussion on this issue). Nonetheless, we also compared mean lizard abundance per day before the fire with mean abundance after the fire, using transects as replicates (and compared this with before- versus after-fire on unburnt controls). To be precise, for comparing burnt and control transects, we calculated the change in mean abundance before the fire to mean abundance after the fire for each transect; then we used 'change in abundance' as the dependent variable in the ANOVA model, and transects as replicates.

RESULTS

The data on the mean (±SD) numbers of lizards per day along the 300 m of transect, both before and after fire, for both treatment and controls, are given in Table 2. Post-fire means include counts on only burnt parts of the transect, because fire affected 100% of all the study transects (see methods). Although the numbers of lizards observed at each transect were often small, we were still able to identify some species-specific patterns.

The numbers of *Lacerta bilineata* tended to remain relatively stable after fire at all treatment transects, as well as in the control transects (means of the numbers of lizards observed per day were never statistically different before vs. after fire). Overall, the mean change in abundance of lizards was not significantly different before vs. after fire (ANOVA, $F_{1,10}$=3.218, P=0.103).

The numbers of *Podarcis muralis* were significantly higher after fire at transects (A) and (B), but not in the other three treatment transects and neither in any control transect. The mean change in abundance of lizards was significantly different before vs. after fire (ANOVA, $F_{1,11}$=7.652, P=0.018), with lizard numbers that increased after fire treatment.

The numbers of *Chalcides chalcides* were significantly lower after fire at transect (A), and were also lower (although not significantly) after fire in the other treatment transects, but not in the controls. The mean change in abundance of lizards was significantly different before vs. after fire (ANOVA, $F_{1,4}$=29.792, P=0.0054), with lizard numbers that decreased after fire treatment.

There was no effect of the year of study on the abundance of any of the three lizard species (all ANOVAs - for *L. bilineata*: $F_{1,23}$=2.68, P=0.115; for *P. muralis*: $F_{1,78}$=0.01, P=0.912; for *C. chalcides*: $F_{1,9}$=2.04, P=0.187).

DISCUSSION

Lacerta bilineata did not decrease noticeably after fire when compared to controls. We suppose that is related to two concurrent factors. First, this lacertid is extremely adaptable and occurs in a variety of habitats in Mediterranean Italy (Bruno & Maugeri, 1977; Corti & Lo Cascio, 2002; Rugiero, 2004). Second, it has a large home range (probably around 300 to 1200 m^2; for the case of the sister-species *Lacerta viridis* see Saint Girons & Bradshaw, 1989), and therefore may escape fire and recolonise the burnt habitat efficiently and in a short time-span.

Overall, *P. muralis* was in part positively affected by fire (in comparisons of treatment vs. control transects). Indeed, there was a significant rise in numbers after fire in transects (A) and (B), and also the mean change in abundance of lizards showed that the numbers of these lizards tended to increase significantly after fire. These positive effects on lizard numbers by fire were likely local trends related to the effects of fire on the site characteristics of the study transects. Indeed, these rises in lizard numbers were probably caused by the sudden opening of new clearings for thermoregulation in the closed wood, which is the typical habitat for *P. muralis* in the study area (Rugiero, 2004). Obviously, these data do not imply that *P. muralis* may benefit from large-scale fires. Our data just indicate that this species may resist small-scale fires better than the other two study species, and that it may derive some advantage from small scale fires, especially areas of closed vegetation.

Chalcides chalcides was negatively affected by fires in all treatment transects (however, the difference before and after-fire was statistically significant in just one transect), and the mean change in abundance of lizards showed an overall statistically significant decreasing trend after fire. As there was no evidence of decline after-fire in any control transect, we are led to believe that fire may really be detrimental to *C. chalcides,* at least when it entirely removes large portions of the grassy vegetation layer which is this species' typical habitat (Rugiero, 1997).

In conclusion, this study confirms previous research on other animals (e. g. Orgeas & Ponel, 2001) indicating that the species which are more versatile in terms of habitat requirements survived the devastations produced by fires better (*L. bilineata* and especially *P. muralis* in our study areas). However, it must be stressed that the situation may be different with large-scale fires.

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