PROCEEDINGS OF THE X, XI, AND XII INTERNATIONAL SYMPOSIA ON VULCANOSPELEOLOGY

Edited by
Ramón Espinasa-Pereña and John Pint

AMCS Bulletin 19

SMES Boletín 7

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Collapse entrance to Dahl Um Quradi in Harrat Khaybar, Saudi Arabia. Photo by John Pint.

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X Symposium
September 9–15, 2002
Reykjavik, Iceland

XI Symposium
May 12–18, 2004
Pico Island, Azores

XII Symposium
July 2–7, 2006
Tepoztlán, Morelos, Mexico

ASSOCIATION FOR MEXICAN CAVE STUDIES
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BOLETÍN 7

2008

Preface

Held at the ex-Convent of Tepoztlán, in the state of Morelos, México, in July 2006, the XIIth Symposium of Vulcanospeleology was sponsored by the Sociedad Mexicana de Exploraciones Subterráneas (SMES), the Commission on Volcanic Caves of the International Union of Speleology (UIS), Grupo Espeleológico ZOTZ, the Association for Mexican Cave Studies, and the State of Morelos Section of the National Institute of Anthropology and History (INAH). It gathered thirty-eight dedicated researchers and specialists from three continents, and over twenty-eight different papers were presented.

During the symposium, the fact that no Proceedings had been published of the two previous symposia was discussed, so a request for these papers was made, with relative success. The abstracts and five papers from the 2002 symposium are therefore included, together with the abstracts and seven papers from the 2004 symposium. Together with the eighteen 2006 papers, this volume therefore includes 30 papers. Due to the success of the six field trips taken during and after the XII symposium, the guidebook is also included.

Topics range from general cave descriptions to highly specialized discussions on volcanic cave geology, archaeology, and biology. The areas covered include México (the 2006 host country), Hawaii, the Azores, the Middle East, Japan, and Iceland.

Dr. Ramón Espinasa-Pereña
2006 Symposium Convener

Cover photograph by Tim Ball.
James Begley in Flóki, Reykjanes Peninsula, Iceland.

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XII

SUPPLEMENTARY MATERIAL ON THE CD

The CD contains, in addition to the PDF file for this proceedings volume, some material to supplement some of the articles. In some cases there are additional photographs or maps. In others, I have judged that a higher-resolution graphic of a map would be significantly more legible than the printed version. Australian Ken Grimes has provided PDF files of some of the papers referred to in an article and also a couple of nice color educational posters.—Bill Mixon, AMCS Editor

Folder **2002 Grimes 1**. Supplement to X symposium paper "Subcrustal Drainage Lava Caves . . . ," by Ken Grimes.

- Image file for additional map of cave H-51.
- PDF files of data forms and maps for caves H-106 and H-108.
- PDF files for referenced papers Grimes 1995, Grimes 2002a, and Grimes 2002b.

Folder **2002 Grimes 2**. Supplement to X symposium paper "A Small Cave in a Basalt Dike . . . ," by Ken Grimes.

- A PDF file of the version of this paper published in *Helictite* in 2006.

Folder **2004 Pint**. Supplement to XI symposium paper "Rare Cave Minerals and Features of Hibashi Cave . . . ," by John Pint.

- Image file of figure 3 (page 92), map of Ghar Al Hibashi.

Folder **2006 Al-Malabeh**. Supplement to XII symposium paper "Al-Fahde Cave, Jordan . . . ," by Ahmed Al-Malabeh, et al.

- Image files of the four sheets of the map of Al-Fahde Cave, figures 2–5, pages 202–204.

Folder **2006 Espinasa**. Supplement to XII symposium paper "Cueva Tecolotlán . . . ," by Ramón Espinasa-Pereña and Luis Espinasa.

- Image file of map of Cueva Tecolotlán, figure 2, page 154.

Folder **2006 Kempe**. Supplement to XII symposium paper "Geology and Genesis of the Kamakalepo Cave System . . . ," by Stephan Kempe, et al.

- Image file of map of Waipouli (Makai) Cave, figure 8, page 236.

Folder **2006 Pint**. Supplement to XII symposium paper "Surveyed Lava Tubes of Jalisco . . . ," by John Pint, et al.

