

# MONITORING AND ASSESSMENT OF THE RESTORATION OF OPEN QUARRIES IN AN INSULAR ENVIRONMENT USING INDICATORS FROM THE LOCAL TERRESTRIAL FAUNA

C. Adamopoulou & A. Legakis  
 Zoological Museum, Dept. of Biology, Univ. of Athens,  
 Panepistimioupoli, GR-157 84 Athens, Greece

## Materials & Methods

### Study plots



**Natural undisturbed plot (A)**

**-control**  
 Vegetation covers 52.1% of plot. The rest is bare sand

**Vegetation:** *Juniperus oxycedrus* ssp. *macrocarpa* (coverage 62.2%) & *Coridothymus capitatus* (coverage 22.5%)



**3-year-old china clay quarry (B\*)**

**Surface deposits of inert materials from a china clay quarry in an early phase of restoration**

**Vegetation (hydroseeded):** *Ditrychia viscosa*, *Artemisia absinthium*, *Centaurea spinosa*, *Atriplex alymus*, *Tamarix* sp. and other smaller graminaceous plants

\* For the arthropod study, Bc, an undisturbed phrygana plot right next to B, was used as control



**8-9-year-old perillite quarry-totally restored (C)**

### (Cs) Slope

*Acacia cyanophylla*, *Myoporum lanceolatum*, *Medicago arborea*, *Tamarix* sp., (all these plants were hydroseeded) and the smaller *Satureja thymbra*, *Spartium junceum* that colonized the area later on.



### (Cp) Plane

*Cistus salvifolius*, *Cistus incannus*, *Satureja thymbra*, *Helichrysum italicum*, *Centaurea spinosa*, *Elymus farctus*, *Otanthus* sp., *Calycotome villosa*, *Genista acanthoclada*, *Sarcopoterium spinosum*. **None of these plants was hydroseeded**

*Podarcis milensis*

### Diversity

#### Reptiles:

Transects (same time of the day/same observer): (A) 70m x 4m, (B) 60m x 4m, (Cs) 234m x 4m, (Cp) 60m x 4 m. **Index species:** capture-recapture & transects-Petersen estimate (Caughley, 1980):  $N=Mn/m$  (1) Bailey (1952):  $N=M(n+1)/m+1$  (2) + Correcting for edge effect

#### Soil arthropods:

Pitfall traps (20 traps/plot- except Bc that had 10 traps). **Index groups:** No of ind/trap/60 days, No of species, Diversity indices & Characteristic species

## Reptiles

**Index species: *Podarcis milensis* endemic lizard species in the Aegean Archipelago**  
 (Mios, Kimolos, Polyagios, Antimilos & small islets)

### 1) Species records

Study plot	A (undisturbed)	B (3-year old)	C (Cs&Cp) (8-9-year old)
Species			
Lizards			
	<i>Cyrtopodion kobczyki</i> <i>Allophryne klabei</i> <i>Podarcis milensis</i> <i>Lacerta bilineata</i> <i>Nanschweileri</i>	<i>Cyrtopodion kobczyki</i> <i>Allophryne klabei</i> <i>Podarcis milensis</i> <i>Lacerta bilineata</i> <i>Nanschweileri</i>	<i>Cyrtopodion kobczyki</i> <i>Allophryne klabei</i> <i>Podarcis milensis</i> <i>Lacerta bilineata</i> <i>Nanschweileri</i>
<b>Total</b>	<b>4 species</b>	<b>4 species</b>	<b>4 species</b>
Snails			
	<i>Macroviperia schweileri</i> <i>Euglyptus fallax</i> <i>Telescopus fallax</i>		<i>Macroviperia schweileri</i> <i>Euglyptus fallax</i>
<b>Total</b>	<b>3 species</b>		<b>2 species</b>

### 2) Population density of index species

Plot	Density	
	Transects	Capture-Recapture
A (undisturbed)	495 ind/ha	395 ind/ha
B (3-year-old)	160 ind/ha	-*
Cs (8-9-year old-slope)	150 ind/ha	-*
Cp (8-9-year old-plane)	208 ind/ha	303 ind/ha

\* Due to dense vegetation the capture-recapture method could not be used

### Conclusions

#### Species records

No of species found follows restoration level. Snakes not found in B maybe due to a) their cryptic behavior & restricted activity hours, b) the plot may not yet fulfill certain requirements (e.g. food, refuges, etc.)

