INTEGRATIVE ACAROLOGY

Proceedings of the sixth Congress of the European Association of Acarologists

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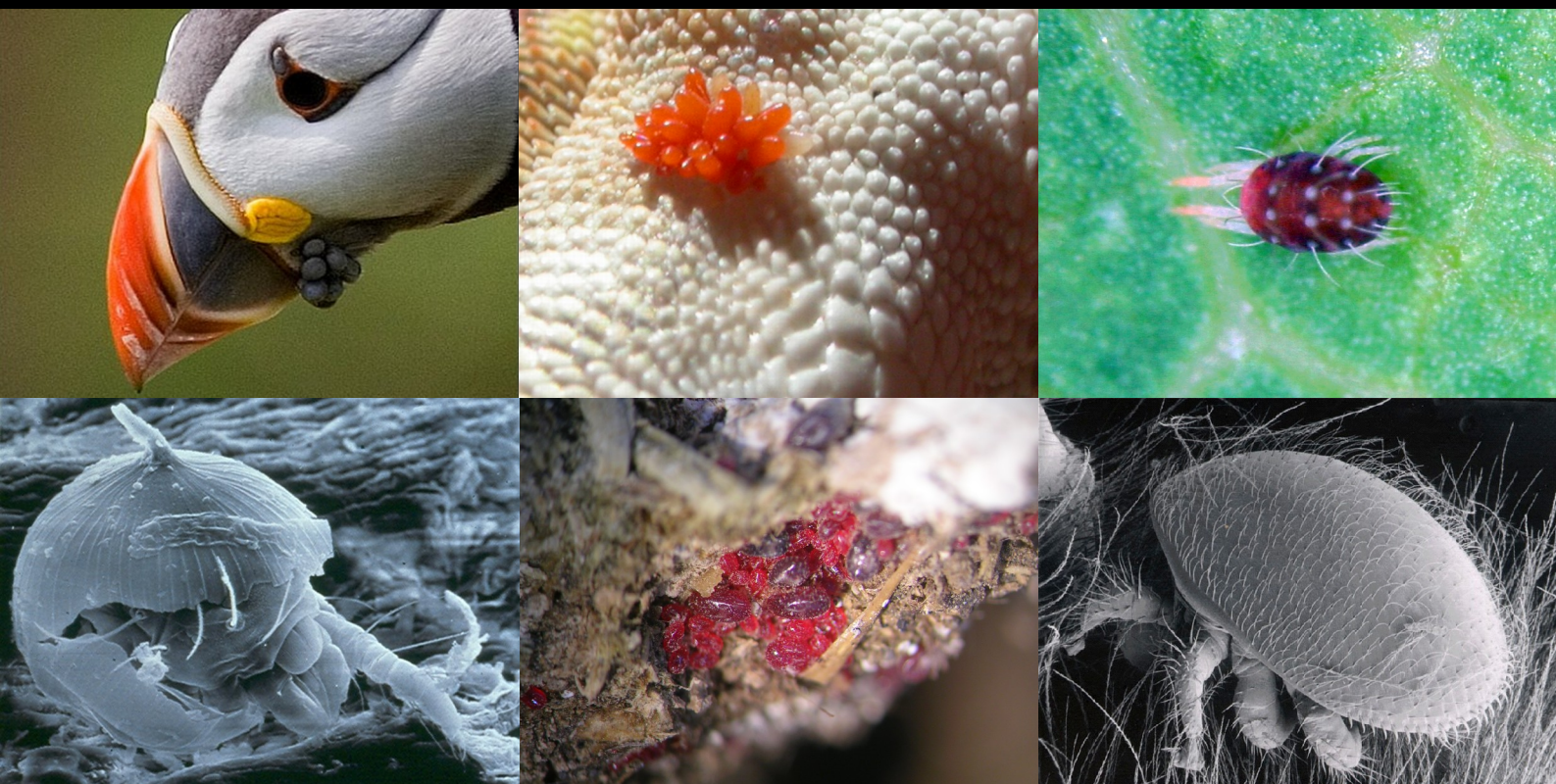

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Integrative Acarology. Proceedings of the 6th European Congress
M. Bertrand, S. Kreiter, K.D. McCoy, A. Migeon, M. Navajas, M.-S. Tixier, L. Vial (Eds.)
European Association of Acarolgists, 2008

THE EFFECT OF FIRE DISTURBANCE ON ORIBATID MITE COMMUNITIES

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Abstract

The effect of fire disturbance on the composition of oribatid mite communities was studied in riv. Vere canyon (Tbilisi, Georgia). Oribatid mites in a severely burnt shrub area and a less severely burnt artificial pine forest were investigated. Two unburnt sites were used as controls. 105 species were registered. *Graptoppia paraanalis* was new for Caucasian fauna. Analyses showed an increase of species dominance corresponding to an increase in mite density and the recovery of plant cover. The recovery of oribatid mite fauna was slower in the severely burnt shrub-strand than in the less severely burnt pine forest. Our research suggest that season, fire intensity, post- fire age and soil characteristics (pH, humidity, humus) all likely influence the composition of oribatid mite communities, supporting their use as indicators of environmental quality.