- PDF file containing four additional color photograph with captions.

Folder **2006 Waters**. Supplement to XII symposium paper "Recent Contributions to Icelandic Cave Exploration . . . ," by Ed Waters.

- Image files of maps of Lofthellir (page 193) and Fjárhólahellir (page 194).
- Image files of additional maps of Burí, Hellinger, and Holgóma.
- PDF file containing four additional color photographs with captions.

Folder **Grimes posters**.

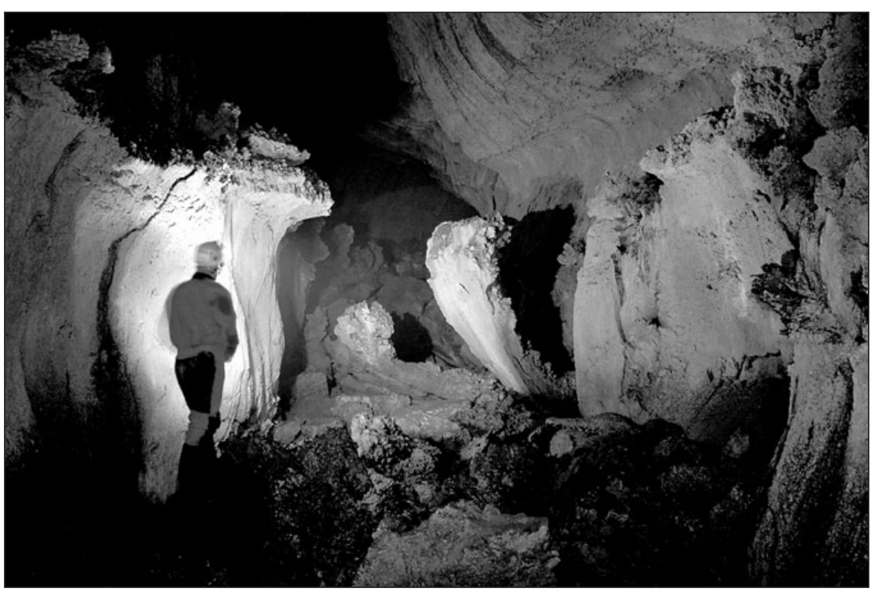
- PDF files of color educational posters prepared in 2005 by Ken Grimes, "Lava Tube Formation" and "Sub-Crustal Lava Caves."

vulcAnospeleology

XII INTERNATIONAL SYMPOSIUM

TEPOZTLAN, MORELOS, MEXICO 2006

JULY 2–7, 2006



The XII International Symposium on Vulcanospeleology is sponsored by the Sociedad Mexicana de Exploraciones Subterráneas (SMES), the Commission on Volcanic Caves of the International Union of Speleology (UIS), Grupo Espeleológico ZOTZ, Club de Exploraciones de México A.C., Veracruz Section (CEMAC), the Association for Mexican Cave Studies (AMCS), and the State of Morelos Section of the National Institute of Anthropology and History (INAH).

A total of 37 abstracts were presented, of which 24 will be oral presentations, 10 will be posters, and there will be three papers *in absentia*. Eleven are about México, the host country. There are papers about Jeju island in Korea, the Azores islands of Portugal and Iceland in the Atlantic Ocean, Arabia, Jordan and Israel in the Middle East, and of course, several papers on Hawaii and one on Japán in the Pacific Ocean. Besides, there are several biospeleology papers, and several miscelaneous or theoretical papers.

All these information has been arranged into four different Sessions: México, Rest of the world, Biology and Theoretical.

México Session, Chairman C. Lloyd: Several papers give information about the Sierra Chichinautzin, where México's most important lava tubes discovered to date are located. Other papers will be about lava tubes in other regions of México. Of special interest are erosional (or solutional) caves hosted in volcanic deposits, and two papers on the role of volcanic sulfur in the development of caves in limestone.

Rest of the World Session, Chairmen K. S. Woo, João C. Nunes and J. Pint: Most papers in this session are special studies on numerous caves distributed around the world. We will get a glimpse of recent advances in the exploration of lava tubes and other volcanic caves in various geological settings (Continental, Island Arch, and Midoceanic).