#### Population density of index species follows restoration level. In B and Cs the smaller densities. In B due to early stages of restoration & dense vegetation and in Cs due to very dense vegetation

It seems that 3 years since restoration are enough for a good population of *Podarcis milensis* to be settled

## Soil arthropods

### 1) Species records

(undisturbed)	(3-year old)	(undisturbed)	(Cs & Cp) (8-9-year old)
Coleoptera	Coleoptera	Coleoptera	Coleoptera
Aranidae	Aranidae	Aranidae	Aranidae
Acarina	Acarina	Acarina	Acarina
Isopoda	Isopoda	Isopoda	Isopoda
Diptera	Diptera	Diptera	Diptera
Collembola	Collembola	Collembola	Collembola
Hymenoptera	Hymenoptera	Hymenoptera	Hymenoptera
Dichyptera	Dichyptera	Dichyptera	Dichyptera
Diphthera	Diphthera	Diphthera	Diphthera
Hemiptera	Hemiptera	Hemiptera	Hemiptera
Arts	Arts	Arts	Arts
Coleoptera	Coleoptera	Coleoptera	Coleoptera
Insect larvae	Insect larvae	Insect larvae	Insect larvae
Psocoptera	Psocoptera	Psocoptera	Psocoptera
Arthropoda	Arthropoda	Arthropoda	Arthropoda
Diptera	Diptera	Diptera	Diptera
Dermatophora	Dermatophora	Dermatophora	Dermatophora
<b>Total 17</b>	<b>13</b>	<b>13</b>	<b>14</b>

### 2) Number of species in May-July

	A (undisturbed)	B (3-year old)	Bc (undisturbed)	C (Cs & Cp) (8-9-year old)
Aranidae	7	18	7	9
Arts	7	8	11	6
Coleoptera	16	36	11	13
Others	7	12	8	9
<b>Total</b>	<b>37</b>	<b>74</b>	<b>37</b>	<b>37</b>

### 3) Mean number of individuals per trap per 60 days

	A (undisturbed)	B (3-year old)	Bc (undisturbed)	C (Cs & Cp) (8-9-year old)
Aranidae	~100	~150	~100	~120
Arts	~100	~150	~100	~120
Coleoptera	~100	~150	~100	~120
Others	~100	~150	~100	~120

### 4) Number of species (total)

• A (undisturbed) - C (Cs & Cp), (8-9-year old): No difference (Mann-Whitney U=3.5, p=0.64)

• Bc (undisturbed) - B (3-year old): Significantly more species in B (Mann-Whitney U=0, p=0.049)

### 5) Numbers of species (Aranee, Coleoptera, Formicidae)

	Site	Mann-Whitney U	p-value	Conclusion
Aranidae	A-C	1.5	0.18	No difference
	B-C	0	0.049	More in Bc
Coleoptera	A-C	0	0.04	More in Bc
	B-C	0	0.046	More in Bc
Formicidae	A-C	0	0.049	More in Bc
	B-C	2	0.26	No difference

### Conclusions

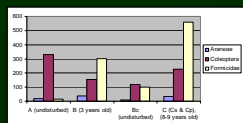
- The sites have characteristic species that are adapted to the conditions at each study area
- Example: Ants**
- Both quarries: *Messor*
- B (3-year-old quarry): *Pheidole* & *Lepisiota*
- C (8-9-year-old quarry): *Cataglyphis* & *Plagiolepis*
- The Margalef diversity of some groups such as spiders in the 8-9-year-old quarry (C) is closer to the diversity in the undisturbed site (A) than to the diversity in the 3-year-old quarry (B)
- The soil arthropod community of the quarries is more similar to the phrygana undisturbed site (Bc) than to the sandy undisturbed site (A)
- The two quarries seem to have acquired communities that do not differ much from the undisturbed communities as far as diversity is concerned
- The difference of the soil community in the 3-year-old quarry (B) from the neighboring undisturbed site (Bc) is bigger than the difference between the 8-9-year-old quarry (C) and its undisturbed neighbor (A)

### We would like to thank:

- Z. Goulioumi, N. Vavatsi, M. Kourias for assistance in the field
- The S&B mining company for permission to carry out the project in their quarries
- Mr. G. Petrakis of S&B for the provision of data on the vegetation and history of the quarries
- The Ministry of Environment, Physical Planning and Public Works for financial assistance within the framework of the Environmental Protection and Sustainable Development Program

The three major groups in terms of number of species - Coleoptera, Araneae, Hym. Formicidae - were chosen as index groups

### 3) Mean number of individuals per trap per 60 days

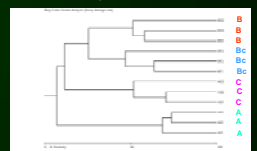


### 4) Numbers of species (total)

• A (undisturbed) - C (Cs & Cp), (8-9-year old): No difference (Mann-Whitney U=3.5, p=0.64)

• Bc (undisturbed) - B (3-year old): Significantly more species in B (Mann-Whitney U=0, p=0.049)

### 8) Clustering



### General conclusions

- The two quarries seem to be on the way to full restoration with the 8-9-year-old quarry being closer
- The differences in vegetation and in soil substrate create reptile communities with different densities and invertebrate communities with different structure
- It is possible that in the future, plants from adjoining natural areas will invade and remove certain differences
- It is also possible that the alien plant species that have been used in some cases for restoration will negatively affect neighboring natural areas

*Macroviperia schweileri*