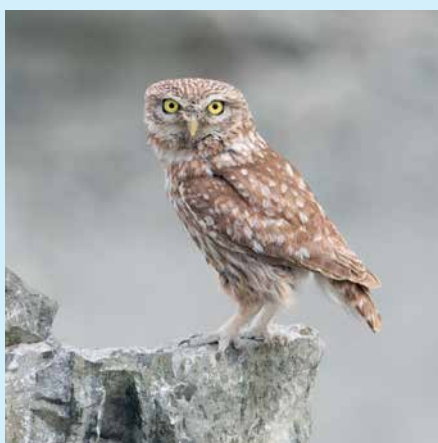


Biodiversity Assessment in Cyprus Aggregates Quarries



MARCH 2025

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DEPARTMENT OF BIOLOGICAL SCIENCES
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Cover photo: Quarry in Androlykou (photo: Christodoulos Makris).

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SUMMARY

The present study has focused on the evaluation of the status of selected biodiversity components in all quarry zones, and in particular at ten (10) aggregates' quarries of Cyprus, and the offering of advice on optimizing restoration practices from a biodiversity-preservation perspective. The study lasted for one year and was funded by the Cyprus Aggregates Producers Association. Due to methodological and logistic issues, the study focused mainly on sites inside quarries where some restoration actions have been undertaken or that have been left unmanaged, and on neighboring sites outside quarries hosting ecosystems representative of the general area, for comparative purposes. Recordings were performed during two seasons (spring – fall) and included the following groups: plants, birds, reptiles and amphibians, beetles belonging to the families Carabidae, Tenebrionidae and Buprestidae, butterflies, and woodlice (Crustacea, Oniscidea). In addition, habitat types occurring at study sites were also recorded.

The effects of quarries on biodiversity has been the subject of many studies in the past few decades with research showing that quarries do not seem to make fields where biodiversity is destroyed or reduced. The emerging picture is more complex, with quarries having an important role in the shaping of new assemblages of local biodiversity. Nevertheless, we lack adequate data on the situation in Cyprus, despite the increasing role of aggregates in the overall development of flourishing construction business and other related activities in the country. Hence, it was deemed necessary to implement a trustworthy and scientifically sound evaluation of the effects that aggregates' quarries have on biodiversity, in order to restrict any negative effects and, at the same time and to the extent possible, to take measures for improving the status of biodiversity by exploiting opportunities offered by quarries.

Based on the findings of this study, the following picture of current biodiversity has emerged:

Overall, seven habitat types have been recorded around the boundaries and in restoration sites of quarries, three of which are of European Community interest. Despite their important role for biodiversity, the temporary ponds formed by water drainage in most quarries have not been considered as one of the habitat types proper, due to their temporary nature. Nevertheless, in some cases, the ponds have been formed in very deep excavations that have reached aquifer levels raising the probability for permanent presence. A focused hydrological study is needed to evaluate the prospects of such ponds in each quarry.

435 plant species have been found, 27 of which are endemic to Cyprus and five are listed in the Red Data Book of the Flore of Cyprus (four VU and one DD). Nine alien invasive species have been recorded, most of which at Agios Sozomenos site and in restoration sites. The richest sites were both control sites outside quarries and in restorations. Control sites hosted a larger number of exclusively occurring species, while no endemic species was found exclusively in restoration sites and no invasive exclusively in control sites. No significant difference in species richness between control and restoration sites was detected. The plant communities are clustered mostly on a local, quarry basis, regardless of type (control or restoration).

Even though no systematic records of mammals was performed, the occurrence of three species was confirmed, with the fox being the most common. Also, 104 species of birds were found, with the richest sites being both in restorations and in controls. The largest number of species are breeding in Cyprus, and there is an important percentage of waders that were seen almost exclusively in the temporary ponds inside quarries. Like in plants, no significant difference in species richness between control and restoration sites was detected and the bird communities are clustered mostly on a local, quarry basis, regardless of type.

Nine species of reptiles and two of amphibians were recorded, five of which are endemic to Cyprus, and three strictly protected. Once more, richest sites were in both control sites and restorations. For reptiles and amphibians too, no significant difference in species richness between control and restoration sites was detected while the communities do not show any general pattern in their associations. An important effect of refugia (mostly stones) and open areas on reptile diversity has been found.

Regarding ground beetles (Carabidae), 64 species were found, with the richest sites being again both restorations and control sites. No difference in abundance or species richness was detected between control and restoration sites, and communities do not exhibit any apparent clustering pattern. In addition, 33 species of Tenebrionidae beetles were recorded, the richest sites of which are the controls. In this case, abundance of control sites was significantly larger than that of restorations, whereas the respective species richness did not differ (marginally in paired comparisons). Clusters of communities was mostly based on site type as far as abundance is concerned, but on quarry for species composition.

35 species of butterflies were recorded, six of which are endemic species or subspecies of Cyprus. The richest sites were both controls and restorations and no difference in species richness was detected between them. Communities are varying in their association patterns.

Finally, 23 species of woodlice (terrestrial isopods) were found, four of which are endemic to Cyprus. Once more, the richest sites were found both in controls and in restorations, and no difference was detected between them either in abundance or in species richness. No clear pattern of community association was shown.

It is evident that the quarry areas host an important biodiversity that can be easily invade into restoration sites, especially when these are connected to undisturbed neighboring sites. Furthermore, most quarries have added components that are lacking from the general areas where they have been installed, mainly through the creation of temporary ponds but also through the formation of rocky cliffs. The overall picture emerging from these findings shows that no clear differentiation between restoration sites and the surrounding areas (controls) can be seen, with one exception being the beetles of the family Tenebrionidae. The qualitative characteristics of recordings, though, reveal some interesting points that can be useful in optimizing future restorations. These have to do mostly with the more intense presence of invasive plants in restorations, the positive role of temporary ponds for birds, and the importance of maintaining connectivity between restoration sites and surrounding areas in order to facilitate the colonization of the former.

Planting of trees or other plants in restorations is not deemed necessary in all cases, as the vegetation of surrounding sites seems to find its way in restorations quite fast and easily, as long as the aforementioned connectivity is maintained (e.g., through corridors with native vegetation). In the cases where planting is needed, the use of a variety of species is strongly advised. Finally, it is important that general environmental and safety rules are strictly enforced, such as those related to decreasing dust and light pollution, the prevention of fire, the forbiddance of burning plastics, and a rational water management.

For a more complete biodiversity evaluation and for safer conclusions, it is necessary to implement a long-termed biomonitoring scheme in selected, representative quarries, as well as a more thorough study of a small number of selected quarries for at least one or two more years.

INTRODUCTION

This report constitutes the final deliverable of the project titled “Provision of Services for the Recording and Evaluation of Biodiversity in Aggregates Quarries of Cyprus”, which was implemented by the University of Cyprus under the coordination of Professor Spyros Sfenthourakis (Laboratory of Ecology and Biodiversity, Department of Biological Sciences). The project commenced on February 12, 2024, and had a duration of one year, with the deadline for the final report set for one month after its completion (i.e., March 12, 2025). The project was commissioned and funded by the Cyprus Quarries Association, with Mr. Antonis Antoniou Latouros acting as the official representative.

The aim of the project was to assess the biodiversity status in selected aggregates quarries in Cyprus through the documentation of key biodiversity components and to provide recommendations for optimizing quarry restoration practices from a biodiversity perspective. The Cyprus Quarries Association proposed the quarry areas, and after field visits, the research team selected the specific sites included in the present study.

It is self-evident that the study does not address other dimensions of quarry operation (e.g., aesthetic, social, economic, landscape, or developmental aspects), and its one-year duration does not allow for an exhaustive investigation of all potential facets of biodiversity across all stages of quarry development. As such, it should be considered a preliminary study that provides the foundation for further exploration of additional aspects.

Furthermore, due to time, methodological, and budgetary constraints, the present study focused on sites where quarrying activity had ceased and either restoration actions had been implemented or the area was left unmanaged. These sites were compared to adjacent areas outside the quarries that host typical ecosystems representative of the surrounding region.

Given that this is essentially the first attempt at systematically evaluating biodiversity in aggregates quarries in Cyprus, the study opted to conduct surveys in ten quarries covering all quarry zones, diverse geographic regions, and a significant range of habitat types found on the island. This approach, while leading to a relatively limited number of survey days per quarry, was deemed necessary. To ensure the best possible outcome, recordings were carried out during two different seasons (spring and autumn), in order to minimize potential biases in observing the target organism groups.

The research team was selected based on the ability of each member to effectively record the groups assigned to them, balanced against the financial constraints of the project. We are confident that the best possible work was carried out with scientific thoroughness and competence, and that we have succeeded in providing a highly useful first snapshot of biodiversity status in restored and abandoned quarry areas. This snapshot adequately reflects the general situation across the country's aggregates quarry network. It should also be noted

that the quarry managers cooperated harmoniously with the research team, offering guidance where and when needed and ensuring the safety and smooth operation of the team's fieldwork.

The environmental impact of quarries, and more specifically their effect on biodiversity, has been the subject of intense research over recent decades (e.g., see Ursic et al. 1997, Souza & Sánchez 2018, Telea et al. 2019, Gentili et al. 2020, Salgueiro et al. 2020, Seelen et al. 2021). This is attributed both to the increased international attention and intensified biodiversity initiatives driven by sociopolitical developments, and to the growing concern among quarry owners and operators about the environmental consequences of their professional activities (e.g., see Holcim Directive 2024). These studies increasingly converge on a revised understanding, challenging the previously dominant perception of quarries as purely destructive to biodiversity. More and more data suggest that the reality is far more complex, with quarries often playing an important role in shaping novel assemblages of local biodiversity, frequently with a positive effect (Richardson & Larson 2009, Roberts 2012).

Regardless of issues such as landscape alteration, spatial planning of quarry locations, and optimization of conditions with respect to greenhouse gas emissions, when it comes to biodiversity itself, there is strong evidence that quarries often provide opportunities for increasing biodiversity, or at least attracting and hosting important components of it.

In the case of Cyprus, the picture remains largely unclear. Although some isolated biodiversity records exist for specific quarries—mainly in the context of national environmental impact assessments—no comparative evaluation has been conducted across a large number of quarry sites, nor across a wide range of biodiversity components using scientifically robust assessment methods. Perhaps the most extensive relevant study (in Xylofagou – Anagiotos 2021) was limited to descriptive species lists of flora and fauna, lacking any ecological analysis of the biodiversity data. Furthermore, it omitted the substantial recording of invertebrate taxa, which constitute the vast majority of biodiversity.

At the same time, it is evident that demand for aggregate quarry products in the country shows no signs of decreasing. On the contrary, construction activity—one of the largest users of such materials—appears to be growing again following setbacks during the financial crisis and the COVID-19 pandemic. This indicates that aggregate quarries will likely continue to be a key element of the country's economic activity in the medium term, at least.

Therefore, it is necessary to implement a reliable and scientifically valid assessment of the effects of these quarries on biodiversity and, more broadly, on the country's natural environment. The goal is to minimize any negative impacts and ensure that quarrying is, as much as possible, compatible with national, European, and global targets for biodiversity conservation and the prevention of further loss. Ideally, such research could even contribute to an increase in biodiversity by exploiting the opportunities that quarries can offer.

Accordingly, the present study aims to provide an objective and scientifically sound assessment of the current state of biodiversity in aggregates quarries in Cyprus, with a view to expanding this research over time to strengthen its conclusions and initiate long-term systematic biodiversity monitoring—aligned with European directives and international conventions signed by the Republic of Cyprus. Additionally, this study seeks to offer practical guidance for optimizing the management and restoration of quarry sites where extraction activity has concluded.

METHODOLOGY

The study began in February 2024. Initially, site visits were carried out by the Research Team, in collaboration with the responsible personnel of each quarry and accompanied by representatives of the Cyprus Quarries Association, to various quarry locations across Cyprus for the purpose of selecting biodiversity recording sites. During these visits, several parameters were assessed, such as accessibility, the representativeness of habitats in restoration areas, spatial distribution, current operational status of the quarries, and others.

Based on these evaluations, the Research Team decided to conduct biodiversity surveys at the ten quarries listed in Table 1, which also includes the coordinates of both internal (within-quarry) and external (outside-quarry) survey sites. Figure 1 shows a map of Cyprus with the locations of these quarries, while Annex 1 provides detailed maps and photographs of the recording sites.

In addition to these primary locations, supplementary observations and recordings were carried out at specific points of special interest for certain organism groups, such as water collection points for birds or particular microhabitats for plants.



Figure 1. Locations of the quarries studied in the present research.

Sites were selected both within the quarries, at locations where restoration actions had been carried out following the cessation of quarrying activities or that had been left to regenerate without intervention, and outside, in areas very close to the quarry boundaries featuring habitats typical of the respective region and in relatively undisturbed condition. These sites would serve to compare the findings inside and outside the quarries, in order to assess any potential impact of land use on biodiversity.