Biospeleology Session, Chairman Luis Espinasa: Several papers will introduce recent advances in the knowledge of microorganisms in lava tubes, while the studies of bat population and other species in the Sierra Chichinautzin provide information on biospeleological aspects of caves discussed in the México Session.

Theoretical Session, Chairman J. P. Bernal: A paper on the possible uses of Uranium dating and paleoenvironmental studies, several proposals for cave data bases, and a very welcome review of lava tube morphogenesis round up the discussions of the symposium.

Oral Presentation

Use of ATLANTIS Tierra 2.0 in Mapping the Biodiversity (Invertebrates and Bryophytes) of Caves in the Azorean Archipelago

Paulo A.V. Borges[1,2,3], Rosalina Gabriel[3], Fernando Pereira[1,2,3], Enésima P. Mendonça[3], and Eva Sousa[3]
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In this contribution the software ATLANTIS Tierra 2.0 is described as a promising tool to be used in the conservation management of the animal and plant biodiversity of caves in Macaronesia. In the Azores, the importance of cave entrances to bryophytes is twofold: i) since these are particularly humid, sheltered habitats, they support a diverse assemblage of bryophyte species and circa 25% of the Azorean brioflora is referred to this habitat and ii) species, either endemic or referred in the European red list due to their vulnerability (19 species) or rarity (13) find refuge there. Cave adapted arthropods are also diverse in the Azores and 21 endemic obligate cave species were recorded. Generally these species have restricted distributions and some are known from only one cave. ATLANTIS Tierra 2.0 allows the mapping of the distribution of all species in a 500 x 500 m grid in a GIS interface. This allows an easy detection of species rich caves (hotspots) and facilitates the interpretation of spatial patterns of species distribution. For instance, predictive models of species distribution could be constructed using the distribution of lava flows or other environmental variables. Using this new tool we will be better equipped to answer the following questions: a) Where are the current "hotspot caves" of biodiversity in the Azores? b) How many new caves need to be selected as specially protected areas in order to conserve the rarest endemic taxa? c) Is there congruence between the patterns of richness and distribution of invertebrates and bryophytes? d) Are environmental variables good surrogates of species distributions?

Poster Presentation

Bryophytes of Lava Tubes and Volcanic Pits from Graciosa Island (Azores, Portugal)

Rosalina Gabriel[1], Fernando Pereira[1,2], Sandra Câmara[1], Nídia Homem[1], Eva Sousa[1], and Maria Irene Henriques[1]
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Mainly due to historical reasons, Graciosa Island is the poorest island of the Azores regarding the number of bryophytes (119), especially of rare and endemic species. However, Lava Tubes (Furna da Maria Encantada, Furna do Abel, Galeria Forninho) and Volcanic Pits (Furna do Enxofre) seem to offer refuge to some interesting plants. Previous studies have recorded, among others, the European endemic moss, *Homalia webbiana*, present only in four of the nine Azorean Islands and with less than 10 localities recorded in the archipelago. The main purposes of the fieldwork were: i) to update with field work, the bibliographic records of bryophytes that may be observed in the volcanic formations of Graciosa; ii) to identify in those formations, endemic bryophyte species (from the Azores, Macaronesia and Europe) and species with a conservation risk associated, according to the European Committee for the Conservation of Bryophytes (ECCB). The results show that although no Endemic plants from the Azores were found at this point, six European endemic species and four Macaronesian endemic species were confirmed in the entrances of these volcanic formations, including one Vulnerable species and three rare species, according to ECCB criteria. In conclusion, besides the rich geological interest of the caves in Graciosa, their entrances continue to harbour rare or endemic bryophytes, not commonly found on other parts of the island, possibly due to the greater stability of these habitats. This is an additional reason to preserve the caves and a further possible motive of interest to all that visit them.

