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The helminth community of the common shrew in a post-fire regenerated Mediterranean ecosystem

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Summary

As part of a multidisciplinary project concerning the dynamics of post-fire recolonization by small mammals and the study of their helminth parasites as biological tags in the process of post-fire regeneration in Mediterranean ecosystems, the helminth community of the common shrew in the Spanish Natural Park of the Serra Calderona has been analysed.
The results show a helminth community consisting of 15 helminth species, characterised by moderate diversity, with a predominance of indirect biological cycle helminth species. The helminth infracommunity determined by its origin of capture, burned or non-burned (control) areas, shows only insignificant differences. It is suggested that the common shrew helminth community may not be an adequate biological tag of the post-fire regeneration in Mediterranean ecosystems.

Key words: *Crocidura russula*; helminth community; post-fire; Mediterranean ecosystem; Serra Calderona; Spain

Introduction

Numerous parasitological studies have demonstrated the capacity of helminths to provide information on the biology, ecology, zoogeography, systematics, evolution and phylogeny of their hosts, and even on their diet, trophic relationships, ethology or survival. In this context, Galán-Puchades *et al.* (1999) proposed a methodology for the use of helminth parasites as biological tags in the study of post-fire ecosystem regeneration processes.
The patterns of relationships between small mammals and helminths in Mediterranean ecosystems affected by fire have been examined, particularly the helminths of insectivores and rodents appearing in Mediterranean post-fire successions. The parasitological data confirm those obtained in studies of the repopulation dynamics of the hosts in zones affected by fire, this, in turn, depends upon vegetation speed (Fons *et al.*, 1988, 1993; Feliu *et al.*, 1993; Fuentes *et al.*, 1998; Galán-Puchades *et al.*, 1998). These studies have also recognised the wood mouse, *Apodemus sylvaticus*, as the pioneer small mammal in the process of recolonization after fire. However, Fuentes *et al.* (1998) proposed that the common shrew, *Crocidura russula*, may also serve as a quality marker of the regeneration of the Mediterranean ecosystems affected by a wildfire.
Thus, and following the methodology proposed by Galán-Puchades *et al.* (1999), the present study analyses the helminth community of the common shrew in the Spanish Natural Park of the Serra Calderona – a Mediterranean ecosystem in regeneration 11 years after a wildfire – with the aim of gaining insight into the possible use of their helminths as biological tags in this post-fire regeneration process.

Material and Methods

The study area is a Spanish Mediterranean ecosystem located in the Serra Calderona Natural Park (39º35'-39º51'N, 0º15'-0º43'W), a mountain-range situated in Comunitat Valenciana, with a surface of 52 000 ha, which suffered a large wildfire at the end of the summer of 1992 affecting a total of 9 500 ha including forests and cultivated land which had been left abandoned.
A multidisciplinary project concerning the dynamic post-fire recolonization by small mammals and the study of their helminth parasites as biological tags in the process of post-fire regeneration was initiated in February 1994, the winter of the 2nd year after fire. The present article includes the study of 69 individual common shrews, *Crocidura russula*, captured prior to February 2003, the spring of the 11th year after fire. Thirty-two individual hosts originate from the burned area and 37 from the control area.
The host material was obtained in trapping sessions using the capture-recapture method, seasonal/annual collection of data according to the methodology described by Galán-Puchades *et al.* (1999) and Fuentes *et al.* (2000).

For the extraction of helminths and after collecting the data on each individual host, routine procedures were used in the dissection and study of all organs. The helminths detected were studied standard usual helminthological techniques (Fuentes *et al*., 2000).
The study of the helminth community compositions and structures, for both burned and unburned areas, was carried out considering each particular biological cycle and calculating the prevalence, mean abundance, median intensity and range (Bush *et al*., 1997).
The analysis of the helminth community components was carried out calculating the abundance index (Bush, 1973; Pence & Eason, 1980) and the frequency distribution of hel-minths. This distribution was calculated by means of the Lefkovitch index (L), by which L = (1/45) $tang^{-1}$ (variance/ mean) –1 ranging from –1 (positive binomial or uniform distribution), 0 (Poisson or random distribution) and +1 (negative binomial or aggregated distribution). The hel-minth infracommunity structure study was carried out ana-lysing the number of helminths, number of helminth spe-cies, the Brillouin index (Pielou, 1975; Magurran, 1988), Brillouin index for infected hosts only and percentage of hosts infected.
Where possible, standard non-parametric tests were applied, and statistical significance was established at $P < 0.05$.