The organism groups to be recorded in detail were also selected based on existing time constraints and the expertise of the Research Team members. The target groups were defined as: plants, birds, reptiles and amphibians, butterflies, beetles in the families Buprestidae, Carabidae and Tenebrionidae, and terrestrial isopods (Crustacea: Oniscidea). Additionally, habitat types in each area were recorded, along with non-flying mammals based on indirect evidence, tracks and signs. The Research Team considers that these groups cover a significant spectrum of local biodiversity and can provide a reliable approximation of overall biodiversity, especially for a study aiming at assessing diversity and not at identifying specific taxa (e.g. species listed in European Directives).

To record the highest possible proportion of species from the target groups and given the time and financial constraints of the study, the optimal strategy selected was to conduct surveys in two seasons of the year, specifically spring and autumn. These are the seasons during which the biological activity of the target groups is at its highest, according to both the experience of the team members and the biological characteristics of the organisms involved.

The recording methodology differed for each organism group but generally falls into three sampling types:

A) Visual observation along transects within the survey sites, with capture of individual species when necessary for safe identification. This methodology was applied to plants, reptiles and amphibians, butterflies, and partially to Buprestidae.

B) Visual recording with binoculars from selected observation points within the survey sites, as well as from other points of interest within the quarries (e.g. water collection sites).

C) Placement of pitfall traps. Ten traps were placed at each survey site and remained operational for 15 days, once in spring (May) and once in autumn (November). The pitfall traps consisted of 200 ml plastic cups, which were embedded in the ground so that their rim was flush with the soil surface. The cups were filled one-third with propylene glycol, a non-volatile substance that preserves the condition of the organisms that fall into it. This method is widely used for mobile ground-dwelling arthropods, such as ground beetles. Here, it was applied for collecting Carabidae, Tenebrionidae and partially Buprestidae beetles, as well as terrestrial isopods. Sorting, identification, and counting of these species were carried out at the Ecology and Biodiversity Laboratory of the University of Cyprus. The data were initially recorded by trap and season, and later grouped by survey site. It should be noted that results are presented

in pairs of sites per quarry (restored and external), except for the quarry at Androlykou, where two within-quarry sites were recorded: one restored and one unmanaged, due to their markedly different overall characteristics.

Visual surveys were carried out for three days per quarry and per season, although for certain groups the duration of the surveys varied to enable detection of species with different periods of activity (e.g. plants with varying flowering dates).

Due to the ecology of reptiles and amphibians, which vary in detectability depending on species, and the inherent difficulties in recording mammals, the method of active search per unit of time was selected, using simple observation both on the surface and beneath rocks, logs, and other forms of shelter. Active searches were conducted per quarry, per site (restored and external), and per season (spring and autumn), with two 40-minute sessions, during which the researcher recorded the direct and indirect presence (shed skins, droppings, vocal signals) of reptiles, amphibians, and mammals.

For birds, recordings were carried out along linear transects within the quarry, at restored sites, and in neighboring areas outside the quarry. The same route was followed at each visit. Observations were conducted using visual detection (with Leica Ultravid 8x42 binoculars) and acoustic identification, recording both the number of individuals and their behavior. In the corresponding results tables, minimum numbers of individuals are listed to avoid duplicate recordings. The results of the surveys for all organism groups per quarry are presented in detail in Annex 1.

Statistical analysis of the data was performed using open-source software (Past, Hammer et al. 2001) and included estimation of diversity indices, as well as comparisons of survey sites in terms of species abundance and composition, both per quarry and overall (restored and external sites). These analyses are discussed together with the corresponding results in the “Results” section.

The Table 2 provides some descriptive information about the location of each quarry (elevation, general environmental features, year restoration began). Elevation is shown as a range that includes the various survey sites. The start date of restoration was not always known, as many quarries do not keep such records. The habitat descriptions provided here are general, while more precise details about habitat types are presented in the “Results” section.

Table 1. The quarries where biodiversity recordings were conducted, and the coordinates of

the main survey sites per quarry (within and outside the quarry). In addition to these sites, for certain groups, supplementary recordings were carried out at sites of particular interest (e.g. water bodies for birds). From here on, quarries will be referred to by their regional location.

QUARRY	LOCATION	Coordinates of restored area	Coordinates of external area
IACOVOU BROTHERS	XYLOFAGOU	34.9549691, 33.8778740	34.9605455, 33.8743787
PYRGA QUARRIES	PYRGA	34.9072800, 33.4450452	34.9092475, 33.4462345
		34.9077669, 33.4461677	34.9099415, 33.4466324
MOSHILOTI QUARRIES	MOSHILOTI	34.9507911, 33.4422920	34.9559820, 33.4400621
ELMENI (QUARRIES)	AGIOS SOZOMENOS	35.0755059, 33.4422624	35.0706532, 33.4379200
		-	35.0735756, 33.4456082
ELEFThERIOS PANAGI & SONS	SIA	34.9447873, 33.3781781	34.9444334, 33.3761614
KYTHREOTIS QUARRIES	PAREKKLISIA	34.7868521, 33.1486333	34.7872370, 33.1633955
		-	34.7881030, 33.1587761
SKYRA VASAS	VASA	34.7751205, 33.2109149	34.7779813, 33.2096576
FARMAKAS QUARRIES	FARMAKAS	34.9411491, 33.1421145	34.9425500, 33.1420934
EME	MITSERO	35.0617464, 33.1287464	35.0583776, 33.1265809
GENNADIOS THEOLOGOU & SONS	ANDROLYKOU	35.005101, 32.389631	35.0053784, 32.3893801
		35.0057066, 32.882217	-

Table 2. Summarized descriptive data on the quarries studied and the recording localities.

QUARRY	ALTITUDE (m)	RESTOR. START	RESTORED AREA	OUTSIDE AREA	COMMENTS
Ag. Sozomenos	200-250	2019-20	Sandy soil with acacia trees (<i>Acacia</i> spp.) and an understory of herbaceous plants. Seasonal water accumulation in autumn and early spring.	Open phrygana habitat, with low shrubs and herbaceous plants.	Adjacent to the Natura 2000 site "Alykos River – Agios Sozomenos" (CY2000002).
Androlykou	220-260	2017-20	Mosaic of phrygana and planted carob trees (<i>Ceratonia siliqua</i>) on rocky soil. Lower down, an abandoned area of older quarrying activity with herbaceous vegetation on sandy soil and seasonal water collections in autumn and early spring.	Open phrygana habitat with scattered carob and olive trees.	It borders the SPA of the Natura 2000 area "Akamas Peninsula" (CY4000023), and the Akamas National Forest Park.
Farmakas	670-740	2012-13	Pine planting, under the canopy of which various shrubs grow.	Pine forest (<i>Pinus brutia</i>) with a dense understory mainly composed of rockroses (<i>Cistus</i> spp.).	Approximately 300m from the Natura 2000 area "Tzionia Area" (CY2000013).
Mitsero	420-450	2010-13	Planted pines and cypresses, mixed with various shrubs on sandy soil (different from the soil outside the quarry).	Open phrygana habitat with scattered olive trees on rocky ground.	Borders the Natura 2000 site "Mitsero – Agrokipia Area" (CY2000003).
Mosfiloti	260-300	2011	Scattered planted pines mixed with various shrubs and grasses.	Open habitat with grasses, phrygana, and olive trees, as well as some pines within a radius of approx. 200 m.	
Parekklesia	420-440	'90s	Plantation with pines and an understory of various shrubs. Dense layer of pine needles.	Open habitat with sparse pines (<i>Pinus brutia</i>), olive trees, and shrubs.	Approx. 150m from the Natura 2000 site "Limassol Forest" (CY5000001).
Pyrga	280-300	1999-2020	Plantation with pines, in the understory of which various shrubs grow.	Pine forest (<i>Pinus brutia</i>) with a dense understory of <i>Cistus</i> spp. and thorny broom (<i>Calicotome villosa</i>).	Approx. 250m from the Natura 2000 site "Panagias Stazousas River" (CY6000007).
Sia	390-410	2009-15?	Plantation with sparse pines and an understory of <i>Cistus</i> spp. and other low shrubs.	Pine forest (<i>Pinus brutia</i>) with an understory of <i>Cistus</i> spp. and a dense layer of mosses.	
Vasa	240-260	'90s	Pine plantation with an understory of low shrubs, such as <i>Cistus</i> spp.	Sparse olive grove with low shrubs and a few pine trees on rocky soil.	
Xylofagou	5-50	2013-14	Shrubland (maquis vegetation) with mastic trees (<i>Pistacia lentiscus</i>) and other shrubs, and muddy area with helophytic and halophytic plants (<i>Atriplex halimus</i> and <i>Tamarix</i> spp.). Carob tree (<i>Ceratonia siliqua</i>) plantation.	Herbaceous phrygana vegetation on rocky soil and fields with various low shrubs.	

Table 3. The biotic and abiotic characteristics, species richness, and Shannon-Wiener diversity index per site and season (where applicable). A: restored site, E: site outside the quarry, s: spring, a: autumn. The slope index refers to the difference between the highest and lowest elevation in meters. The columns “open area,” “trees,” and “refuges” refer to the surface area covered in square meters, respectively. The Shannon-Wiener index is based on the relative contribution of each species (relative abundance) to the total number of individuals (total abundance) observed and is indicative of the diversity of each area. The higher the value, the greater the diversity.

Locations		Temperature (°C) (s-a)	Altitude range m	Open Area m ²	Trees m ²	Refugia m ²	No. of Species (α - ϕ)	Shannon- Wiener Index
Ag. Sozomenos	A	25.5-22	11	1645.07	864.76	577.25	4-4	0.66
	E		0	357.64	89.05	2053.31	2-4	0.28
Androlykou	A	31.5-19	2	1400.2	553	546.8	4-4	1.29
	E		6	1275.95	95.15	1128.9	5-3	1.19
Vasa	A	29.5-24	1	1103.53	547.15	849.32	4-3	0.60
	E		25	1167.44	288.1	1044.46	3-2	0.71
Mitsero	A	30.5-32.5	6	183.91	1080.63	1235.46	5-4	1.16
	E		2	2215.39	136.35	148.26	3-3	0.19
Mofhiloti	A	24-22	17	1745.3	409.6	345.1	5-3	0.66
	E		13	502	206.33	1791.67	4-2	0.49
Xylofagou	A	26.5-26	2	1167.60	1332.4	0	1-2	0.00
	E		1	932.2	111.22	1576.8	7-5	1.13
Parekklesia	A	24.5-27.5	5	1099.8	896.2	504	3-3	0.23
	E		12	958.4	248.8	1292.8	2-2	0.62
Pyrga	A	27-23	9	1435.9	582	482.1	3-1	0.32
	E		11	1312.2	714.8	473	4-2	0.38
Sia	A	22-30	9	1126.72	223.14	1150.14	3-4	0.84
	E		9	1260.2	1000.2	239.6	2-1	0.00
Farmakas	A	27.5-29	13	1745.83	218.5	535.67	3-3	0.69
	E		4	855.93	674.54	969.53	4-3	0.90

Specifically for reptiles, through field observations and the use of satellite imagery (Google Earth) covering an actual area of 2.5 km², along with Google Earth Pro software, certain key features of each area were quantified (per m²) and categorized. These included elevation, slope index (difference between maximum and minimum elevation), open space, refuges (rocky and shrubby vegetation), as well as tree cover (Table 3). After categorizing these features, the Jaccard similarity index was used to assess whether the restored and undisturbed areas share similar characteristics (0 = completely different, 1 = completely identical). Subsequently, after logarithmic transformation of the data and using linear regression, it was tested whether the number of species in the restored areas depends on the degree of similarity with the undisturbed area. Additionally, the Shannon-Wiener diversity index was calculated for reptiles, for which quantitative data were collected (Table 3).

Finally, using multimodel inference, the impact of certain abiotic and biotic characteristics of the study sites on the diversity and composition of their reptile fauna was examined.

RESULTS

The results of the recordings are presented here by organism group (and for the habitat types), and by site within each quarry, covering the entire recording period. Alongside the raw recording results, the outcomes of statistical analyses are also provided for each organism group. These analyses aimed to compare biodiversity in the restored areas within the quarries with the representative habitat sites of each surrounding region outside the quarries. Where necessary, additional data are included for supplementary sites (e.g., water collection points).

Detailed species lists and photographic material are provided in Annexes I and II of this document.

Habitat Types

The habitat types (according to the European Directive 92/43/EEC, see Delipetrou & Christodoulou 2010) recorded in the study areas are as follows (habitat types of priority interest for the EU are marked with an asterisk):

5212 Arborescent matorral with *Juniperus phoenicea* (= *Juniperus turbinata*)

Recorded in Androlykou.



Figure 2. Shrubland habitat with *Juniperus phoenicea* (= *Juniperus turbinata*) in Androlykou. (Photo: Ch. Makris)

5220* Shrublands with *Ziziphus lotus* (palloura)

Recorded in Mitsero.



Figure 3. Habitat of shrublands with *Ziziphus lotus* (palloura) in Mitsero (Photo: Ch. Makris)

5420 Phrygana of the Eastern Mediterranean (Cisto-Micromerietea)

Primarily composed of the species *Sarcopoterium spinosum*, *Thymra capitata*, *Cistus creticus*, and *Cistus parviflorus*. This is also a widespread habitat type found in many sites.