Poster Presentation

First Approach to the Comparison of the Bacterial Flora of Two Visited Caves in Terceira Island, Azores, Portugal

Lurdes Enes Dapkevicius[1], Rosalina Gabriel[1], Sandra Câmara[1], and Fernando Pereira[1,2]
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"Algar do Carvão" and "Gruta do Natal" are two interesting volcanic show caves in Terceira Island. The purposes of this work were: i) to characterize the main groups of bacteria observed on their walls and ceiling in four different illumination conditions: darkness, artificial light, half-light and under natural light; ii) to look for *Actinomycetales*, mainly from the family *Streptomyceteae*, due to their ability to produce high-value biochemical products; iii) to investigate if the human activities associated with the economic exploitation of the caves (artificial illumination, visiting activities, cattle raising in their vicinities) had ecological impacts on the composition of the local microbial flora. Although it was not possible to isolate *Actinomycetales* at this point, the preliminary results show that the bacterial flora of both caves was diverse; 52 different isolates were obtained, and these are mostly the result of water infiltration from the overlying fields. In "Algar do Carvão", the half-light area supported the highest diversity of bacterial flora, with 26 isolates, including mostly bacteria associated with the grazing activity that occurs above the Algar. The most interesting species isolated was *Sphingobacterium multivorum*, which has the natural ability to accumulate zeaxanthin, a molecule used as a food pigment and which recently has been considered important in eye-health, reducing

Use of ATLANTIS Tierra 2.0 in Mapping the Biodiversity (Invertebrates and Bryophytes) of Caves in the Azorean Archipelago

Paulo A.V. Borges[1,2,3], Rosalina Gabriel[3], Fernando Pereira[1,2,3], Enésima P. Mendonça[3], Eva Sousa[3]

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Abstract

In this contribution the software ATLANTIS Tierra 2.0 is described as a promising tool to be used in the conservation management of the animal and plant biodiversity of caves in Macaronesia. In the Azores, the importance of cave entrances to bryophytes is twofold: i) since these are particularly humid, sheltered habitats, they support a diverse assemblage of bryophyte species and circa 25% of the Azorean brioflora is referred to this habitat and ii) species, either endemic or referred in the European red list due to their vulnerability (19 species) or rarity (13) find refuge there. Cave adapted arthropods are also diverse in the Azores and 21 endemic obligate cave species were recorded. Generally these species have restricted distributions and some are known from only one cave. ATLANTIS Tierra 2.0 allows the mapping of the distribution of all species in a 500 x 500 m grid in a GIS interface. This allows an easy detection of species rich caves (hotspots) and facilitates the interpretation of spatial patterns of species distribution. For instance, predictive models of species distribution could be constructed using the distribution of lava flows or other environmental variables. Using this new tool we will be better equipped to answer the following questions: a) Where are the current "hotspot caves" of biodiversity in the Azores?; b) How many new caves need to be selected as specially protected areas in order to conserve the rarest endemic taxa?; c) Is there congruence between the patterns of richness and distribution of invertebrates and bryophytes?; d) Are environmental variables good surrogates of species distributions?