Results

Serra Calderona

Sixty-five of a total of 69 (94.2 %) individual hosts analysed were parasitised with 15 species (Table 1).
Twelve of the helminth species found have indirect life cycles while only 3 have direct cycles. 42.0 % of the individuals analysed were infected with a direct-cycle helminths and 92.8 % were infected with indirect-cycle helminths. This difference was statistically significant ($P < 0.0001$).
The tapeworm *Pseudhymenolepis redonica* was not included in any of the analyses due to its hyperapolitic behaviour (Joyeux & Baer, 1936) and the resulting difficulty in finding its scolex and determining the total number of individuals in each infrapopulation.

Burned area

Thirty of a total of 32 individual hosts analysed (93.8 %) were parasitised with 12 species: 1 trematode (3.1 %), 5 cestodes (90.6 %) and 6 nematodes (78.1 %) (Table 1).
The most prevalent helminth was *Aonchotheca europaea* (71.9%), while *Staphylocystis biliarius* was the most abundant and presented the highest median intensity. The highest values of the component species (prevalence > 10 %) infrapopulations correspond with the cestode adult stages whose median intensity values are the greatest. *Staphylocystis pistillum* is worth mentioning since it presents infrapopulations up to 403 individuals.
The analysis of the abundance index values (Table 2) makes it possible to establish the following helminth community structure: *S. biliarius*, *S. pistillum*, *Staphylocystis tiara*, *A. europaea* and *Paracrenosoma combesi* as dominant species; *Liniscus incrassatus*, *Parastrongyloides winchesi* and Digenea gen. sp. as co-dominant species; *Pseudophysaloptera* sp. as successful immigrant species; and Acuariinae gen. sp. larvae and *Mesocestoides* sp. larvae as unsuccessful immigrant species. *P. redonica* must be considered a co-dominant species.
The analysis of frequency distributions for the various helminth populations (Table 2) shows that all dominant and

Table 1.- Selected characteristics of the helminth fauna of all shrews in post-fire and control areas

Helminth species			Prevalence 95 % CI		Mean abundance ± SE		Median intensity range	
	Site	LC	PF	C	PF	C	PF	C
Brachylaima simoni	S	I	-	5 (1-19)	-	0.1 (0.08)	-	2 (2)
Digenea gen. sp.	I	I	3 (0-16)	3 (0-15)	0.2 (0.2)	0.03 (0.03)	5 (5)	1 (1)
Mesocestoides sp. larvae	BC	I	3 (0-16)	5 (1-19)	1.9 (1.9)	6.9 (6.8)	61 (61)	128 (2-253)
Staphylocystis pistillum	I	I	28 (15-48)	11 (4-27)	19.7 (13.2)	2.6 (2.0)	12 (1-403)	9 (5-73)
S. biliarius	I	I	28 (15-48)	32 (21-53)	21.2 (11.1)	36.3 (16.9)	23 (1-261)	43 (1-468)
S. tiara	I	I	44 (29-65)	41 (29-63)	11.2 (8.3)	4.1 (2.1)	6 (1-266)	4 (1-72)
Pseudhymenolepis redonica	I	I	56 (39-73)	35 (24-57)	-	-	-	-
Hymenolepididae gen. sp.	I	I	19 (8-38)	3 (0-15)	0.4 (0.2)	0.03 (0.03)	2 (1)	1 (1)
Liniscus incrassatus	B	D	44 (29-65)	30 (19-51)	0.9 (0.2)	0.5 (0.2)	2 (1-5)	1 (1-5)
Aonchotheca europaea	I	I	72 (56-88)	78 (65-92)	6.9 (1.6)	5.9 (2.1)	7 (1-30)	3 (1-65)
Capillarinae gen. sp.	O	D	-	3 (0-15)	-	0.05 (0.05)	-	2 (2)
Parastrongyloides winchesi	I	D	3 (0-16)	5 (1-19)	0.2 (0.2)	0.4 (0.3)	5 (5)	7 (5-8)
Paracrenosoma combesi	L	I	16 (6-34)	5 (1-19)	1.4 (0.9)	0.1 (0.1)	3 (1-26)	3 (2-3)
Longistriata sp.	I	D	-	3 (0-15)	-	0.03 (0.03)	-	1 (1)
Pseudophysaloptera sp.	I	I	3 (0-16)	3 (0-15)	0.03 (0.03)	0.1 (0.1)	1 (1)	3 (3)
Acuariinae gen. sp. larvae	I/BC	I	9 (2-26)	24 (14-44)	0.7 (0.5)	1.8 (1.1)	3 (1-17)	2 (1-39)

CI – confidence interval; ± SE – standard error; LC – life cycle; S – stomach; I – intestine; BC – body cavity; B – bladder; O – oesophagus; L – lungs