Figure 4. Phrygana habitat of the eastern Mediterranean (Cisto-Micromerietea) in Mitsero. (Photo: Ch. Makris)

9320 Evergreen sclerophyllous shrublands (Ceratonio-Rhamnion) (Androlykou)

Mainly formations dominated by olive trees and carob trees. Primarily found in Androlykou.



Figure 5. Evergreen sclerophyllous shrubland habitat (Ceratonio-Rhamnion) in Androlykou. (Photo: Ch. Makris)

9390* Shrublands and forest patches of *Quercus alnifolia* (Golden oak)

Recorded in Farmakas.



Figure 6. Habitat of shrubland and forest stands of *Quercus alnifolia* (golden oak) in Farmakas. (Photo: Ch. Makris)

9540 Forests of Calabrian pine (*Pinus brutia*)

A widespread habitat type across many sites. The pine forests are usually mixed with shrubs characteristic of Mediterranean maquis vegetation, such as kermes oak (*Quercus coccifera*) and mastic tree (*Pistacia lentiscus*), as well as lower shrubs like rockroses (*Cistus* spp.).



Figure 7. Habitat with Calabrian pine (*Pinus brutia*) forest in Sia. (Photo: Ch. Makris)

Additionally, in certain locations, **Mediterranean temporary ponds (3170*)** also occur, but they have not been systematically recorded, as their presence depends on prevailing weather conditions.



Figure 8. Habitat of Mediterranean temporary ponds in Androlykou. (Photo: Ch. Makris)

Finally, the water bodies formed within the quarries are not assessed as a formal habitat type, as they are temporary. Nevertheless, it is important to note that in the older of these, riparian vegetation with reeds and/or other hydrophilic plants does appear, and they play a significant role for certain fauna species (see below)

Plants

In total, 435 plant species were recorded (Table A1), of which 27 are endemic to Cyprus. Five species are included in the Red Data Book of the Flora of Cyprus (Tsintides et al., 2007), four of which are classified as Vulnerable (VU: *Herniaria hemistemon*, *Ornithogalum trichophyllum*, *Rumex vesicarius*, and *Umbilicus horizontalis*) and one as Data Deficient (DD: *Allium guttatum* subsp. *guttatum*). All five were recorded only once each, and in different quarries—two in restoration sites and three in external quarry areas. Nine of the species are invasive (alien), with most of them appearing in Agios Sozomenos and, in general, more frequently in restoration sites. The species *Nicotiana glauca* (in six sites), *Symphyotrichum squamatum*, *Atriplex semibaccata*, and *Bassia indica* (each in one site) were found exclusively in restoration areas.

Only three species were found in all sites (*Aegilops* sp., *Brachypodium distachyon*, and *Helichrysum stoechas* subsp. *barrelieri*), another three in all quarries (*Avena* sp., *Bromus* sp1, and *Sarcopoterium spinosum*), and three in all quarries except Xylofagou (*Crepis foetida* subsp. *foetida*, *Ononis reclinata*, and *Plantago afra*).

The most species-rich sites were the external area of Androlykou (183 species), and the restoration sites of Vasa (157) and Pyrga (156). The poorest sites in terms of species diversity were the restoration site of Xylofagou (45 species), and the external areas of Xylofagou (78) and Mosfiloti (95).

Out of the total species recorded, 104 were found in only one site, and another 31 in only one quarry (including both its restoration and external sites). Among the species recorded only once, 48 were found in restoration areas and 56 in external ones. The highest numbers of unique records were from the external area of Androlykou (17), the external area of Xylofagou (10), and the restoration site of Farmakas (10). Regarding species found only in a single quarry, most were recorded in Androlykou (8), Pyrga (6), and Farmakas (5).

Figure 9 presents the species found exclusively outside of quarries and in restoration sites, respectively, both in terms of total number of species (99 vs 75), as well as the number of endemic species (11 vs none) and invasive species (none vs four).

Furthermore, in most external sites (8 to 10), 40 species were found, while in restoration areas the corresponding number was 34, of which 23 are shared with the external sites.



Figure 9. The plant species found exclusively either outside quarries or in restoration sites, in terms of total species, endemic species, and invasive species, respectively.

According to the one-way analysis of variance (one-way ANOVA), there is no statistically significant difference in the number of plant species between restoration sites and external quarry areas ($F = 0.35$, $P \gg 0.05$ – Levene’s test $P \gg 0.05$).

Likewise, the paired t-test analysis between restoration and external sites did not show statistically significant differences in the number of species ($t = -0.93$, $P \gg 0.05$).

The clustering analysis (Figure 10) clearly shows grouping by quarry, with the exception of Xylofagou, whose sites differ from all the others.

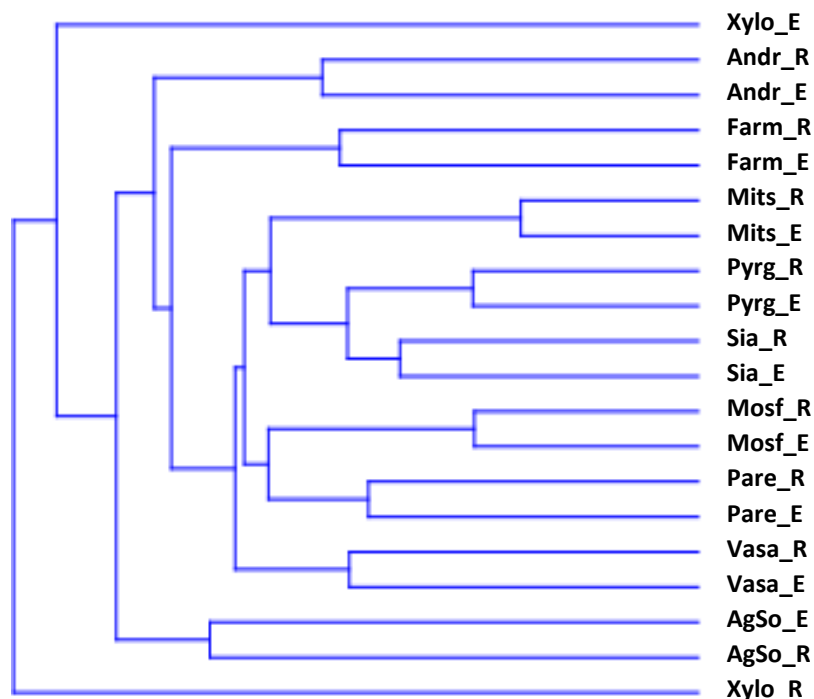


Figure 10. Cluster analysis of the recording sites based on plant species composition (UPGMA, Jaccard similarity index). A clear clustering of the sites by quarry is evident, with the only deviation being those of Xylofagou. (Abbreviations of sites based on first four letters of locality names, plus R for restorations and E for external sites.)

Non-flying Mammals

The results for non-flying mammals (Table 4) are based on indirect observations of tracks and signs, and should not be considered exhaustive.

Moreover, due to the high mobility of these species, comparing sites inside and outside of quarries is not meaningful. Therefore, although the observations are listed by recording site, it should be assumed that these species move throughout the entire area of each site.

In total, only three species of non-flying wild mammals were recorded, with the most common being the red fox. It is expected that rodents also occur, at least the synanthropic species *Mus musculus* and *Rattus norvegicus*, while it would be of interest to investigate the potential presence of the endemic species *Mus cypriacus* and *Acomys nesiotus*.

It would be useful in the future to also record bats (Chiroptera), especially the presence of *Rousettus aegyptiacus* (Egyptian fruit bat), which is a species of interest under the European Directive 92/43/EEC.

Table 4. Observations of non-flying mammals at the recording sites.

		Hare (<i>Lepus europaeus</i>)	Fox (<i>Vulpes vulpes</i>)	Hedgehog (<i>Hemiechinus auritus</i>)
Ag. Sozomenos	Restored	+	+	
	External	+	+	
Androlykou	Restored		+	
	External	+		
Farmakas	Restored		+	
	External		+	
Mitsero	Restored		+	
	External	+	+	
Mosfiloti	Restored		+	
	External		+	
Parekklisia	Restored	+	+	
	External			
Pyrga	Restored		+	
	External	+	+	
Sia	Restored			+
	External		+	
Vasa	Restored	+	+	
	External			
Xylofagou	Restored		+	
	External		+	+

Birds

A total of 104 bird species were recorded (Table A2). Of these, 10 were recorded in all sites and another five in all but one, thus in all quarries. Additionally, 20 species were observed in only one site, 10 of which are wading birds. Finally, 17 more species were observed in only two sites, six of which in only one quarry.

The richest sites were the restoration areas in Agios Sozomenos (55 species) and Androlykou (46), and the external sites in Xylofagou (46) and Pyrga (46). The poorest were the restoration areas in Pyrga (33) and Xylofagou (34), and the external site in Vasa (35). Sixty-five of these species breed in Cyprus (43 species are permanent residents), while the rest are winter visitors and/or passing migrants. Notably, 10 of the 18 wading birds, which were mostly recorded in temporary water bodies, are breeding species in Cyprus.

Particularly important is the presence of species listed under increased protection status (according to national legislation and/or European Directives). A total of 23 such species were recorded, 11 of which in only one quarry each: *Nycticorax nycticorax* (restoration site in Mosfiloti), *Ardea purpurea*, *Ardeola ralloides*, *Aythya nyroca* and *Luscinia svecica* (restoration site in Agios Sozomenos), *Calidris pugnax* (both sites in Xylofagou), *Tringa glareola* and *Falco naumanni* (restoration site in Androlykou), *Falco eleonora* (both sites in Sia), *Curruca ruppeli* (external site in Xylofagou), and *Emberiza hortulana* (both sites in Agios Sozomenos). Also noteworthy is the presence of 11 species of birds of prey, the most interesting of which is the appearance of the protected, permanent resident *Buteo rufinus* in six quarries. It is evident that the formation of open areas with sparse and low vegetation favors this species' foraging activity.

Finally, it should be noted the widespread occurrence of two of the three endemic species of Cyprus (*Oenanthe cypriaca* – in all sites, and *Curruca melanothorax* – in eight of the ten quarries, except Agios Sozomenos and Xylofagou). The third, the Cyprus Scops Owl – *Otus cyprius* – was recorded in two external sites (in Androlykou and Pyrga), but it should be noted that no systematic nocturnal bird survey was conducted.

Figure 11 shows the species found exclusively outside the quarries and in restoration sites, respectively, both in terms of the total number of species (13 vs. 22), as well as waders (0 vs. 15) and breeding species (9 and 9 – seven of which are waders). Also, in most external sites (in 8 to 10 sites), 27 species were recorded, while the corresponding number for the restoration sites was 23, all of which were also found in the external sites.

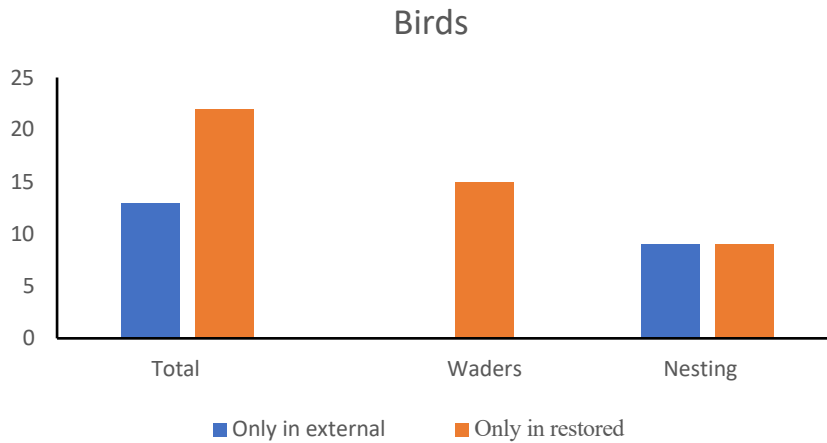


Figure 11. Bird species found exclusively either outside the quarries or in restoration sites, in terms of the total number of species, the wading birds, and the breeding species, respectively.

According to the one-way analysis of variance (one-way ANOVA), there is no statistically significant difference in the number of bird species between restoration and external quarry sites ($F = 0.02$, $P \gg 0.05$ – Levene’s test $P \gg 0.05$).

Additionally, the paired t-test analysis between restoration and external sites showed no statistically significant differences in the number of species ($t = -0.12$, $P \gg 0.05$).

The cluster analysis (Figure 12) shows a clear grouping by quarry, with some exceptions. The sites in Xylofagou differ more significantly from the rest.