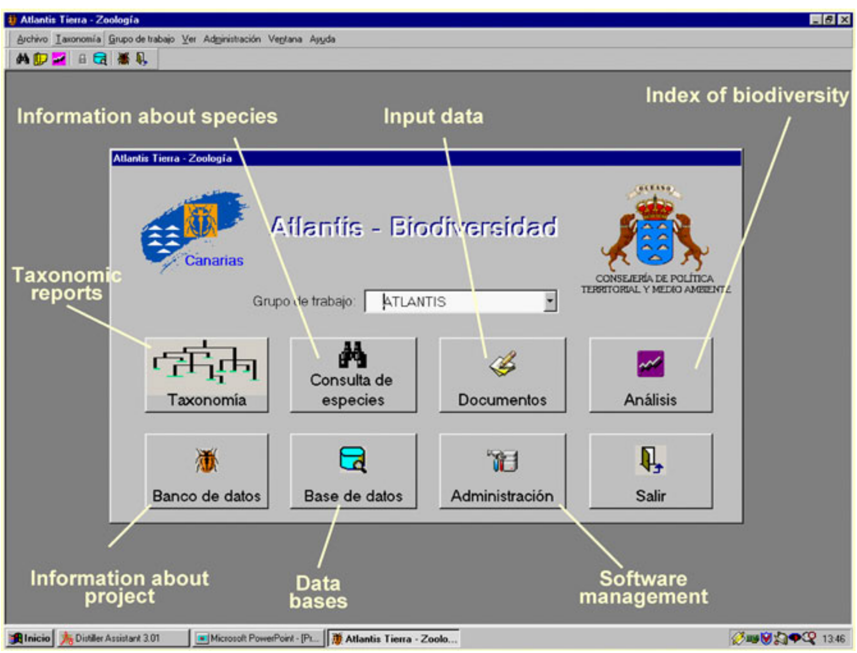

Figure 1. Entrance window of ATLANTIS Tierra 2.0, in which it is possible to observe eight possible entrance gateways, the most relevant being the taxonomic reports ("Taxonomía"), information about species ("Consulta de espécies") and data analysis ("Consulta de análisis").

Introduction

The study of Azorean cave fauna and flora only started in 1988 with two expeditions of "National Geographic" under the supervision of Pedro Oromí (Univ. de La Laguna) and Philippe Ashmole (Univ. de Edinburg) and with the support of the speleological Azorean group "Os Montanheiros" (see Oromí *et al.* 1990, González-Mancebo et al. 1991). After those two expeditions in 1988 and 1990, the University of the Azores and "Os Montanheiros" performed most of the biospeleological work in the Azores (see Borges & Oromí 1994, 2006, Gabriel & Dias 1994). In the Azores, the importance of cave entrances to bryophytes is twofold: i) since these are particularly humid, sheltered habitats, they support a diverse assemblage of bryophyte species and circa 25% of the Azorean brioflora is referred to this habitat and ii) species, either endemic or referred in the European red list (ECCB 1995) due to their vulnerability (19 species) or rarity (13) find refuge there. Cave adapted arthropods are also diverse in the Azores and 21 endemic obligate cave species were recorded (Borges & Oromí 2006). Generally these species have restricted distributions and some are known from only one cave (Borges & Oromí 2006).

There is a general agreement among scientists that biodiversity is under assault on a global basis and that species are being lost at greatly enhanced rates due to human processes such as habitat loss and fragmentation, invasive species, pollution and global climate change

(Lawton & May 1995; Chapin et al. 2000). Moreover, some recent studies indicate that there are some concerns related with invasive species and the conservation of native biodiversity in the Azores (Silva & Smith 2004, Borges et al. 2006).

In this contribution, a new software, ATLANTIS Tierra 2.0, is described as a promising tool to be used in the conservation management of the animal and plant biodiversity of caves from the Azores.

ATLANTIS Tierra 2.0

Since 1998 the Government of the Canary Islands as been conducing an important project on biodiversity, Project BIOTA (see Izquierdo *et al.* 2001, 2004). A Visual Basic software, called ATLANTIS Tierra 2.0, was developed for biodiversity data storage. With this database it will be possible to gather detailed information about all species on the surveyed geographical areas of interest. This software has several important tools, namely a taxonomic tool and a conservation management analysis tool (Fig. 1) that allows the calculation of species richness, their rarity or complementarity in all 500x500 m cells of a particular island or, in any special area in one island.

With this software all the information we could think of about a species (e.g. the cavernicolous ground-beetle *Trechus montanheirorum*) is available in clicking the **information about species** (“**Consulta de espécie**s”) window (see Fig. 2). In this window it is also possible to check the detailed distribution of the species in a 500 x 500 m scale (Fig. 3). With this tool we may also investigate the distribution of the species throughout time in asking for its distribution in different time intervals. To each signalized 500 x 500 m grid cell correspond a cave for which the species was signalized in the literature.

However, it is in the data analysis facility that ATLANTIS Tierra 2.0 is more interesting in terms of its application in a conservation management study. As an example in Fig. 4 we see the species richness of the European Rare Bryophytes (ECCB 1995) in caves from Graciosa Island (Azores). The grid-cell with the highest number of species corresponds to the location of Furna do Enxofre, currently a volcanic pit protected by law and under the special management of the Government. In Fig. 4 we can see also the list of species in grid cell with the highest number of species and that list could be exported to another software (e.g. Excel).

