NOTE BRÈVE

EFFECTS OF FIRE AND FOREST RESTORATION ON TWO SYMPATRIC SPECIES OF LACERTIDAE (REPTILIA) IN A MEDITERRANEAN ECOSYSTEM OF CENTRAL ITALY

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RÉSUMÉ. — *Effets des feux et de la restauration forestière sur deux espèces sympatriques de Lacertidés (Reptiles) dans un écosystème méditerranéen de l'Italie centrale.* — Les effets d'un incendie et de la restauration forestière qui a suivi ont été étudiés sur deux espèces de lézards du genre *Podarcis* dans une pinède côtière de l'Italie centrale. Trois stations très proches ont été échantillonnées : deux brûlées, dont une ayant ensuite fait l'objet de travaux de restauration, et une autre qui n'a pas été atteinte par le feu. Cinq sessions d'échantillonnage sur la démographie des lézards et leur choix du microhabitat ont été effectuées entre mars 2003 et mars 2004. *P. sicula*, espèce pionnière, a été récolté tant dans les stations brûlées que dans celles qui ne l'ont pas été, tandis que *P. muralis* n'a été trouvé que dans la forêt intacte. L'abondance de *P. sicula* est plus grande dans les zones brûlées. Dans des conditions naturelles, ces espèces sont différenciées par leur niche spatiale, puisqu'elles utilisent différents niveaux de la végétation, plus élevés pour *P. muralis*. L'absence de cette dernière espèce après l'incendie a facilité l'élargissement da le niche spatiale de *P. sicula*.

Fire is a common event in some ecosystems, such as the Mediterranean ones, and sometimes it constitutes an important ecological process to maintain typical vegetal communities (*e.g.*, Trabaud, 1981; Harper, 1978; Groves & Di Castri, 1991). In addition, fire is frequently and questionably used for ecosystem management, especially in Australia and in America (*e.g.*, Friend, 1993).

Fire creates a mosaic of habitats, which seem to maintain high species richness (Morris, 1975; Mushinsky, 1985; Pianka, 1994), but can also produce habitat fragmentation, which isolates populations previously connected. For some species, especially those with low vagility, living in isolated patches can cause a loss of genetic diversity, an increased inbreeding and a reduction of population size (Diaz *et al.*, 1998; Brisson *et al.*, 2003). These factors result in increased sensitivity to environmental fluctuations and disturbances, and extinction of populations (Debinsky & Holt, 2000).

Effects of fire on reptile populations depend on the intensity and the season of fire, as well as on species-specific habitat preferences (Fyfe, 1980; Mushinsky, 1992). Reptiles are considered to be resilient to the short-term effects of fire (Friend, 1993). Such resilience is probably an adaptation to arid conditions, as well as the use of burrows for shelter and

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ectothermy, which permits to remain inactive under the ground for months, until an appropriate vegetation structure has been re-established.

Effects of fire on lizards is still debated. Some studies suggest that lizard communities of fire-dependent ecosystems increase in species richness or density following fire, but decline in long-time unburnt sites (Lillywhite, 1977; Campbell & Christman, 1982; Mushinsky, 1985; Cunningham *et al*., 2002; Brisson *et al*., 2003). However, opposite results emerge from other studies (Barbault, 1974; Patterson, 1984; Caughley, 1985; Singh *et al*., 2002). Fire influences shelter, microclimate and food availability, having important specific implications in thermoregulation, locomotion and egg-laying (Lunney *et al*., 1991; Kutt, 1993; McLeod & Gates, 1998).

Considerable progress in knowledge of fire response has been made for plants, especially in the Mediterranean ecosystems (*e.g*., Noble & Slatyer, 1977; Cattelino *et al*., 1979; Keeley, 1986); scarce information on animals, especially reptiles, has been obtained in North America and Australia (*e.g*., Simovich, 1979; Fyfe, 1980; Mushinsky, 1985; Pianka, 1994). Regrettably, no research on fire effects on the herpetofauna in the Mediterranean Region, and especially in Italy, has been published, except a recent contribution (Rugiero & Luiselli, 2006).

On the 4th of July 2000 a devastating fire was provoked in the pinewood of Castelfusano Park (State Natural Reserve of "Litorale Romano") near Rome, burning about 300 hectares of the forest. For legal reasons, the area was out of bounds for a brief period, and afterwards opened to researchers for a vast project of biodiversity monitoring aimed at examining fire effects on different animal communities in burnt and unburnt habitats (Bologna, 2002). The post-fire management, started on November 2000, consisted in salvage-logging of burnt trees, and afterwards in reforestation by planting young pines, holm and cork oaks and other Mediterranean species.