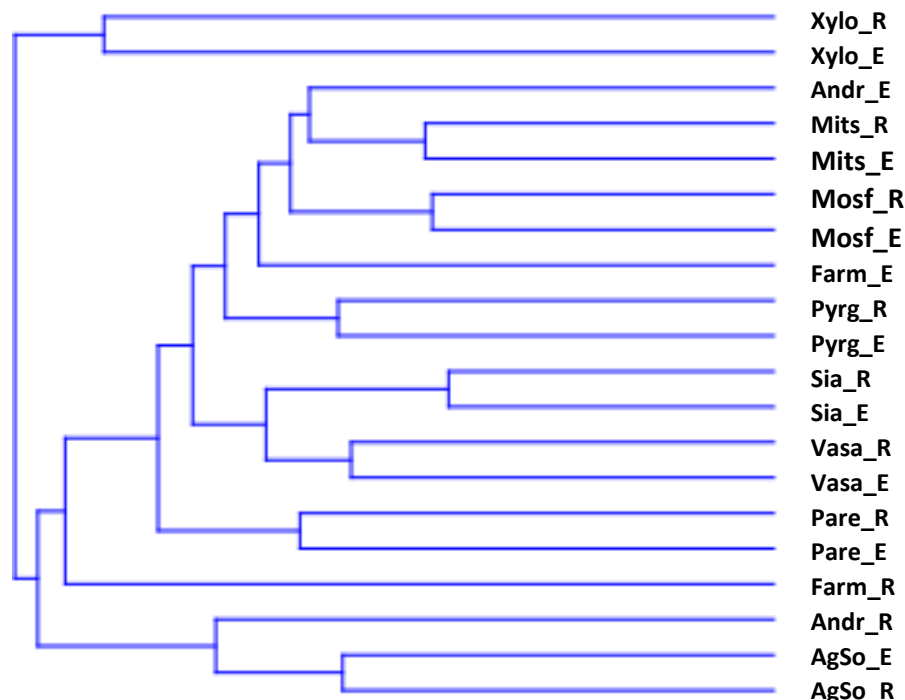


Figure 12. Cluster analysis of the recording sites based on bird species composition (UPGMA, Jaccard similarity index). A clear clustering of the sites by quarry is observed, with minor deviations (sites in Andriou and Farmakia). The most differentiated quarry in terms of bird community composition is that of Xylofagou. (Abbreviations as in Fig. 10.)

Reptiles - Amphibians

A total of nine reptile species (seven lizards and two snakes) and two amphibian species were recorded. Table 5 presents a summary of the results for reptiles and amphibians, and Table A3 provides the detailed data.

Three of the reptile species and both amphibian species are endemic species/subspecies (*Acanthodactylus schreiberi schreiberi*, *Laudakia cypriaca*, *Phoenicolacerta troodica*, *Bufo cypriensis*, *Pelophylax cypriensis*), while three reptile species are listed in Annex III of Law 153(I)/2003 of the Republic of Cyprus for the protection and management of nature and wildlife, as species of Community interest that require strict protection [*Chalcides ocellatus*, *Dolichophis jugularis* (listed as *Coluber jugularis*), and *Laudakia cypriaca* (listed as *Stellio stellio*)].

The most common species were *Ophisops elegans*, *Acanthodactylus schreiberi*, and *Laudakia cypriaca*, in terms of both individual numbers and the number of sites where they were recorded (18, 9, and 11 respectively). Five species were recorded at only one site each, either within restoration sites or outside the quarries.

The richest sites in terms of reptile and amphibian abundance were the two sites in Androlykou and the off-quarry site in Farmakas. Regarding species richness, the richest site was the off-quarry site in Xylofagou (6 species), followed by the restoration sites in Androlykou, Mitsero, and Mosfiloti (each with 5 species).

According to the one-way ANOVA, there was no statistically significant difference in the number of reptile and amphibian species between restoration sites and off-quarry sites, either in terms of species richness ($F = 0.11$, $P \gg 0.05$ – Levene’s test $P \gg 0.05$) or abundance ($F = 0.78$, $P \gg 0.05$ – Levene’s test $P \gg 0.05$). Likewise, the paired t-test analysis between restoration and off-quarry sites showed no statistically significant differences in either species richness ($t = 0.27$, $P \gg 0.05$) or abundance ($t = -1.55$, $P > 0.05$).

Due to significant differences in abiotic and biotic characteristics between sites, multimodel inference analysis was performed separately for restoration and off-quarry sites. The results (Table 6) showed a significant effect on reptile diversity from the presence of refuges across all sites, and of available open area only in off-quarry sites.

The cluster analysis (Figure 13) did not reveal a grouping trend by quarry or by site type.

Table 5. Summary results for reptiles and amphibians per sampling site. For each site, the following are provided: total number of species, abundance (number of individuals), diversity indices (Simpson, Shannon-Wiener, and Fisher's α), equitability, and an estimate of the true number of species using the Chao-1 index. The three highest values in each column are shown in bold, except for the equitability column, in which the lowest values are highlighted, indicating dominance by a single species.

		No. of Species	Abundance	Simpson	Shannon	Equitability	Fisher's α	Chao-1
Ag. Sozomenos	Restored	3	34	0.493	0.769	0.700	0.794	3
	External	2	37	0.150	0.281	0.406	0.453	2
Androlykou	Restored	4	38	0.708	1.296	0.935	1.128	4
	External	5	59	0.640	1.196	0.863	0.975	4
Farmakas	Restored	2	18	0.494	0.687	0.991	0.576	2
	External	3	38	0.555	0.896	0.816	0.764	3
Mitsero	Restored	5	20	0.620	1.163	0.723	2.140	8
	External	2	21	0.091	0.191	0.276	0.544	2
Mosfiloti	Restored	5	18	0.383	0.838	0.521	2.293	11
	External	3	15	0.240	0.485	0.442	1.128	4
Parekklesia	Restored	3	17	0.215	0.444	0.404	1.057	4
	External	4	22	0.485	0.791	0.720	0.979	3
Pyrga	Restored	2	10	0.180	0.325	0.469	0.752	2
	External	2	16	0.219	0.377	0.544	0.603	2
Sia	Restored	4	25	0.566	0.964	0.695	1.344	5
	External	1	14	0	0	-	0.247	1
Vasa	Restored	2	24	0.413	0.604	0.871	0.519	2
	External	3	21	0.390	0.709	0.645	0.958	3
Xylofagou	Restored	1	1	0	0	-	0	1
	External	6	15	0.604	1.297	0.724	3.706	9

Table 6. Results of the multimodel inference analysis to identify which of the examined variables affect reptile diversity (based on the Shannon-Wiener index). UC: Unstandardized Coefficient, SC: Standardized Coefficient, RI: Relative Importance.

Reptile Diversity in Restored Sites			
	$R^2 = 0,93$		
Parameter	UC	SC	RI
Shelters	0.642	0.946	1
Temperature	-1.060	-0.134	0,11
Reptile Diversity in Non-Restored Sites			
	$R^2 = 0.63$		
Parameter	UC	SC	RI
Shelters	1.764	1.110	1
Open Area	2.464	0.906	0.65

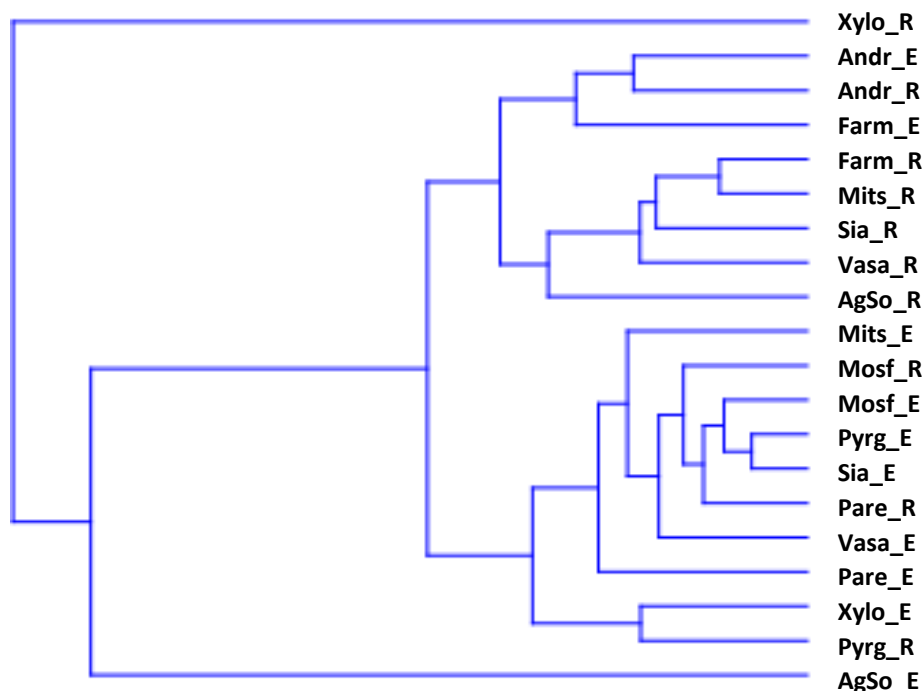


Figure 13. Cluster analysis of the sampling sites based on reptile abundance (UPGMA, Bray-Curtis similarity index). The sites are grouped independently of quarry and site type [restoration (A) or non-quarry (E)]. A similar pattern (not shown here) was observed when considering only species presence (Jaccard similarity index). (Abbreviations as in Fig. 10.)

Beetles

Family Carabidae

The summary results for Carabidae beetles are presented in Table 7, with detailed data in Table A4.

A total of 64 species were recorded. Most of them (56) were found during the spring sampling period, with only eight species added in the autumn (and 29 from the spring not found again). The most abundant species were *Calathus reflexus*, *Bembidion curtulum*, and *Microlestes luctuosus*. Six endemic species and/or subspecies were found, five of which were recorded exclusively outside quarry sites.

No species was recorded in all quarry sites, while 25 species were found at only one site and 16 species at only two. These species were mostly recorded in Xylofagou, Androlykou, and Mosfiloti, both inside and outside quarries. A clear indication of habitat heterogeneity is that the most abundant species was found in only five sites: Farmakas (outside), Parekklesia (restoration), Pyrga (outside), and Sia (both outside and restoration).

The richest sites in terms of species were the non-quarry site in Mitsero (17 species), the non-managed site inside the quarry in Androlykou, and the restoration site in Agios Sozomenos (16 species each). According to the Chao-1 estimator, the sites with the highest estimated actual species richness were Androlykou (outside), Agios Sozomenos (restoration), and Mosfiloti (outside) and Pyrga (restoration), both with equal species richness. The most abundant sampling sites were found in Pyrga, Androlykou, and Sia, all outside quarry areas. In contrast, the poorest sites were Vasa (both outside and restoration) and Parekklesia (outside).

Regarding diversity indices, no consistent pattern was observed, with high values found in both restoration and outside-quarry sites. Fisher's α , which is generally considered independent of sample size, gave notably higher values in two restoration sites. Also worth noting is that the evenness index showed very low values only in the three areas with the highest abundance, reflecting the dominance of a single species with much greater abundance than the others.

According to the one-way ANOVA, there were no statistically significant differences between restoration and non-quarry sites in terms of abundance ($F = 1.42$, $P > 0.05$ – Levene's test $P > 0.05$) or number of Carabidae species ($F = 0.49$, $P \gg 0.05$ – Levene's test $P \gg 0.05$). Likewise, the paired t-test between restoration and outside sites did not reveal statistically significant differences in either abundance ($t = -1.29$, $P > 0.05$) or species richness ($t = -0.46$, $P \gg 0.05$).

The cluster analysis (Figure 13) did not show a grouping trend either by quarry or by site type.

Table 7. Summary results for beetles of the family Carabidae by sampling site. For each site, the following are provided: the total number of species, abundance (number of individuals collected), the diversity indices Simpson, Shannon-Wiener, and Fisher's α , equitability, and an estimate of the true number of species according to the Chao-1 index. The three highest values in each column are shown in bold, except for the equitability column, where the lowest values are highlighted, indicating dominance by a single species.