Table 2. Abundance index and Lefkovitch index of all shrews in post-fire and control areas

Helminth species	AI		L	
	PF	C	PF	C
Brachylaima simoni	-	0.11	-	0.40
Digenea gen. sp.	0.16	0.03	0.75	0.00
Mesocestoides sp. larvae	0	0	0.98	1.00
Staphylocystis pistillum	19.72	6.89	0.99	0.98
S. biliarius	21.22	36.27	0.99	1.00
S. tiara	11.22	4.38	0.99	0.97
Hymenolepididae gen. sp.	0.38	0.03	0.42	0.00
Liniscus incrassatus	0.94	0.51	0.41	0.41
Aonchotheca europaea	6.91	5.92	0.89	0.96
Capillariinae gen. sp.	-	0.05	-	0.41
Parastrongyloides winchesi	0.16	0.35	0.75	0.81
Paracrenosoma combesi	1.41	0.14	0.93	0.52
Longistriata sp.	-	0.03	-	0.00
Pseudophysaloptera sp.	0.03	0.08	0.00	0.59
Acuariinae gen. sp. larvae	0	0	0.91	0.95

AI – abundance index; L – Lefkovitch index; PF – post-fire; C – control

co-dominant species had a negative binomial distribution.
Table 3 shows the diversity of the infracommunities determined by the Brillouin value index taking into account the total of each infracommunity as well as that of the infested hosts only.

Control area

Thirty-five of a total of 37 individual hosts analysed (94.6 %) were parasitised with 15 species: 2 trematodes (8.1 %), 5 cestodes (78.4 %) and 8 nematodes (86.5 %) (Table 1).
In this unburned area the species most prevalent, abundant and with the highest median intensity were the same as in the burned area. However, *S. biliarius* had the highest infrapopulation with up to 468 individuals in a single shrew.
The analysis of the abundance index values (Table 2) makes it possible to establish a very similar helminth community structure as found in the burned area, while merely *P. combesi* seemingly a co-dominant species, stands out.

Table 3. Diversity characteristics of the infracommunities of helminths of *Crocidura russula* of Serra Calderona determined by areas of origin

Characteristics		PF	C
No. of helminths	X	65.3	59.5
	SE	17.8	22.0
No. of helminth species		12	15
	X	3.3	2.9
	SE	0.3	0.2
Brillouin index	X	0.44	0.45
	SE	0.06	0.06
B.I. infected *C. russula* only	X	0.47	0.47
	SE	0.06	0.06
% of *C. russula* infected		93.8	94.6

PF – post-fire area; C – control area

The analysis of frequency distributions for the various helminth populations (Table 2) also shows similar results as in the burned area.
The study of the diversity of the infracommunities determined by the Brillouin value index (Table 3) reveals a similar diversity in the burned as well as in the control areas.

Discussion

Of the 15 species detected in *C. russula* in Serra Calderona Natural Park only the metacestodes of the tapeworm *Mesocestoides* sp. are a new finding for this host in this park. The other 14 helminth species were previously reported in the common shrew by Fuentes *et al.* (2000).
As reported by Fuentes *et al.* (1998), the greater parasitism by helminths of an indirect cycle can be contributed to the diet of this insectivore which consists primarily of arthropods, snails and other invertebrates, typical intermediate hosts of heteroxenous helminth species present in its helminth community.
If we compare the burned and control area from a qualitative point of view, the only difference between these infracommunities is the absence of 3 helminth species in the burned area: *Brachylaima simoni*, Capillariinae gen. sp. and *Longistriata* sp. This absence is probably of little significance as these 3 species parasitised only 1 or 2 individual hosts in the control area.
In both infracommunities the more prevalent as well as the more abundant helminth species remain *A. europaea* and *S. biliarius*, respectively, and, although the values are always greater in the control-area infracommunities, the differences are statistically insignificant.
All component species, apart from *L. incrassatus*, present a clearly negative binomial distribution in both study areas. This highly aggregated distribution concentrates the effect of density-dependent limitation on parasitism leading to a potential stabilizing influence (Shaw & Dobson, 1995), i.e. the helminth community has a low destabilising capacity on the common shrew population.
Fuentes *et al.* (1998) proposed the study of the common shrew population dynamics as a biological tag of the quality of ecosystem-post-fire regeneration. However, the small size of the common shrew populations, the difficulties in obtaining suitable host material and the minor differences – both qualitative and quantitative – within the burned and the control areas 11 years after fire allow us to draw the unexpected conclusion that the helminths of the common shrew may not be an adequate biological tag of the post-fire regeneration in Mediterranean ecosystems.

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