The present research focused on two Lacertidae lizards, *Podarcis sicula campestris* (De Betta, 1857) and *P. muralis nigriventris* Bonaparte, 1836, both protected by the Berne Convention. The first subspecies is a thermophilic element, endemic to Central and Northern Italy and Corsica, usually associated with open areas; the second subspecies is a sciaphilous element, endemic to the coastal area of Latium, usually associated with woods or rocky habitat. A herpetological survey in the Castelfusano Park was in progress before the fire and continued immediately after this event. Before the fire, the presence of three species of lacertid lizards [both *Podarcis* species and *Lacerta bilineata* (Daudin, 1802)] was recorded in the pinewood, and during the first months after the blaze some probably survivors of *P. muralis* were sighted.

The aim of this study is to outline the effects of a big fire and of the post-fire management on the population density and the space use of these two lizards.

MATERIALS AND METHODS

Study area

The research was carried out in the "Pineta di Castelfusano" Urban Park (a part of the "Litorale Romano" State Nature Reserve), situated in the middle-southern coastal area of Latium (Italy), close to Ostia, about 25 km SW of Rome, at about 5-10 m of elevation. This Tyrrhenian area has a typical Mediterranean climate, belonging to the xerothermic bioclimatic region (thermo-Mediterranean/ meso-Mediterranean subregion) (Blasi, 1994). The mean rainfall is 20 mm during the summer season, but more abundant (100 mm) during the fall-winter season. From a pedological point of view, two main soil types can be recognized. The first type is represented by the ancient dunes, presently covered by a pine-forest (*Pinus pinea*), planted in the last two centuries, and by *Quercus ilex* woods and Mediterranean maquis. The second type occurs on the ancient dune slacks, and it is represented by fragments of the wetland vegetation (characterized by a *Populus alba* and *Quercus robur* association), which covered a vast area before the extensive water drainage occurring in the last centuries (see Gisotti, 1985).

The research was carried out in three 1-ha mature pinewood sites, two burnt by a "canopy fire", but with different post-fire treatments (A, B), and one unburnt (C). Site A is located at 164-322 m from adjacent unburnt pinewood areas; it was logged after the fire, and few burnt trunks and stumps were still maintained on the ground which is covered by grass and widely separated bushes. Site B is close to A and located at 0-158 m from the adjacent unburnt pinewood areas; no post-fire treatments were performed in this site, to utilize it as a witness research area, and consequently it is characterized by the presence of several burnt trees and fresh growth Mediterranean maquis, which form a thick vegetation. Site C was used as a control area representing the pre-fire situation.

Sampling techniques and statistical analyses

Observations and captures were made in five sampling sessions of six days each over the course of one year, from March 2003 to March 2004. Each session took place in an area of 20 m × 20 m inside the three sites (A, B, C), daily sampling sessions lasting two hours per site. Samplings were always done during the morning, recording the starting and ending hours, alternating the sequence of the sites. Weather conditions were also noted.

Lizards were observed, captured by a noose, sexed and marked by painting dots on the back with non-toxic paint in order to allow individual recognition. For every specimen the following measurements were recorded using a calliper with a resolution of 0.01 mm: snout-vent length (SVL), hind leg length (HLL), fore leg length (FLL), head width (HW) and head length (HL). Each individual was released on the capture spot.

Some environmental parameters were recorded at the first sight point (FSP) of each individual: substrate slope, height from the ground, distance from the nearest bush. In case of recapture during the same session, only FSP parameters were recorded.

The sighting frequency of lizards in the three sites was calculated as the ratio of the number of sighted lizards to the searching effort (hours of search × number of searchers; see Lambert, 1981; Kabigumila, 2001). The obtained sighting frequency in the 20 × 20 m sampling areas was extrapolated to one hectare in order to estimate the population density.

The population densities obtained in each session from the different group of individuals were compared by the Mann-Whitney U test. To compare statistically biometrical data, we used the analysis of variance (ANOVA). Capture site features were compared by means of Mann-Whitney U test.

RESULTS

Population density

We found *P. sicula* in all the three sampled sites, but *P. muralis* only in the unburnt pinewood. We observed more *P. sicula* individuals in burnt areas than in the unburnt one. The abundances of this lizard in A and in B were greater than in C (Site $B_{P.s.}$ mean = 24.17 ind./(man-hour) ha, st.dev. = 9.24; site $A_{P.s.}$ mean = 25.21 ind./(man-hour) ha, st.dev. = 9.44; site $C_{P.s.}$ mean = 11.46 ind./(man-hour) ha, st.dev. = 2.32) ($A_{P.s.}$ *vs* $C_{P.s.}$: U = 0.00, p = 0.014; $B_{P.s.}$ *vs* $C_{P.s.}$: U = 0.00, p = 0.014; Mann-Whitney U test). On the other hand, the abundances of *P. sicula* in the two burnt areas were not statistically different (U = 11.5, p > 0.05, Mann-Whitney U test). The same result occurred in the comparison between the syntopic populations of *P. sicula* and *P. muralis* (Site $C_{P.m.}$ mean = 11.81 ind./(man-hour) ha, st.dev. = 1.70) in site C ($C_{P.s.}$ *vs* $C_{P.m.}$: U = 5.5, p > 0.05, Mann-Whitney U test).