		No. of species	Abundance	Simpson	Shannon	Equitability	Fisher's α	Chao-1
Ag. Sozomenos	Restored.	16	60	0.776	2.051	0.740	7.139	34.00
	External.	7	38	0.540	1.199	0.616	2.520	7.25
Androlykou	Unmanag ed.	16	79	0.882	2.345	0.846	6.055	26.50
	Restored.	14	57	0.784	2.039	0.773	5.925	16.50
	External.	12	104	0.462	1.109	0.446	3.505	40.00
Farmakas	Restored.	10	51	0.833	1.993	0.866	3.719	10.33
	External.	6	21	0.776	1.617	0.902	2.806	6.00
Mitsero	Restored.	7	14	0.827	1.847	0.949	5.571	7.20
	External.	9	68	0.596	1.406	0.640	2.780	9.50
Mosfiloti	Restored.	12	19	0.886	2.333	0.939	13.980	21.33
	External.	17	52	0.861	2.348	0.829	8.792	29.00
Parekklisia	Restored.	8	66	0.393	0.938	0.451	2.383	9.00
	External.	4	7	0.694	1.277	0.921	3.878	4.50
Pyrga	Restored.	8	16	0.656	1.537	0.739	6.367	29.00
	External.	7	125	0.220	0.523	0.269	1.602	10.00
Sia	Restored.	9	13	0.864	2.098	0.955	12.940	14.00
	External.	6	103	0.331	0.688	0.384	1.389	6.33
Vasa	Restored.	3	4	0.625	1.040	0.946	5.453	3.50
	External.	5	7	0.776	1.550	0.963	7.824	6.00
Xylofagou	Restored.	8	66	0.638	1.331	0.640	2.383	14.00
	External.	15	61	0.886	2.399	0.886	6.353	16.50

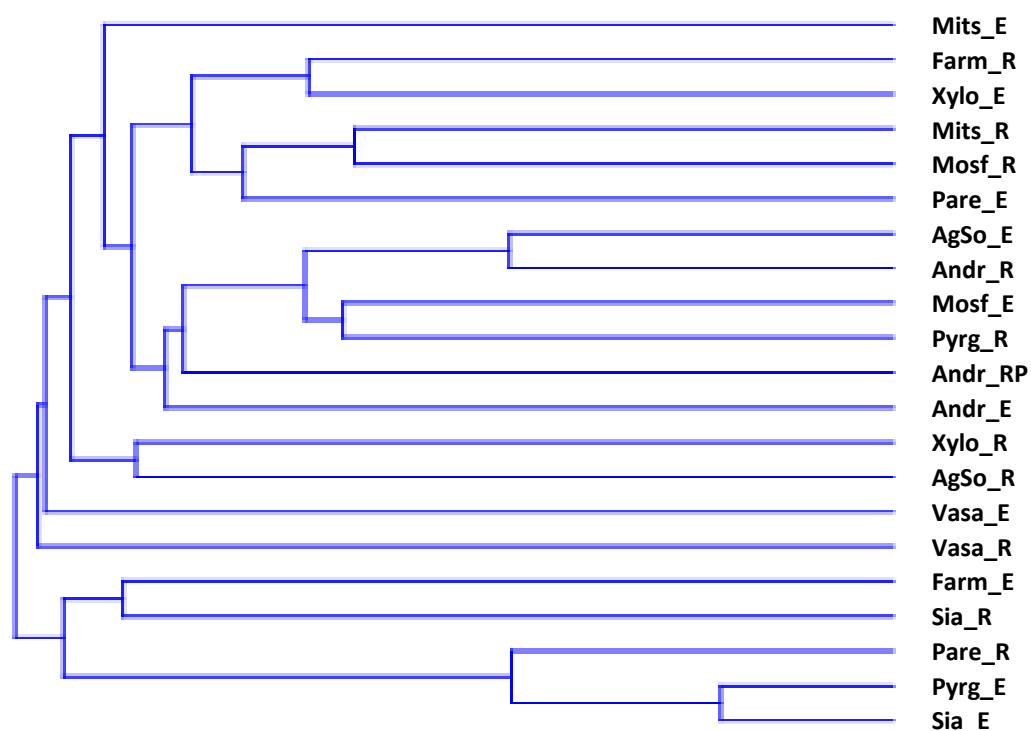


Figure 14. Cluster analysis of the sampling sites based on the abundance of Carabidae beetles (UPGMA, Bray-Curtis similarity index). The sites are grouped independently of the quarry and whether they are located within (restoration, -A) or outside (-E) the quarry. A similar pattern (not shown here) is observed when using species presence data only (Jaccard similarity index). (Abbreviations as in Fig. 10, plus Andr_RP that corresponds to the passive restoration site studied only for ground beetles and isopods.)

Family Tenebrionidae

The summary results for the beetles of the family Tenebrionidae are presented in Table 8 and the detailed results in Table A5. In total, 33 species were recorded. All of them were recorded during the spring sampling period, while only six were found during the autumn period, across nine sampling sites. The most abundant species were *Zophosis punctata*, *Tentyria cypria*, and *Apentanodes globosus*. Eight endemic species and/or subspecies were found, both in restoration sites and in sites outside the quarries.

No species was found in all quarries, while 10 species were recorded at a single site and another four at only two. The majority of these species were found in Xylofagou, mostly in the site outside the quarry. The most abundant species was found at 18 sites (all except the restoration sites in Xylofagou and Sia, and the unmanaged site in Androlykou). The richest sites in terms of species were the outside-quarry sites in Xylofagou and Mosfiloti (12 species each) and Vasa (12 species). These same sites were also identified as the richest in species according to the Chao-1 estimator. The sites with the greatest abundance were those outside the quarries in Xylofagou, Vasa, and Pyrga. In contrast, the poorest were the restoration sites in Sia, Agios Sozomenos, and Androlykou.

Regarding diversity indices, there is no consistent pattern, with both restoration and outside sites showing high values, and with disagreement among the indices. Fisher's α , generally

considered independent of sample size, notably gives the highest values in three restoration sites! Also, it should be noted that the equitability index does not show very low values, only intermediate ones in three areas that do not have particularly high abundance. This suggests that no single species strongly dominates those communities.

According to the non-parametric analysis of variance (Kruskal-Wallis – as Levene's test showed a significant result with $P < 0.01$), there is a statistically significant difference between restoration and outside-quarry sites regarding the abundance of Tenebrionidae (K-W = 8.26, $P < 0.005$), with outside-quarry sites showing higher abundance values (mean outside = 134 vs. mean restoration = 29.5). In contrast, there is no statistically significant difference in the number of species between restoration and outside sites (one-way ANOVA $F = 2.74$, $P > 0.05$ – Levene's test $P > 0.05$). Furthermore, the paired analysis of restoration and outside sites (paired t test) showed statistically significant differences in both abundance ($t = -4.19$, $P < 0.005$) and number of species ($t = -2.31$, $P = 0.046$), although the latter was marginal. In both cases, the outside-quarry sites showed higher values. The cluster analysis (Figures 15, 16) showed a tendency for grouping by site type (restoration – outside) in terms of abundance, and a weaker tendency by quarry regarding species composition.

Table 8. Summary results for Tenebrionidae beetles per sampling site. For each site, the following are provided: the total number of species, abundance (number of individuals collected), the diversity indices Simpson, Shannon-Wiener, and Fisher's α , equitability, and the estimated true number of species according to the Chao-1 index. The three highest values in each column are shown in bold, except in the equitability column, where the lowest values are highlighted, indicating the dominance of a single species.

		No. of Species	Αφθονία	Simpson	Shannon	Equitability	Fisher's α	Chao-1
Ag. Sozomenos	Restored	4	6	0.667	1.242	0.896	5.245	7
	External	7	133	0.557	0.968	0.497	1.573	8.5
Androlykou	Unmanag ed.	2	16	0.219	0.379	0.544	0.603	2
	Restored	6	13	0.781	1.631	0.911	4.322	9
	External	4	30	0.187	0.435	0.318	1.240	7
Farmakas	Restored	5	41	0.303	0.675	0.419	1.493	5.5
	External	6	81	0.398	0.780	0.435	1.496	7.5
Mitsero	Restored	9	47	0.742	1.693	0.770	3.306	10.5
	External	7	100	0.381	0.883	0.454	1.714	8
Mosfiloti	Restored	9	26	0.713	1.689	0.769	4.877	10.5
	External	12	113	0.553	1.377	0.554	3.395	13
Parekklesia	Restored	5	40	0.746	1.439	0.894	1.508	5
	External	8	155	0.512	1.062	0.511	1.788	8.3
Pyrga	Restored	5	26	0.630	1.210	0.752	1.841	6
	External	9	225	0.541	0.952	0.433	1.877	9.8
Sia	Restored	3	4	0.625	1.040	0.946	5.453	3.5
	External	3	11	0.562	0.917	0.834	1.359	3
Vasa	Restored	7	78	0.598	1.187	0.610	1.862	7.5
	External	10	234	0.684	1.420	0.617	2.122	11.5
Xylofagou	Restored	6	14	0.776	1.611	0.899	3.978	9
	External	12	258	0.809	1.858	0.748	2.606	13.5

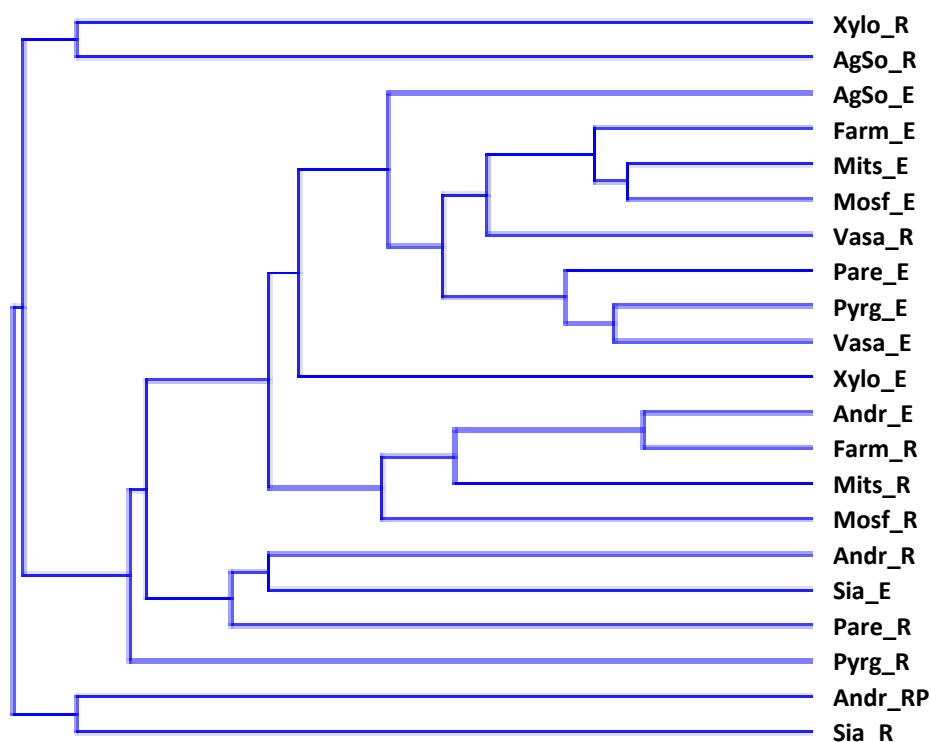


Figure 15. Cluster analysis of the sampling sites based on the abundance of Tenebrionidae beetles (UPGMA, Bray-Curtis similarity index). With some exceptions, the sites are grouped independently of the quarry but based on whether they are located within (restores, -A) or outside (-E) the quarries. (Abbreviations as in Fig. 14.)

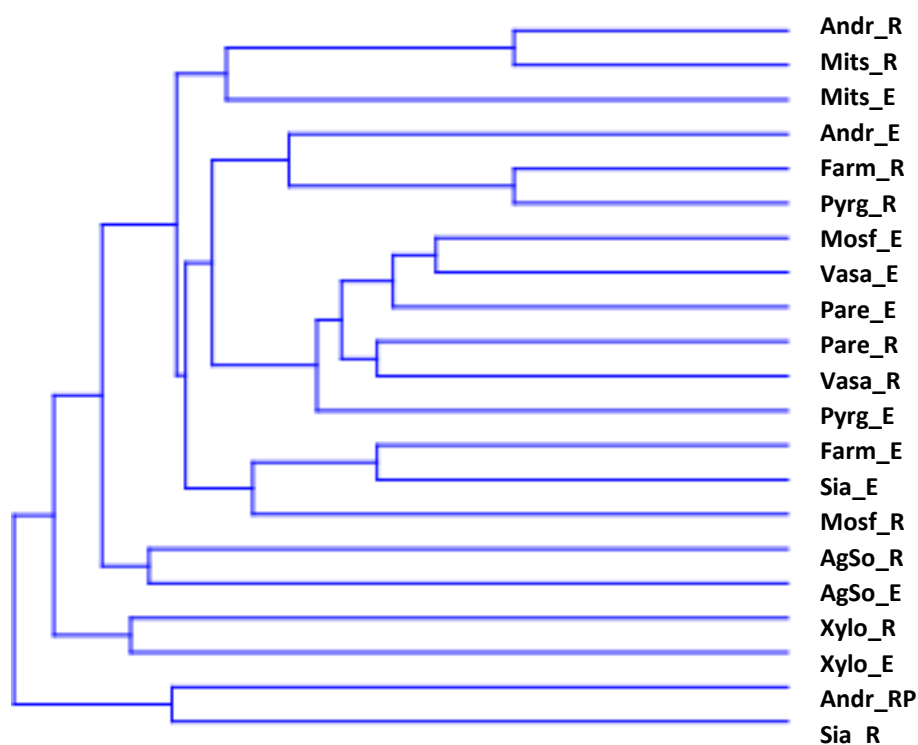


Figure 16. Cluster analysis of the sampling sites based on the species composition of beetles of the family Tenebrionidae (UPGMA, Jaccard similarity index). There is no clear clustering trend, although some tendency for grouping by quarry or by proximity of quarries is observed. (Abbreviations as in Fig. 14.)

Family Buprestidae

The records for beetles of the family Buprestidae were qualitative in nature, providing presence/absence data of species, which are presented in Table A6. A total of 42 species were recorded, of which seven are endemic to Cyprus (with an additional nine endemic subspecies). No species was found in all sampling sites. The most widespread species were *Acmaeodera flavolineata cypricola* (an endemic subspecies, in 16 sites), *Anthaxia preclara* (12 sites), and *Acmaeodera ceylonensis* (an endemic species, in 11 sites). All were found both in restoration and in external quarry sites. Six species were found in only one site and another eight in two sites, scattered across several quarries, both in restoration and external areas.