Very important in conservation management studies is to ask: “Ho many sites are needed to include all species of interest at least once?”. To answer this question, we could use the complementarity procedure, in which we get the minimum set of caves that combined have the highest representation of species (see Williams 2001). ATLANTIS

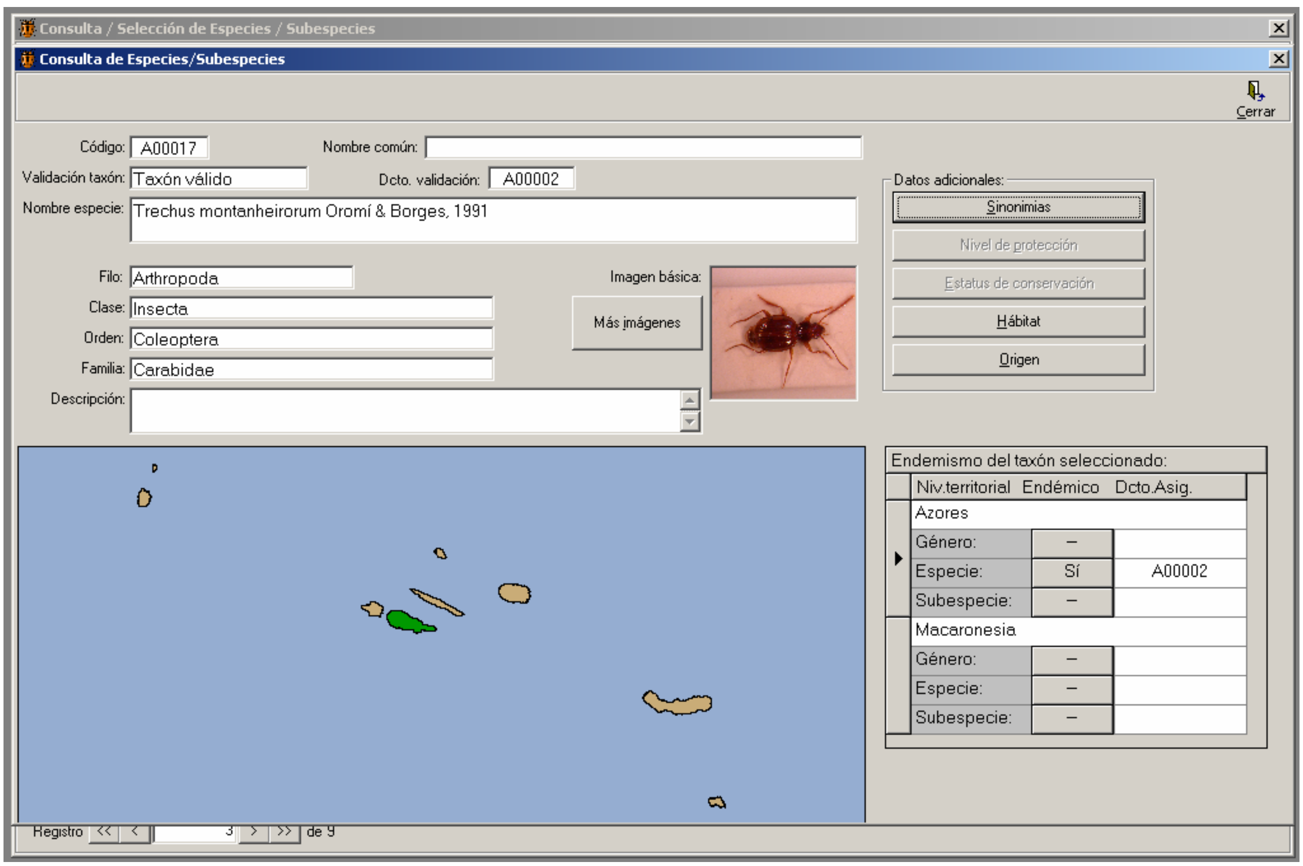

Figure 2. Species management window of ATLANTIS Tierra 2.0, in which it is possible to observe the nomenclature of the species, a picture, the distribution of the species in the archipelago (green island) and other relevant information concerning the habitats, conservation status, biogeographical origin, etc.