The abundance of $A_{P.s.}$ and $B_{P.s.}$ groups of individuals fluctuated during the sampling year, but decreased from the beginning (respectively 35.41 ind./(man-hour) ha and 26.04 ind./(man-hour) ha) to the end of the samplings (respectively 20.83 ind./(man-hour) ha and 18.75 ind./(man-hour) ha) (Fig. 1).

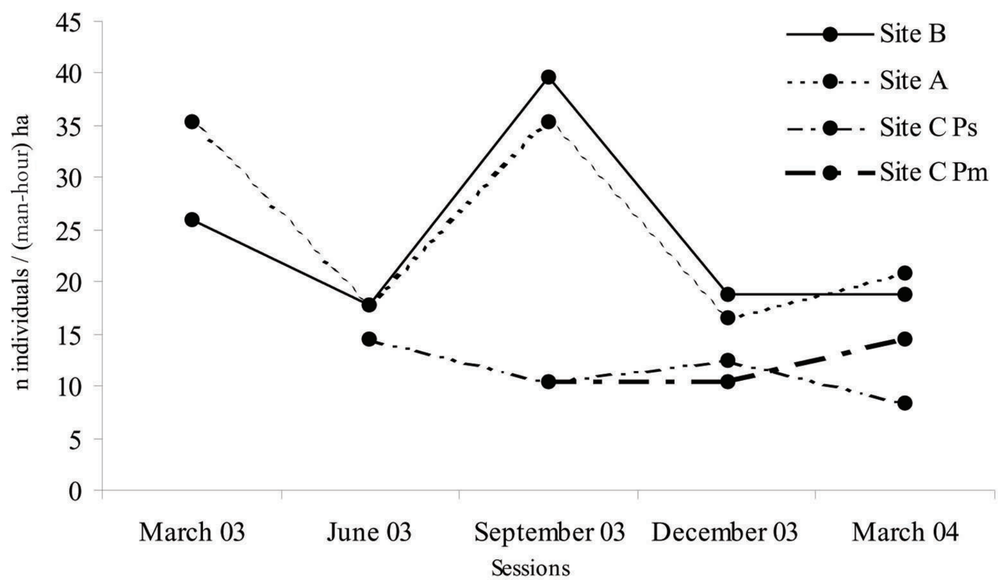

Figure 1. — Trend of abundance of *P. sicula* and *P. muralis* during the sampling year.

TABLE I

ANOVA of biometrical parameters of P. sicula

Variables	F	p
HL_FEMALE	0.110	0.896
HL_MALE	0.046	0.955
HW_FEMALE	0.595	0.555
HW_MALE	0.084	0.920
SVL_FEMALE	0.584	0.561
SVL_MALE	0.035	0.966
AL_FEMALE	0.155	0.857
AL_MALE	0.118	0.889
PL_FEMALE	3.113	0.052
PL_MALE	0.090	0.914

As concerns biometrical parameters, the three groups of individuals of *P. sicula* did not present significant differences (Tab. I).