Key-words

Oribatid mites, fire, Simpson's index of diversity, Tbilisi.

Introduction

Fire has affected terrestrial ecosystems since ancient times. Thus, it is considered as a significant ecological factor and ecosystems have become adapted to frequent fires. Fire is considered as an important limiting factor as well, but unlike other limiting factors, humans can control its intensity. Two major types of fire disturbance are known: the first type of fire completely destroys the plant cover, whereas the second is more selective and supports the development of fire stable vegetation (Odum, 1971).

In natural ecosystems, fire influence may be considered as a positive factor and it is frequently followed by pyrogenic succession. In urban conditions, where the creation and maintenance of forest patches is associated with significant expenses, the destruction of these forests by accidentally or carelessly induced fires is great loss for society.

In the end of August 2006, in the riv. Vere canyon, an accidental, human-caused fire destroyed part of an artificial pine forest and a shrub- area. The fire resulted in the destruction of the soil litter and organic layer. According to the literature data, fire induces changes in the abundance and composition of soil microarthropod communities (Radea C., Arianoutsou M., 2000, Henig-Sever N. et al., 2001, Migliori M. et al., 2004, Dress W. J., Boerner R. E. J., 2004). The main goal of our investigation was to study the response of oribatid mites to fire disturbance at different time of burning and at different seasons.

Material and Methods

Research was carried out in the riv. Vere canyon (Tblisi, Georgia). Oribatid mites in a severely burnt shrub area and a less severely burnt artificial pine forest were investigated. Two unburnt sites were used as control. The first sampling was performed 10 days after the fire in 08.09.2006. Variations in oribatid mite communities were then monitored in soil samples collected from under the burnt vegetation every month during one year. At each site, three soil samples of 10 cm^3 were taken with a distance of 10-15m between samples. The mites were extracted by use of modified Berlese funnels and preserved in 70% ethanol for further studies. After clearing, the specimens were studied in lactic acid in an open hollow-ground microscope slide. For identification the keys of Weigmann (2006) and Ghilarov, Krivolutsky (1975) were primarily used, as well as typed specimens preserved in collections of Institute of Zoology. The densities of oribatid mites and the dominance index for each species were determined. Simpson's index of diversity (1-D) was calculated. The value of this index ranges between 0 and almost 1; the greater the value, the greater the sample diversity. The index represents the probability that two individuals randomly selected from a sample will belong to different species (Simpson, 1949). The average annual density, index of diversity and number of species were calculated for each sampling site.
In burnt and control sites, soil pH and humidity were measured and the percent of humus in soil was determined at the Laboratory of Analytical Chemistry of the A. Tvalchrelidze Institute of Mineral Raw Materials.

Ecological characteristics of the sites were as follows:

P1 – Control: unburnt pine forest. *Pinus eldarica*, understorey represented by *Cerasus incana, Paliurus spina-christi, Lonicera sp., Cotoneaster sp., Quercus iberica, Rhamnus pallasii, Prunus spinosa, Carpinus orientalis, Jasminum.* N 4174742; E 4468042; Elevation – 695m.s.l.

P2 – Burnt pine forest. Fire completely destroyed the understorey, but the pine trees remained in tact.. N 4171742; E 4468042; Elevation – 695m.s.l.

Sh1 – Control: unburnt shrub area. *Paliurus spina-christi, Cerasus incana, Cotoneaster sp., Festuca pratensis, Andropogon ischaemum, Asparagus, Papaver sp.* N 4171626; E 4468707; Elevation – 640m.s.l.

Sh2 – Burnt shrub area. Fire destroyed all vegetation. N 4171429; E 4468321; Elevation – 638m.s.l.

Results

During one year of study 105 species of oribatid mites were identified. Three species – *Licnodamaeus costula, Epimerella smirnovi* and *Simkinia tianschanica* were new to Georgian fauna and *Graptoppia paraanalis* was new to Caucasian fauna.