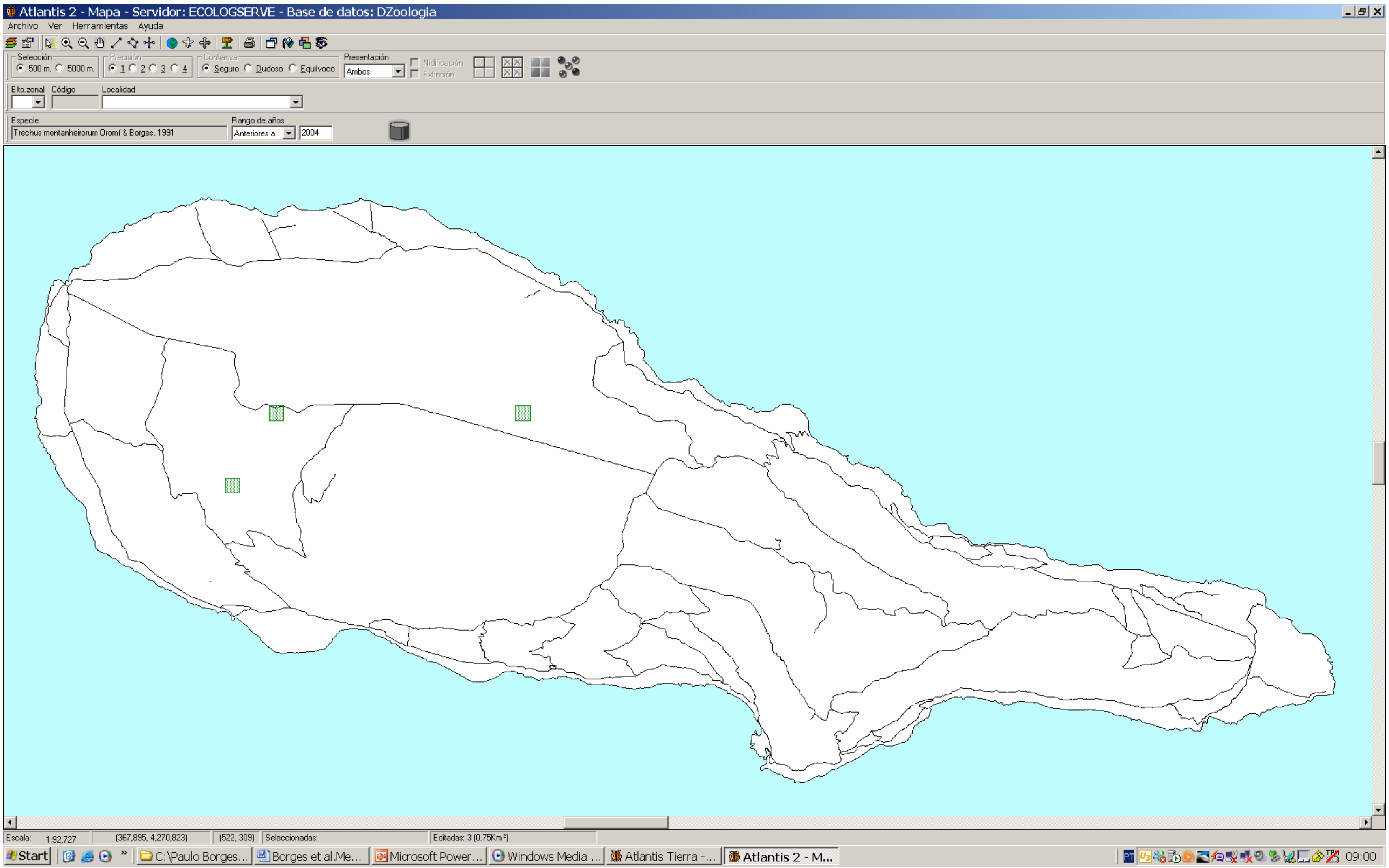

Figure 3. Species managment window of ATLANTIS Tierra 2.0, in which it is possible to observe the detailed distribution of *Trechus montanheirorum* in the island of Pico (lines are main roads in the island).