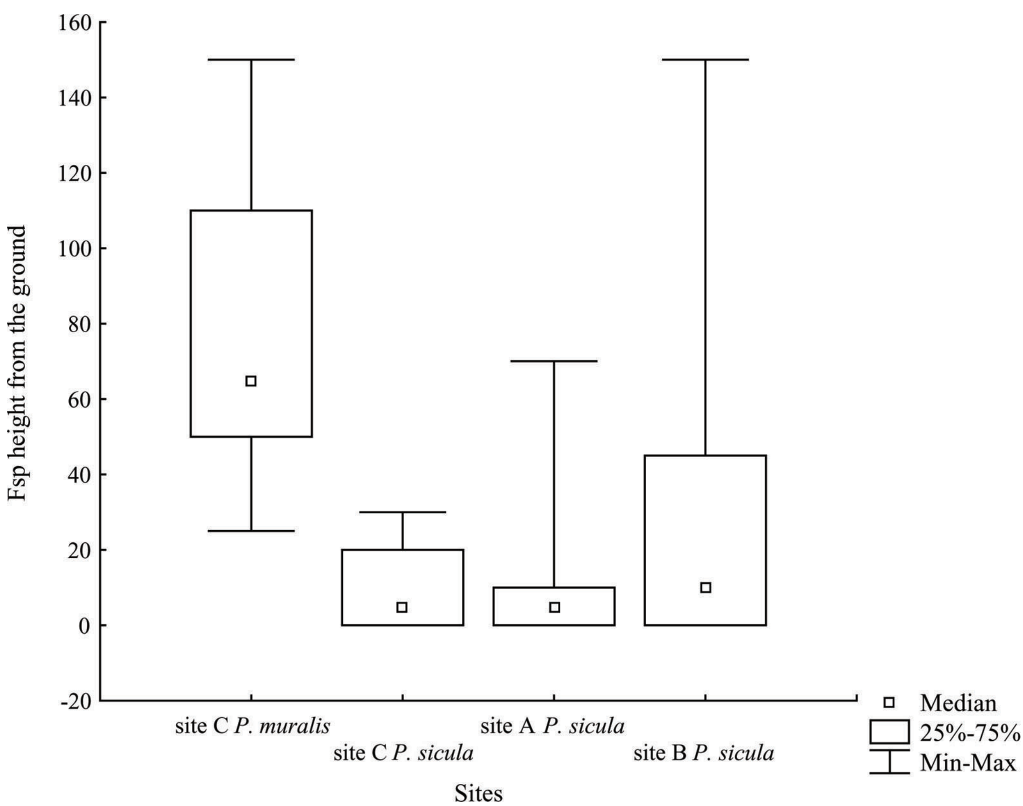

Figure 2. — Niche separation (FSP height from the ground) between *P. sicula* and *P. muralis* in the sampling sites.

Microhabitat choice

Among the four groups of individuals, significant differences were not evidenced as concerns the FSP slope ($A_{P.s.}$ *vs* $B_{P.s.}$: U = 2697, p > 0.05; $A_{P.s.}$ *vs* $C_{P.s.}$: U = 754.5, p > 0.05; $B_{P.s.}$ *vs* $C_{P.s.}$: U = 707.5, P > 0.05; $C_{P.s.}$ *vs* $C_{P.m.}$: U = 59, p > 0.05; Mann-Whitney U test), the two syntopic populations of site C showed a significant difference in the distance from the nearest bush ($A_{P.s.}$ *vs* $B_{P.s.}$: U = 2 297, p > 0.05; $A_{P.s.}$ *vs* $C_{P.s.}$: U = 541, p > 0.05; $B_{P.s.}$ *vs* $C_{P.s.}$: U = 537.5, P > 0.05; $C_{P.s.}$ *vs* $C_{P.m.}$: U = 35.5, p = 0.02, Mann-Whitney U test).

The height from the ground of *P. sicula* FSP in site B is significantly greater than in A (U = 2 007, p = 0.003; Mann-Whitney U test) and in C (U = 489.5, p = 0.049; Mann-Whitney U test), while non significant differences were evidenced between A and C (U = 715.5, p > 0.05; Mann-Whitney U test) (Fig. 2). The individuals of all the tree groups of *P. sicula* frequented lower substrates than *P. muralis* in the unburnt site ($A_{P.s.}$ *vs* $C_{P.m.}$: U = 11.5, p = 0.00; $B_{P.s}$ *vs* $C_{P.m.}$: U = 91.5, p = 0.00; $C_{P.s.}$ *vs* $C_{P.m.}$: U = 1.5, p = 0.00; Mann-Whitney U test) (Fig. 2).

DISCUSSION

Structural habitat preferences may influence the post-fire responses of lizard assemblages (Mushinsky, 1985; Pianka, 1992). The most evident effect of fire and post-fire habitat simplification on the lizards guild of Castelfusano, is the local extinction of *Podarcis muralis* and *Lacerta bilineata*. We observed just after the fire a demographic increase of *P. sicula* which rapidly re-occupied the burnt areas, appearing as a pioneer species. After this numeric increment, probably related to the presence of open areas and to the lack of competitors, the number of individuals of *P. sicula* progressively decreased, following the process of the vegetal succession and the growth of maquis. Burnt areas resulted as an unsuitable habitat for *P. muralis*, which prefers ecosystems with bushy or arboreal vegetation or other vertical surfaces. The subsequent reduction and stabilization of *P. sicula* abundance in the two burnt sites could be explained by males establishing new territories after the first period of invasion and explosion of the local population.

Lizards divide up environmental resources in three major ways: by being active at different times, by spending time in different places, and by eating different foods. Such ecological differences reduce competition, hence facilitating coexistence (Pianka, 1994). In accordance with this hypothesis, we found that the two species differentiate their use of substrates in syntopic condition as in other examined Italian areas: *P. sicula* on the ground and *P. muralis* in higher vegetation layers (Bombi & Bologna, unpublished). *P. sicula* enlarges its spatial niche, climbing on vegetation or other substrates, when *P. muralis* is missing, as in the present case. This result shows how niche separation in a lizard guild can change depending on vegetation structure and on the presence of competitors, even if determined by fire events.

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