Widely distributed oribatid mites characterized all studied sites. Eurytopic species, such as *Oppiella fallax, Ramusella clavipectinata, Ceratoppia quadridentata, Tectocepheus sarekensis, T. velatus* and *Punctoribates punctum* predominated throughout the entire year. These species increased in dominance with the recovery of plant cover in burnt sites. *Spherochthonius splendidus* showed strict seasonal dependence and appeared only in fall and spring months (Sept-Nov; Mar-June), whereas in summer and winter it was totally absent (Jan-Mar; July) or presented in very low quantities (Dec, Aug) (tab. 1). Xerophilous species *Passalozetes africanus, Epilohmannia cylindrica, Thrypochthnius tectorum, Licnodamaeus costula and Scutovertex sculptus* were constantly found during the whole year, but at a lower abundance. The whole faunal composition seems very similar to Mediterranean maquis oribatid mite fauna, which is adapted to frequent fire disturbance (Migliori et al., 2004).

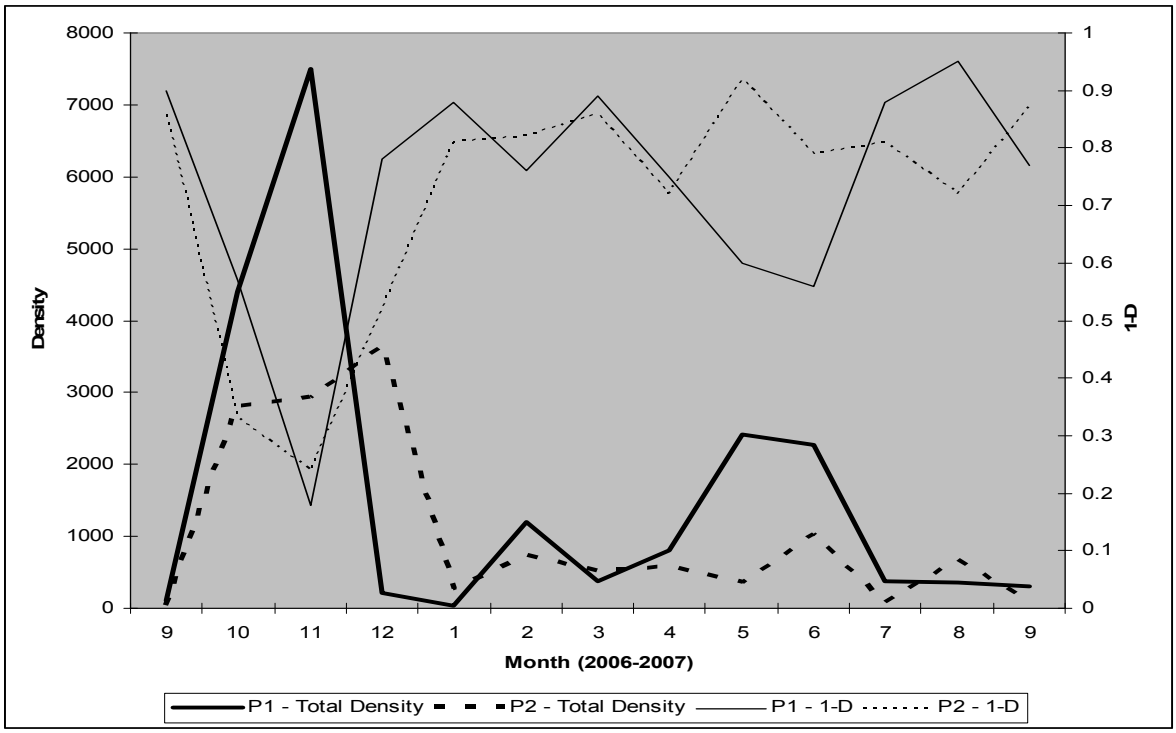
Changes in the densities of oribatid mite communities over the year showed a reduction in the number of mites immediately after a fire. Plant cover in the shrub-area was completely destroyed; the first sampling date showed only 12 species with a total density of 92n/m^2 (fig. 1a,b). In the pine forest (P2), where fire only destroyed the understorey, 7 species were registered with a density of 29n/m^2. Recovery of oribatid mite fauna in the pine forest was evident four months after fire. The number of species and densities increased and exceeded the same indices in the control site (P1). In the severely burnt shrub area, faunal recovery was seen five to six months after the fire (fig.1a, b).

Changes in the Simpson's index of diversity correlated negatively with changes of density. In almost all studied sites Simpson's index of diversity (1-D) was low, when total faunal density was high. In most cases, high density was caused by the increase of wide-spread, dominant species, whereas faunal diversity remained low. For example, during the second sampling date (10.06) in the control pine forest (P1), the density of oribatid mites equaled 4407 n/m^2, due to high density of *Oppiella fallax* – 2367n/m^2 and *Tectocepheus velatus* – 1633n/m^2. At the same

sampling time, the total density of oribatid mites in the burnt pine forest site (P2) equaled 2816n/m^2 and the density of *Oppiella fallax* – 2300 n/m^2 (Fig.1a, b).