The richest sites were all outside quarries, specifically in Vasa (29 species), Parekklesia (28), and Farmakas (25).

According to the one-way analysis of variance (ANOVA), there is no statistically significant difference in the number of Buprestidae species between restoration and external quarry sites ($F = 1.33$, $P > 0.05$ – Levene’s test $P > 0.05$). On the contrary, the paired t-test analysis between restoration and external sites showed marginally significant differences in the number of species ($t = -2.26$, $P = 0.05$), with slightly higher values in the external sites (mean: $E = 13$, $R = 8.3$). The cluster analysis (Figure 17) did not show a grouping trend either by quarry or by site type.

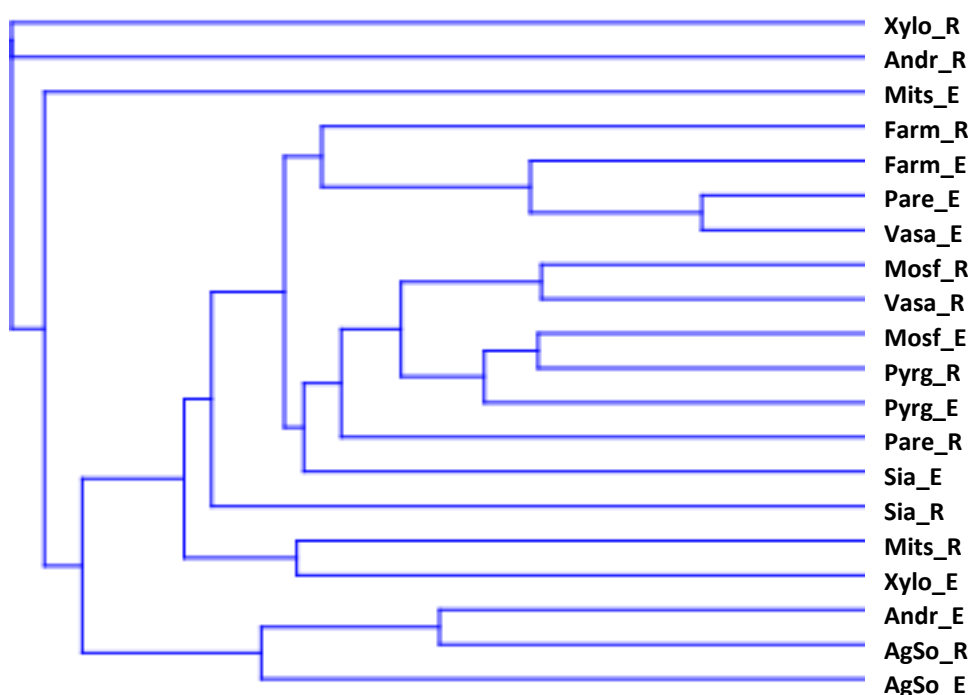


Figure 17. Cluster analysis of the sampling sites based on the species composition of beetles from the family Buprestidae (UPGMA, Jaccard similarity index). There is no grouping trend according to quarry or site type (restoration or external). (Abbreviations as in Fig. 10.)

Butterflies

The butterfly records were qualitative in nature, providing presence/absence data for each species, as presented in Table A7. A total of 35 species were recorded, including all six endemic species and subspecies of Cyprus (*Allanacstria cerisyi cypria*, *Hipparchia syriaca cypriaca*, *Hipparchia cypriensis*, *Chazara briseis larnacana*, *Maniola cypricola*, and *Glaucopsyche paphos*). Two species were found in all recording sites (*Pieris brassicae* and *Colias croceus*). In addition to these, *Pieris rapae*, *Vanessa cardui*, and *Lycaena phlaeas* were also widespread (recorded in 18 sites, all except Xylofagou). Only one species (*Pelopidas thrax*) was recorded at a single site, specifically the restored part of the Agios Sozomenos quarry.

The richest sites in terms of species were the restored parts of the quarries at Parekkklisia (28), Vasa (26), Farmakas and Mosfiloti (23), as well as the external part of the Androlykou quarry (23).

According to the non-parametric Kruskal-Wallis variance analysis (as Levene's test showed statistical significance: $P < 0.005$), there was no statistically significant difference in the number of butterfly species between restored parts and external parts of the quarries ($K-W = 0.036$, $P \gg 0.05$). The paired t-test analysis between restored and external parts of the quarries also showed no significant difference in the number of species ($t = 0.35$, $P \gg 0.05$).

The cluster analysis (Figure 18) showed a mixed pattern of grouping, with some sites clustering by quarry (Xylofagou, Mitsero, Agios Sozomenos), others by site type (restored or external – Parekkklisia, Vasa), and others without a clear pattern (Androlykou, Farmakas, Sia, Mosfiloti, Pyrga).

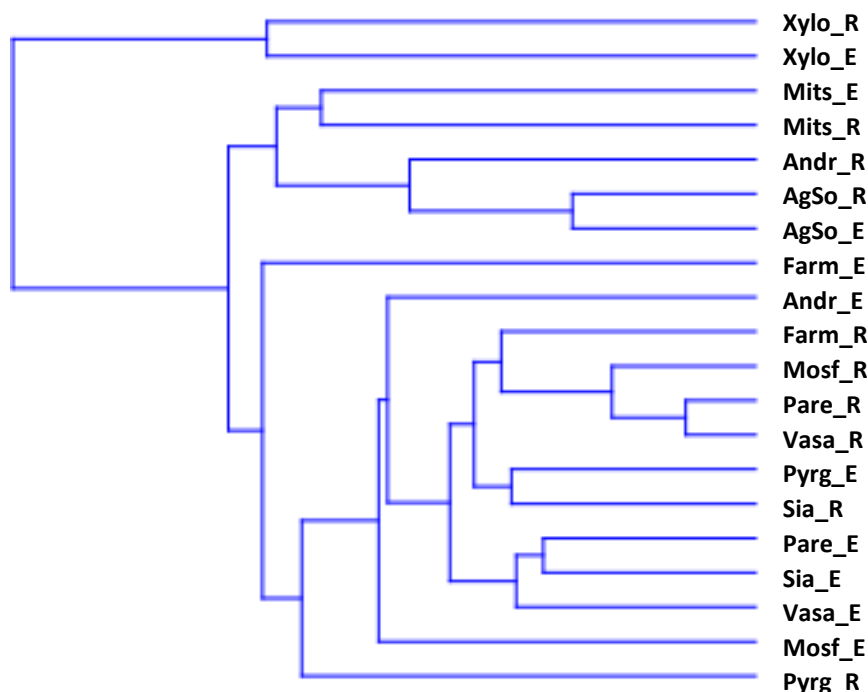


Figure 18. Cluster analysis of the recording sites based on butterfly species composition (UPGMA, Jaccard similarity index). A mixed clustering pattern is observed, with certain sites grouping by quarry (Xylofagou, Mitsero, Agios Sozomenos), others by site type (restored or external part – Parekkklisia, Vasa), and others showing no specific pattern (Androlykou, Farmakas, Sia, Mosfiloti, Pyrga). (Abbreviations as in Fig. 10.)

Terrestrial Isopods

The summary results for terrestrial isopods (Crustacea, Malacostraca, Isopoda, Oniscidea) are presented in Table 9, with detailed results in Table P8. A total of 23 species were recorded. Most (21) were recorded during the spring sampling period, while 13 were found in the autumn, only two of which had not been observed in the spring. The most abundant species were *Armadillidium marmoratum*, *Schizidium fissum*, and *Armadillo konstantinou*. Four species are endemic to Cyprus (*Porcellio mavromoustakisi*, *Porcellionides cyprius*, *Schizidium christosi*, and *Armadillo konstantinou*) and were found both in restored parts of quarry sites (except the first) and in sites outside the quarries. No species was found in all quarries, while six species were found in only one site, and another five in only two. These species were recorded across various sites, both inside and outside the quarries. The most abundant species was found only in the two sites (restored and external parts) of Agios Sozomenos, Androlykou, and Mitsero. The most widespread species was the endemic *A. konstantinou*, found in all quarries except Xylofagou, where its cryptic counterpart *A. officinalis* was recorded (the two species are morphologically indistinguishable and can be identified only at the genetic level).

The richest sites in terms of species were the external quarry sites in Androlykou (nine species) and Xylofagou (seven), and the restored part in Mosfiloti (eight). According to the Chao-1 estimator, the sites with the highest estimated actual species richness were the external site in Androlykou, the restored part of Agios Sozomenos, and equally the external site in Mosfiloti and the restored part in Pyrga. The sites with the highest abundance of individuals were the restored parts of Androlykou and Agios Sozomenos, and the external site in Parekklesia. In contrast, the lowest abundances were found in the restored parts of Parekklesia, Sia, and Xylofagou.

Regarding diversity indices, no consistent pattern was observed, with high values recorded in both restored and external sites. The Fisher's α index, generally considered independent of sample size, showed higher values in two restored sites. Furthermore, the equitability index showed very low values in two of the three sites with the highest abundance, reflecting the dominance of a single species in those communities. Conversely, in the restored part of Agios Sozomenos, despite the relatively high abundance, equitability was high, indicating a more balanced community.

According to the one-way ANOVA, there was no statistically significant difference between restored and external sites in either abundance ($F = 0.46$, $P \gg 0.05$ – Levene's test $P \gg 0.05$) or the number of terrestrial isopod species ($F = 0.16$, $P \gg 0.05$ – Levene's test $P \gg 0.05$). Similarly, the paired t-test analysis between restored and external sites showed no statistically significant differences in either abundance ($t = -0.62$, $P \gg 0.05$) or species richness ($t = 0.40$, $P \gg 0.05$). The cluster analysis (Figures 19, 20) did not show a grouping trend either by quarry or by site type in terms of abundance, but a trend was observed by quarry in terms of species composition.

Table 9. Summary results for terrestrial isopods per sampling site. For each site, the total number of species, abundance (number of individuals collected), diversity indices (Simpson, Shannon-Wiener, and Fisher's α), equitability, and estimated actual species richness (Chao-1 index) are presented. The three highest values in each column are shown in bold, except for equitability, where the lowest values are highlighted, indicating dominance by a single species.

		No. Of species	Abundance	Simpson	Shannon	Equitability	Fisher's α	Chao-1
Ag Sozomenos	Restored	5	290	0.708	1.345	0.836	0.858	5
	External	6	52	0.649	1.254	0.700	1.753	6
Androlykou	Unmanaged	3	458	0.034	0.095	0.086	0.430	3
	Restored	9	63	0.727	1.601	0.729	2.873	15
	External	5	228	0.149	0.360	0.224	0.903	5
Farmakas	Restored	5	59	0.586	1.046	0.650	1.304	5
	External	5	27	0.716	1.383	0.859	1.805	5
Mitsero	Restored	5	44	0.685	1.309	0.813	1.452	5
	External	5	25	0.739	1.450	0.901	1.879	5
Mosfiloti	Restored	8	56	0.700	1.460	0.702	2.554	9
	Εξωτ.	4	47	0.589	1.023	0.738	1.045	4
Parekklesia	Restored	3	8	0.531	0.900	0.819	1.743	3
	External	3	277	0.130	0.295	0.269	0.470	3
Pyrga	Restored	5	60	0.683	1.278	0.794	1.297	5
	External	4	23	0.616	1.103	0.800	1.399	4
Sia	Restored	4	13	0.556	1.032	0.744	1.974	5
	External	5	31	0.712	1.412	0.877	1.687	5
Vasa	Restored	3	19	0.460	0.766	0.697	1.002	3
	External	3	131	0.088	0.207	0.188	0.547	3
Xylofagou	Restored	3	13	0.462	0.790	0.719	1.223	3
	External	7	49	0.765	1.594	0.819	2.235	7.5

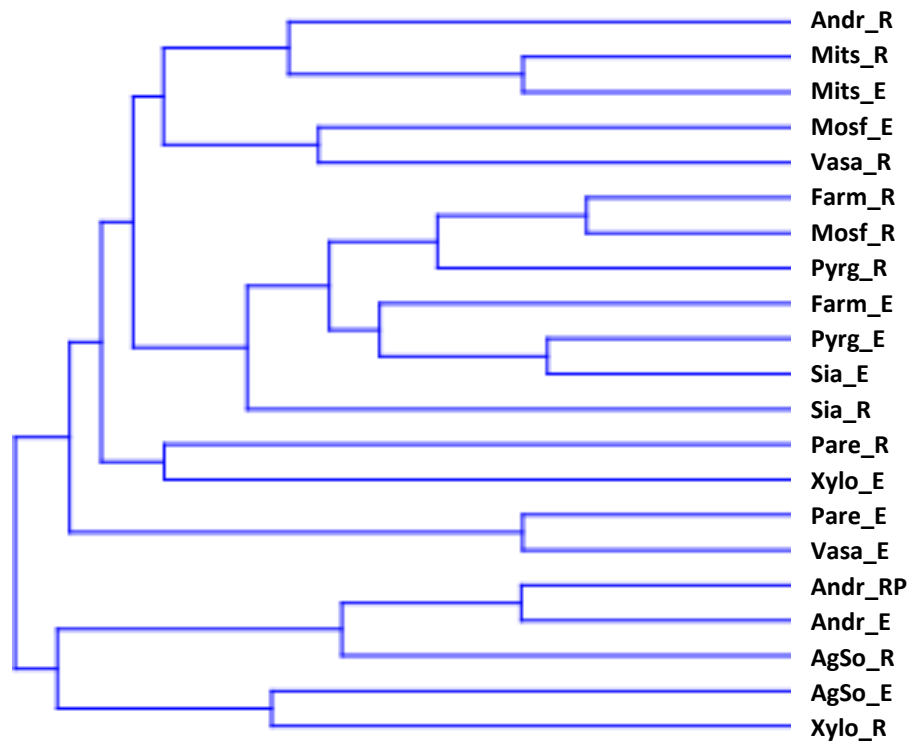


Figure 19. Cluster analysis of the sampling sites based on the abundance of terrestrial isopods (UPGMA, Bray-Curtis similarity index). The sites are grouped independently of the quarry and whether they are located within (restored part, -A) or outside (-E) the quarries. (Abbreviations as in Fig. 14.)