Table 1. Changes in the percent dominance of common species in the sampled sites over 1 year. P1 = control pine forest; P2 = burnt pine forest; Sh1 = control shrub area; Sh2 = burnt shrub area.

species	site	09.06	10.06	11.06	12.06	01.07	02.07	03.07	04.07	05.07	06.07	07.07	08.07	09.07
Oppiella fallax	P1		54	91	43		11	97	17	62	65	14	20	1
	P2	10	82	2	59	32	35	32	51	20	41	3	10	3
	Sh1	9	12	17	23	93	39	34	45	21	48	15	8	10
	Sh2		5	13		19	25	55	74	40		7	5	
Ramusella clavipectinata	P1		2	2	9		38	14		4	6	9		
	P2		1	<1	36	26	4	6	2	6	11	3	3	
	Sh1	1	1	5			25	5	4	5	<1	2	1	
	Sh2	28	3	6	5	5			<1	4	8		2	
Tectocepheus sarekensis	P1	25	1	<1	15			2	12	7	<1	17	28	
	P2		1	87	1	10	2	1	8	3		29	5	
	Sh2	29	35			1	6		6	5	5	7	14	
	Sh2	11	1	3			2		6	5			8	20
T. velatus	P1		37	1			4	2			9	5	5	10
	P2		6	1			16	2		5	10		50	7
	Sh1		1	52	33	1		2			27		8	26
	Sh2	7	32	9	17	23	21	2		1	22			7
Ceratoppia quadricarinata	P1	9	1	<1	5	17	<1	2	2	2	4	3	3	43
	P2			<1	<1		14	5	8	6	6		1	3
	Sh1	1	<1	<1		<1	3	4	5	<1	1	5	1	14
	Sh2			2		4	4	3	<1	5	1	16		7
Sphaerochthonius splendidus	P1	9	<1						2					
	P2		<1	<1	<1				1				1	
	Sh1	5	32	<1						<1	<1		2	
	Sh2	11	8	9						2	1			
Punctoribates punctum	P1		<1	<1	3				1	<1	<1		4	
	P2		<1	2		1		1	5	1	1			
	Sh1			3		<1			<1	1	1		31	1
	Sh2					2	<1	2	<1	3	7		3	20



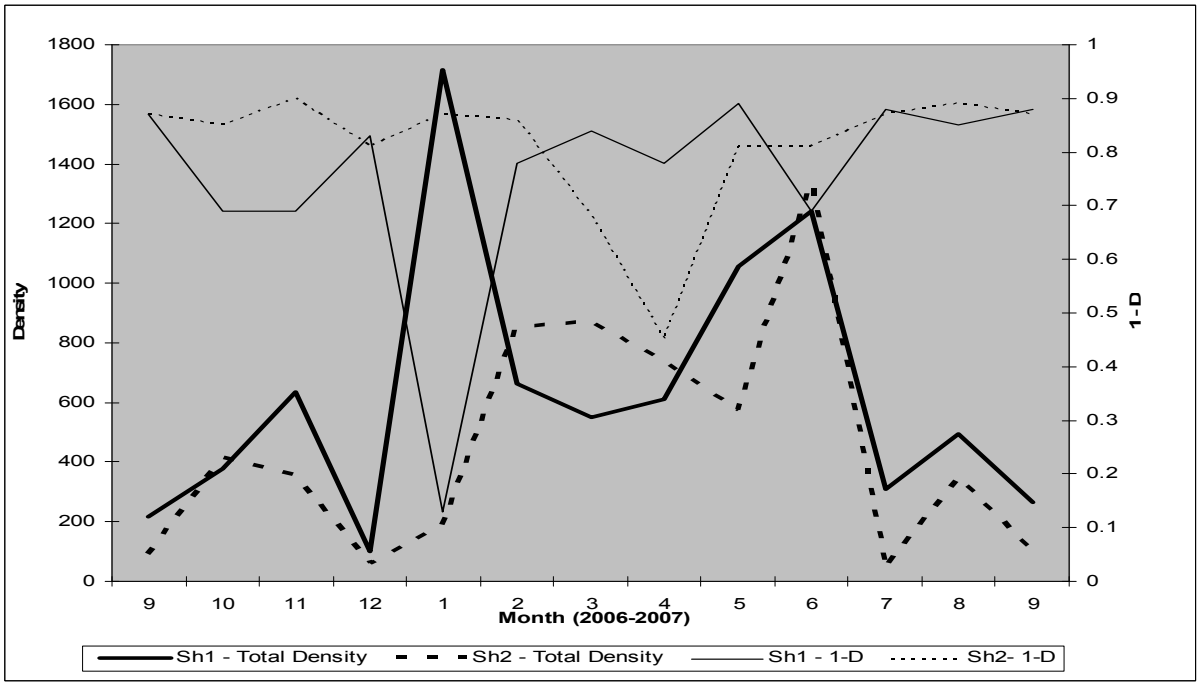


Figure 1. Changes in the densities of oribatid fauna and Simpson's index of diversity (1-D) in a)-top- control (P1) and burnt (P2) pine forest sites and b)-bottom- control (Sh1) and burnt (Sh2) shrub areas.

The number of species collected per site per month ranged from 7 species (P2 at 09. 06) to 33 (P1, P2 at 11. 06). The high number of species corresponded to high density during spring and fall; this pattern is likely determined by the two periods of vegetation growth that characterize ecosystems around the Tbilisi region and are associated with increased humidity (Darejanashvili Sh. D., Gomelauri L. A., 1975; Murvanidze M., 1999).

The average annual density calculated for each site, showed that the annual densities of control sites (P1, Sh1) were higher than the burnt sites (P2, Sh2). Average annual Simpson's index of diversity (1-D) and number of species per site showed no such difference (tab. 2).

Table 2. Average annual densities, number of species and Simpson's index of diversity (1-D) for the studied sites (P1 = control pine forest; P2 = burnt pine forest; Sh1 = control shrub area; Sh2 = burnt shrub area).

sampling sites	density n/m^2	number of species	1-D
P1	1569	21	0,73
P2	1061	22	0,71
Sh1	633	23	0,75
Sh2	459	19	0,81

Chemical analyses performed on soil samples showed that the pH was close to neutral in pine forest, whereas in shrub area it was slightly alkaline. Humus percentage in soil was higher in burned sites than in control sites due to an increasing amount of humus due to the addition of organic matter after the fire (tab. 3).

Table 3. Measurements of soil pH and humus percentage in burnt (P2, Sh2) and control (P1, Sh1) sites.

sites	soil humidity (%)	pH	humus (%)	humus per dry mass (%)
P1	3,49	7,46	6,73	6,97
P2	3.95	7,40	10,62	11,05
Sh1	4,77	8,20	6,5	6,8
Sh2	4,48	7,80	8,9	9,3

Discussion

The study of fire influence on the oribatid mite communities of the semi-arid ecosystems of Tbilisi showed that the fire resulted in an immediate drop in the population density and in moderate changes in the mite species composition. The effect of fire reflected changes in species inhabiting litter and soil surface, while animals living in deeper layers survived. Community recovery begun by increasing the number of ubiquitous and wide spread species that can tolerate extreme conditions: members of family *Oppiidae, Tectocepheus sarekensis, T. velatus, Punctoribates punctum* and *Fosseremus laciniatus.* Indeed, recent studies have shown that *T. velatus* is the most heat-tolerant species within Oribatida. It can stand temperatures of 40^{0}C during 4 hours (Malmström, 2008).

Litter dwellers such as *Nothrus biciliatus, Liacarus brevilamellatus, Eupelops torulosus, Peloptulus phaenotus* and *Pilogalumna crassiclava* gradually increased their numbers, most likely due to hidden microhabitats where they survived the fire (under stones, deep in moist moss, on the tree bark etc.). This also occurred for typical pine species – *Eniochthonius minutissimus, Jacotella ornata* and *Oribatula tibialis* that composed an important part of the pine forest fauna.

The recovery of plant cover begun after the rains in October- November 2006 and resulted in new grass cover that was gradually followed by new shrub vegetation; increasing mite densities coincided with this period. Recovery of oribatid mite fauna was slower in the severely burnt shrub-strand than in the less severely burnt pine forest (four months after the fire in the pine forest and six months after the fire in the shrub-strand). Soil analyses showed an increase in humus mass in burnt plots due to the addition of organic matter after burning. This resulted in an increase in faunal composition and density after the fire.

Our research showed that season, fire intensity, post- fire age and soil characteristics (pH, humidity, humus) all influenced the composition of oribatid mite communities, supporting the use of these species as indicators of environmental quality.

Acknowledgements

The research was funded by joint grant of Georgian National Science Foundation and Scientific Technical Center Ukraine. GNSF-STCU 07/129, project 4327 "The invertebrate animals as bioindicators of urban environment".

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