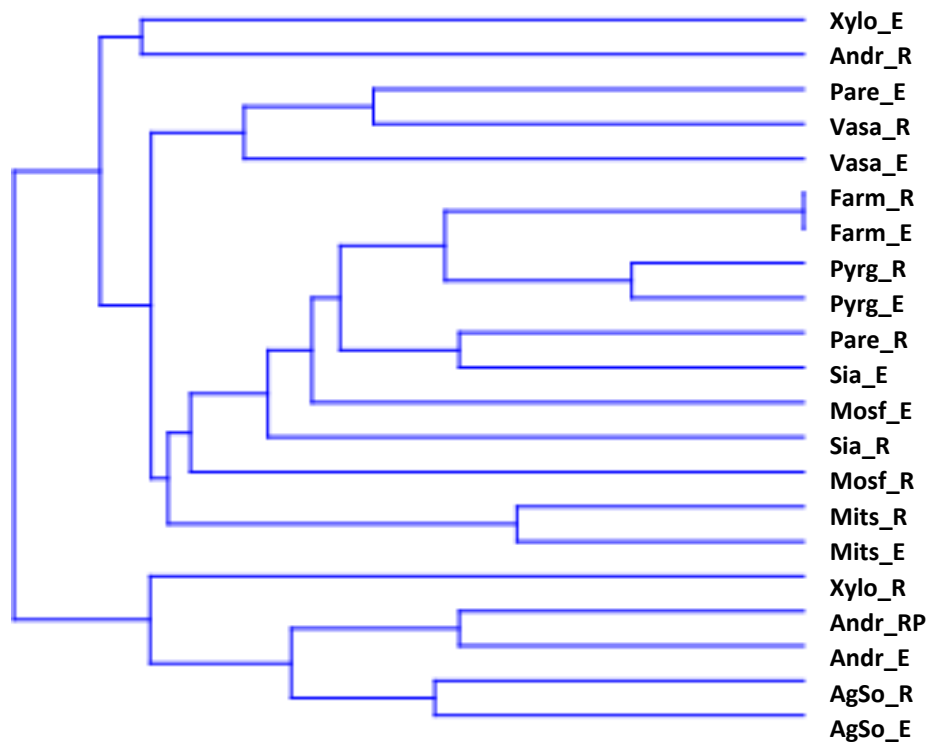


Figure 20. Cluster analysis of the sampling sites based on the species composition of terrestrial isopods (UPGMA, Jaccard similarity index). A certain tendency of grouping by quarry or by proximity of quarries is observed. (Abbreviations as in Fig. 14.)

SUMMARY OF THE RESULTS

- Biodiversity at the sites both within and outside the quarries studied can generally be considered high, with a large number of recorded species relative to the area surveyed and/or the high levels of disturbance from quarrying activities.
- Biodiversity in the restoration sites generally does not show significant differences from that of neighboring sites outside the quarries.
- This similarity suggests that biodiversity within quarries is significantly influenced by the presence and good condition of natural/semi-natural habitats in the surrounding and adjacent areas.
- The different organism groups exhibit variation in their patterns of occurrence, with plants and birds mainly clustering by quarry, other groups by site type (restoration or outside quarry), and some independent of either quarry or site type.
- There is a tendency for more endemic species to be found outside the quarries, and more invasive and other human-tolerant species to occur in restoration sites — a factor that should be considered in future restoration efforts.
- The presence of water collections within quarries constitutes a significant factor in shaping biodiversity, especially for birds, with several species recorded exclusively in these features.
- Overall, quarries do not appear to negatively impact the overall state of biodiversity (at least for the organism groups studied) in the areas where they are located.

*It is understood that the above findings do not address other dimensions of quarry operations that may affect biodiversity, such as impacts on specific conservation-interest species not included in this study (e.g., the fruit bat or other bat species). The study also does not cover other environmental issues, such as landscape alteration, pollution, or socio-economic aspects.

SPECIFIC OBSERVATIONS

In addition to the general findings, several targeted observations were made regarding the overall status of biodiversity and specific species groups. Quarries have introduced a variety of semi-natural and man-made habitats—such as industrial structures, water bodies, and rock outcrops—into native Mediterranean ecosystems like phrygana, pine forests, shrublands, and agricultural landscapes. Despite their disturbed nature, these habitats support diverse fauna thanks to increased structural complexity and water availability. For instance, man-made structures are inhabited by birds such as the Spanish Sparrow (*Passer hispaniolensis*) and House Sparrow (*Passer domesticus*), along with the Common Kestrel (*Falco tinnunculus*). Rock-crevice specialists such as the Cyprus Wheatear (*Oenanthe cypriaca*) and the Blue Rock Thrush (*Monticola solitarius*) also breed or forage in less active quarry zones. Quarry water bodies—especially those surrounded by vegetation like reedbeds—support species such as the Cetti's Warbler (*Cettia cetti*) and Eurasian Reed Warbler (*Acrocephalus scirpaceus*), as well as both endemic amphibians: the Cyprus Green Toad (*Bufo cypriensis*) and the Cyprus Water Frog (*Pelophylax cypriensis*). Predatory birds also frequent these areas to hunt, taking advantage of the open terrain. Field observations revealed several threats to biodiversity, accompanied by recommended conservation actions where feasible.

1. Habitat Loss

The very alteration of the landscape and the removal of topsoil inevitably lead to habitat loss, which, in most cases, is effectively permanent. Therefore, restoration measures are necessary for all quarry sites, depending of course on their current and/or future operational use. Restoration efforts should aim to re-establish the types of habitats that previously existed in the area, taking into account the habitats surrounding the quarries. Beyond this primary goal, it is also both appropriate and desirable to enhance biodiversity wherever possible (see below). Of particular importance is the assessment of soil condition, as the removal of topsoil during quarrying activities is expected to have led to increased erosion and/or decreased fertility. As such, the planting and maintenance of native tree species can significantly contribute to restoration—at least in most cases. Finally, the diversity of plant species used in restoration must also be considered, as greater plant variety will in turn support greater faunal diversity.

2. Invasive Plant Species

Habitat degradation and disturbance often facilitate the spread of invasive plant species in restoration areas (see Table P1). The most common invasive species found in the studied quarries include the tree tobacco (*Nicotiana glauca*) and acacias (*Acacia* spp.), while *Oxalis pes-caprae* is also widespread. Other significant invasive species (e.g., *Lycium ferocissimum* and *Dodonaea viscosa* – see Image 21) appear in only a few locations, which makes their control and the prevention of their spread to other sites more manageable. It is important to address the spread of these species—at least those for which control is feasible—both within

restoration sites and around quarry perimeters. This can be done through regular removal efforts, at least until native vegetation becomes well established.



Figure 21. Spread of the invasive species *Dodonaea viscosa* in the habitats surrounding the Mitsero quarry. (Photo: Ch. Makris)

3. Dust

Dust produced during various stages of quarrying activity (e.g., see Fig. 22) inevitably travels considerable distances into surrounding ecosystems, causing problems for the reproduction of many species as well as hindering photosynthesis. It is important to minimize both the production and dispersion of dust as much as possible (e.g., through regular watering of soil surfaces).



Figure 22. Dust in the Farmakas quarry. (Photo: Ch. Makris)

4. Drying

The presence of quarries inevitably leads to a reduction in soil moisture in areas surrounding soil extraction sites, which can seriously affect both vegetation and some segments of the fauna. It is crucial that water extracted or pumped during quarry operations is used in environmentally responsible ways—such as creating water collection ponds to support conservation (e.g., for waders, amphibians) in the less disturbed parts of the quarries. This water can also be used to irrigate restoration areas. Existing water bodies in several quarries are already attracting important species of flora and fauna and should be preserved in the long term to enrich local biodiversity. Relevant studies by qualified environmental engineers are necessary to ensure proper implementation.

5. Light Pollution

Light pollution is one of the most underestimated environmental threats to components of biodiversity. It is important that lighting is used with discretion—only where and when absolutely necessary. The use of motion sensors or photocells should be prioritized in areas where constant lighting is not required. Additionally, downward-facing lighting should be preferred over traditional general-purpose floodlights. Light intensity should also be regulated and not exceed 1600 lumens per source. The maximum color temperature should remain below 2700 Kelvin to avoid biologically disruptive colors (especially white and blue light). Red light is considered acceptable for permanent lighting sources (e.g., on top of buildings).

6. Noise and Blasting

Although no specific observations or measurements were made regarding this issue, it is expected that the noise from blasting in quarry areas causes some level of disturbance to certain species, especially birds and mammals. These disturbances are typically brief and localized, but it is still important to consider the potential impact on habitat usage by some species near or within quarry zones. While blasting is an unavoidable part of quarry operations, it could be scheduled at times that minimize disturbance (e.g., not near dusk or early morning), particularly during the breeding season or peak bird migration periods (e.g., April–June and October).

7. Ecological Traps

The water bodies formed from excess water accumulation often attract waders and other aquatic or water-dependent organisms to quarry sites. While this phenomenon has clear positive aspects, it may also lead to adverse impacts—particularly in cases of sudden drying of these water bodies. Such abrupt drying events were observed in some locations (e.g., Sia and Farmakas), resulting in the affected organisms being left without sufficient water. Many of these species, such as *Gallinula chloropus*, *Fulica atra*, *Tachybaptus ruficollis*, and most amphibians, are not able to relocate easily to alternative sites and are therefore at risk. For this reason, the creation of permanent water reservoirs in relatively isolated areas of each quarry is strongly recommended, to support the conservation of biodiversity associated with such habitats.

It goes without saying that general safety measures and environmental risk prevention—such as fire prevention, chemical spill control, etc.—as well as strict compliance with all relevant environmental legislation (e.g., disposal of plastics and rubber materials), are also critical for the protection of biodiversity and must be consistently observed.

A key factor supporting biodiversity within quarries is the availability of water year-round, which is not always the case in surrounding areas. Furthermore, when restoring a quarry area, it is essential to consider the preservation of the site's natural character in terms of landscape design—such as the presence of rocky formations, rock clusters, and the composition of the substrate. These features provide vital shelter that supports the return of associated biodiversity, including reptiles, arthropods, and small mammals. Also important is the presence of inaccessible vertical cliffs and rock piles (see Figure 23), which are preferred roosting or nesting sites for several bird species. These features help protect them from nocturnal predators and offer shelter to various other organisms.

Lastly, it must be emphasized that the natural habitats surrounding a quarry are of vital importance. Without them, the presence of many species within the quarry would not be possible. These surrounding areas serve as temporary refuges during peak quarry operation hours and provide a rich food supply for both insectivorous and granivorous birds.



Figure 23. Fox on a rock pile in Sia. (Photo: Ch. Makris)

RECOMMENDATIONS FOR IMPROVING THE EFFECTIVENESS OF QUARRY RESTORATION FROM A BIODIVERSITY PERSPECTIVE

Based on the biodiversity study conducted in 10 quarries across Cyprus by the University of Cyprus Research Team (March 2024 – February 2025), several observations emerged concerning the current restoration practices applied after the end of quarrying activities. Therefore, this document forms an integral part of the aforementioned study and constitutes one of the deliverables of the related project.

Quarry restoration is generally considered a challenging objective, as the long-term alteration of the landscape and the removal of substrate materials (excavations, blasting, stripping of topsoil) lead to numerous transformations of habitats and species' niches (Gentili et al. 2020, Mexia et al. 2020). Studies on quarry restoration have shown early colonisation and establishment of flora from nearby areas on abandoned sites, with beneficial effects on ground-dwelling arthropods (e.g., beetles, spiders: Baasch et al. 2012, Prach and del Moral 2015, Tropek et al. 2010, 2012), although the choice between passive and active restoration methods remains debated (Baasch et al. 2012, Mexia et al. 2020). The effectiveness of restoration in abandoned or rehabilitated quarry sites may not be immediate, or it may require specialised methodologies to ensure success, as numerous factors may play a critical role — such as the type of habitat surrounding the quarry and its biodiversity, as well as the selection of restoration components (e.g., native vs. exotic flora) in relation to the undisturbed surrounding area (Zhang et al. 2018).

In this study, we compared biodiversity between undisturbed adjacent areas and actively restored sites within the quarries, with the exception of one site in Androlykou, where an additional abandoned site was also examined. Below are observations and recommendations aimed at improving restoration efforts both on a case-by-case basis and more generally.

Agios Sozomenos

At Agios Sozomenos, areas with sandy surface soils have formed due to the deposition of excavation by-products. Temporary water bodies appear, mainly from late autumn to early summer (November–June), along with some permanent ponds surrounded by reedbeds and other vegetation. These areas are of particular importance for biodiversity and should be safeguarded.

A concern is the growth and dominance of invasive acacias (*Acacia* sp.), especially on the edges of the restoration zones. The dominance of acacias may hinder the establishment of native plant species, preventing the restored areas from integrating with the surrounding habitats. Although some unique species were recorded in the restored area, concerns remain regarding its long-term viability. Therefore, it is recommended that acacias be removed where feasible, and native plant species from the local flora be planted.

It is also important to attempt the re-establishment of *Ornithogalum trichophyllum*, a species listed as Vulnerable (VU) in the Red Data Book of the Flora of Cyprus, in the restored areas. This must be done with the permission, guidance, and supervision of the Forestry Department.

Additionally, it is strongly recommended to preserve the temporary and permanent water bodies, as they attract and provide suitable habitat for a variety of taxa — from beetles to amphibians and birds (Ngongolo & Mtoka 2013; Kettermann & Fartmann 2023). Their preservation, of course, requires the involvement of environmental engineers, given the limited water availability in the area.

Androlykou

This is the only quarry where data were collected from both active restoration (with *Ceratonia siliqua* and xerophytic shrubs on rocky soil) and passive restoration (herbaceous vegetation on sandy soil with temporary water bodies). The abandoned area favors hygrophilous beetle species (e.g., *Chlaenius vestitus*, *Agonum nigrum*) as well as less common species (e.g., *Ascapthidion cyprium*, *Laena glabriuscula*) that were not found in the actively restored zone.

Although native flora has been planted in the actively restored area, mostly common beetle species were recorded there (e.g., *Bembidion curtulum mediorientis*, *Microlestes luctuosus luctuosus*, *Trechus saulcyanus*, *Syntomus impressus* and *S. fuscomaculatus*), in contrast to the passive restoration area. As with Agios Sozomenos, the temporary water body promotes the presence of several species even many years after abandonment (see also Walter et al. 2024). Thus, it is recommended to preserve temporary/seasonal water bodies.

It is also important to maintain both low vegetation and the presence of rocks, which provide shelter for ground-dwelling fauna (Hula and Šťastná 2010; Eufrazio et al. 2020). The absence of low vegetation and limited water availability — combined with homogeneous restoration — can negatively impact faunal communities, as it reduces habitat diversity and favors the dominance of generalist species over specialists and top-down regulating predators (Skalski et al. 2016).

Mitsero

The restoration at Mitsero is based on different soil compared to the habitat outside the quarry. The restoration is mainly characterized by low shrubs, as well as planted pine and cypress trees. Due to the different vegetation and soil, a different overall biodiversity is also expected.

Passive management and small-scale plantings of local species such as jujube (*Ziziphus lotus*), wild olive (*Olea europaea*), and azarole hawthorn (*Crataegus azarolus*) may be preferable at Mitsero, in order to maintain consistency in habitat types with the surrounding area. Although passive (spontaneous) restoration takes more time, it is expected to have longer-term outcomes.

Mosfiloti, Farmakas, Sia, Pyrga, Vasa, and Parekklesia

Restoration in these areas is based on pine planting, while various shrubs or herbaceous plants (Mosfiloti) have also developed, originating from surrounding areas. The restoration sites present open habitats with sparse trees. A notable absence of large predatory beetles (e.g., *Carabus anatolicus*, *Laemostenus cordicollis*) is observed, unlike the forest ecosystems (*Pinus brutia* with *Cistus* spp.) in Sia and Pyrga, where predatory and omnivorous species appear in high densities (e.g., high density of *Calathus reflexus*). The restoration sites also host pollinators and herbivorous species, such as *Omophlus propagatus* and *Megischia curvimana*, which is related to the ability of flying species to reach the sites, as opposed to ground-dwelling predatory species.

All restoration sites have some form of connectivity with the surrounding areas, although in Pyrga, supporting connectivity will have beneficial effects, as in Vasa, where creating corridors between the restoration site and areas outside the quarry will play an important role for biodiversity (Lucas et al. 2014; Talento et al. 2020). Creating corridors or rows of pine trees, and increasing shrub vegetation, will be particularly favorable for the fauna.

Soil enrichment with microorganisms and native flora from neighboring sites will also have significant impact, especially in poor soils and isolated sites such as those in Pyrga (see also Skalski et al. 2016, Zhang et al. 2018).

In Parekklesia, passive restoration is recommended, since surrounding areas maintain connectivity and are not fragmented, making it easier for biodiversity to colonize the restoration sites.

Xylofagou

The restored part in Xylofagou constitutes a special case of combined passive and active restoration. There is a section where *Pistacia lentiscus* and other shrubs have been planted, with a soil type similar to the areas outside the quarry. This site has yielded good results.

In contrast, the area that has been left to spontaneous restoration, where a few seasonal ponds appear, is poor and dominated by *Atriplex* sp. and *Tamarix* sp., mostly with common fauna species. In this case, passive management has led to a homogeneous environment, which may not be ideal for biodiversity in the long term. Additionally, the area is enclosed within the quarry, either by dirt roads used by heavy vehicles or by cliffs at the quarry's boundaries, cutting it off from the surrounding natural areas.

It is recommended to manage the substrate that forms mud, so that vegetation can colonize the site, as well as to create corridors connecting it with natural areas. Mixing with topsoil appears to give satisfactory results and is recommended as a good practice in cases of rich mud.

It should be emphasized that the present study is of a preliminary nature. Therefore, it is necessary to carry out additional biodiversity surveys in order to have a more reliable assessment of its condition. These additional surveys should cover as much of the quarry area as possible, as well as more peripheral, external locations. Furthermore, it is recommended to

extend the surveys to other groups of organisms (e.g. bats, orthoptera). Such an action can be realistically implemented (considering budget and human resources) in a smaller number (e.g. three) of selected representative quarries.

In addition, the design and implementation of a long-term biomonitoring program in selected quarries is necessary, in order to monitor the dynamics of biodiversity over time. If the implementation of such a program is decided and the necessary resources are secured, its design should be carried out by biodiversity experts, who will also undertake the training of quarry personnel in survey and data collection methods.

SUMMARY OF GENERAL RECOMMENDATIONS

- Efforts for the long-term/permanent maintenance of water collections and protection/enhancement of the riparian vegetation developing around them.
- Avoidance of sudden drying of temporary water collections, especially during overwintering or nesting periods of waders.
- Creation/maintenance of corridors connecting restoration sites, both with each other and with the surrounding areas outside the quarries. Such corridors may be created by planting trees and/or shrubs of the local native flora (e.g., pines, carob trees, lentisk).
- Use of planting (with native species) only where necessary (e.g., in sites not sufficiently connected with areas outside the quarries or where rapid soil erosion is observed).
- Plantings should include more than one species of native trees and shrubs and should originate from the spontaneous flora of the surrounding areas.
- Ensuring the presence of microhabitats (mainly refuges such as piles of stones, logs and branches, leaf litter layer) that help attract and sustain several species of significant ecological interest, especially reptiles and mammals (e.g., *Acanthodactylus schreiberi*, *Laudakia cypriaca*, *Phoenicolacerta troodica*, *Acomys nesiotis*), as well as a large number of invertebrates.
- Control/limitation of alien invasive species in restoration sites and, where possible, care to limit them in neighboring areas outside the quarries (in consultation with the competent authorities). Regular removal of *Nicotiana glauca* and *Acacia* spp. is recommended, as well as any other species where feasible locally (e.g., *Lycium ferocissimum* in Agios Sozomenos and Mitsero).
- Rational use of drainage water for irrigation of restoration areas and/or enrichment of water collections.
- Limitation of dust and light pollution to the greatest extent possible.
- Strict implementation of environmental and safety regulations (e.g., regarding fires, pollution, burning of plastics, etc.).
- Soil enhancement where necessary (e.g., removal of sterile mud, application of microorganisms, and planting of native low shrubs and herbaceous plants).
- Conducting more detailed study in more sites inside and outside selected quarries for a longer period of time.
- Implementation of a long-term biodiversity monitoring program in selected quarries.

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ANNEX II. PHOTOGRAPHS



A temporary lake at the Agios Sozomenos quarry (photo Z. Tolgyesi).



External site at Agios Sozomenos quarry (photo Z. Tolgyesi).



Restoration site at Androlykou quarry (photo Ch. Makris).



Restoration site at Androlykou quarry (photo Ch. Makris).



External site at Farmakas quarry (photo Z. Tolyesi).



A temporary lake at Farmakas quarry (photo Z. Tolyesi).



External site at Mosfiloti quarry (photo Z. Tolgyesi).



Restoration site at Mosfiloti quarry (photo Z. Tolgyesi).



Restoration site at Parekklesia quarry (photo Z. Tolgyesi).



Restoration site at Pyrga quarry (photo Z. Tolgyesi).



External site at Xylofagou quarry (photo Z. Tolgyesi).



Restoration site at Xylofagou quarry (photo Z. Tolgyesi).



The endemic toad *Bufotes cypriensis* at Parekklesia quarry (photo Ch. Makris).



The endemic beetle *Acmaeodera ceylonensis* (Coleoptera: Buprestidae) at Parekklesia quarry (photo Ch. Makris).



The endemic butterfly subspecies *Allancastris cerisyi cypria* (Lepidoptera: Papilionidae) at Pyrga quarry (photo Ch. Makris).



The endemic butterfly *Hipparchia cypriensis* (Lepidoptera: Nymphalidae) at Mitsero quarry (photo Ch. Makris).



Tarucus balkanicus (Lepidoptera: Lycaenidae) at Agios Sozomenos quarry (photo Ch. Makris).



Armadillidium marmoratum (Isopoda: Armadillidiidae) at Androlykou quarry (photo Ch. Makris).



Acanthodactylus schreiberi at Mitsero quarry (photo Ch. Makris).



The endemic lizard *Laudakia cypriaca* at Xylofagou quarry (photo Ch. Makris).



***Ophisops elegans* at Farmakas quarry (photo Ch. Makris).**



The endemic *Crocus veneris* at Androlykou quarry (photo Ch. Makris).



The endemic *Onobrychis venosa* at Agios Sozomenos quarry (photo Ch. Makris).



The endemic orchid *Ophrys flavomarginata* at Androlykou quarry (photo Ch. Makris).



The chasmophytic species *Galium canum* at Androlykou quarry (photo Ch. Makris).



The Vulnerable (VU) species, according to the Red Data Book, *Rumex vesicarius* at Vasa quarry (photo Ch. Makris).



The Vulnerable (VU) species, according to the Red Data Book, *Ornithogalum trichophyllum* at Agios Sozomenos quarry (photo Ch. Makris).



The Vulnerable (VU) species, according to the Red Data Book, *Umbilicus horizontalis* at Xylofagou quarry (photo Ch. Makris).



The endemic *Oenanthe cypriaca* (Cyprus wheateater) at Agios Sozomenos quarry (photo Z. Tolgyesi).



The wader *Tringa ochropus* (green sandpiper) at Agios Sozomenos quarry Σωζόμενου (photo Z. Tolgyesi).



Spectacled warbler (*Curruca conspicillata*) at Agios Sozomenos quarry (photo Z. Tolgyesi).



Bonelli's eagle (*Aquila fasciata*) at Androlykou quarry (photo Z. Tolgyesi).



The wader *Tringa glareola* (wood sandpiper) at Androlykou quarry (photo Z. Tolgyesi).



Chukar partridges (*Alectoris chukar*) at Androlykou quarry (photo Z. Tolgyesi).



Common chiffchaff (*Phylloscopus collybita*) at Farmakas quarry (photo Z. Tolgyesi).



Blue rock thrush (*Monticola solitarius*) at Mitsero quarry (photo Z. Tolgyesi).



Long-legged buzzard (*Buteo rufinus*) at Mosfiloti quarry (photo Z. Tolgyesi).



Little owl (*Athene noctua*) at Parekklesia quarry (photo Z. Tolgyesi).



Isabelline wheateater (*Oenanthe isabellina*) at Pyrga quarry (photo Z. Tolgyesi).



Common cuckoo (*Cuculus canorus*) at Sia quarry (photo Z. Tolgyesi).



Western marsh harrier (*Circus aeruginosus*) at Xylofagou quarry (photo Z. Tolgyesi).



The wader *Tachybaptus ruficollis* (little grebe) at Xylofagou quarry (photo Z. Tolgyesi).



Grey wagtail (*Motacilla cinerea*) at Xylofagou quarry (photo Z. Tolgyesi).



The endemic *Curruca melanothorax* (Cyprus warbler) at Mitsero quarry (photo Z. Tolgyesi).