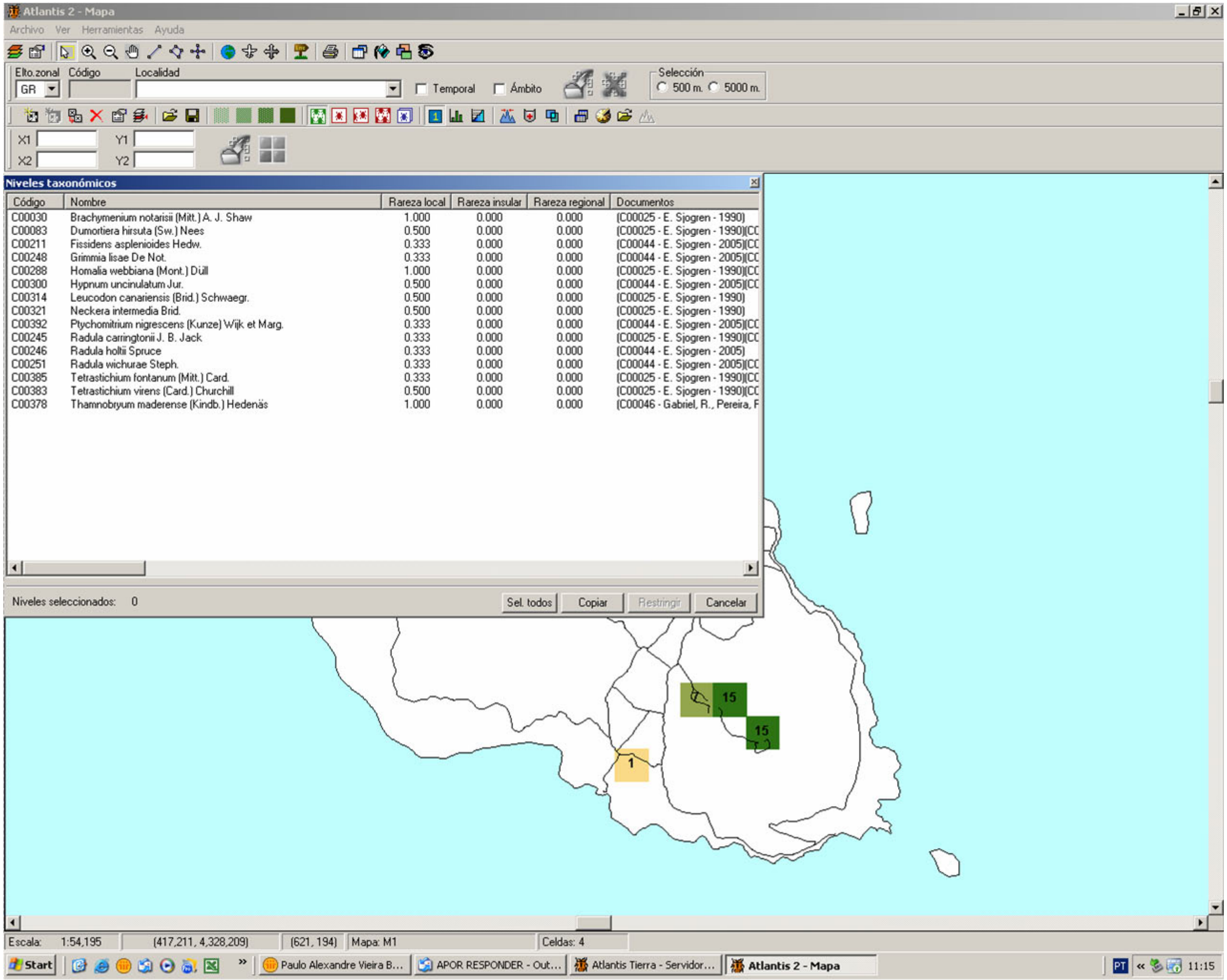

Figure 4. Data analysis window of ATLANTIS Tierra 2.0, in which it is possible to observe the number of bryophyte species in the European Red List present in caves from Graciosa Island (Azores). The list of species in the window corresponds to the grid cell with 15 species (Furna do Enxofre).

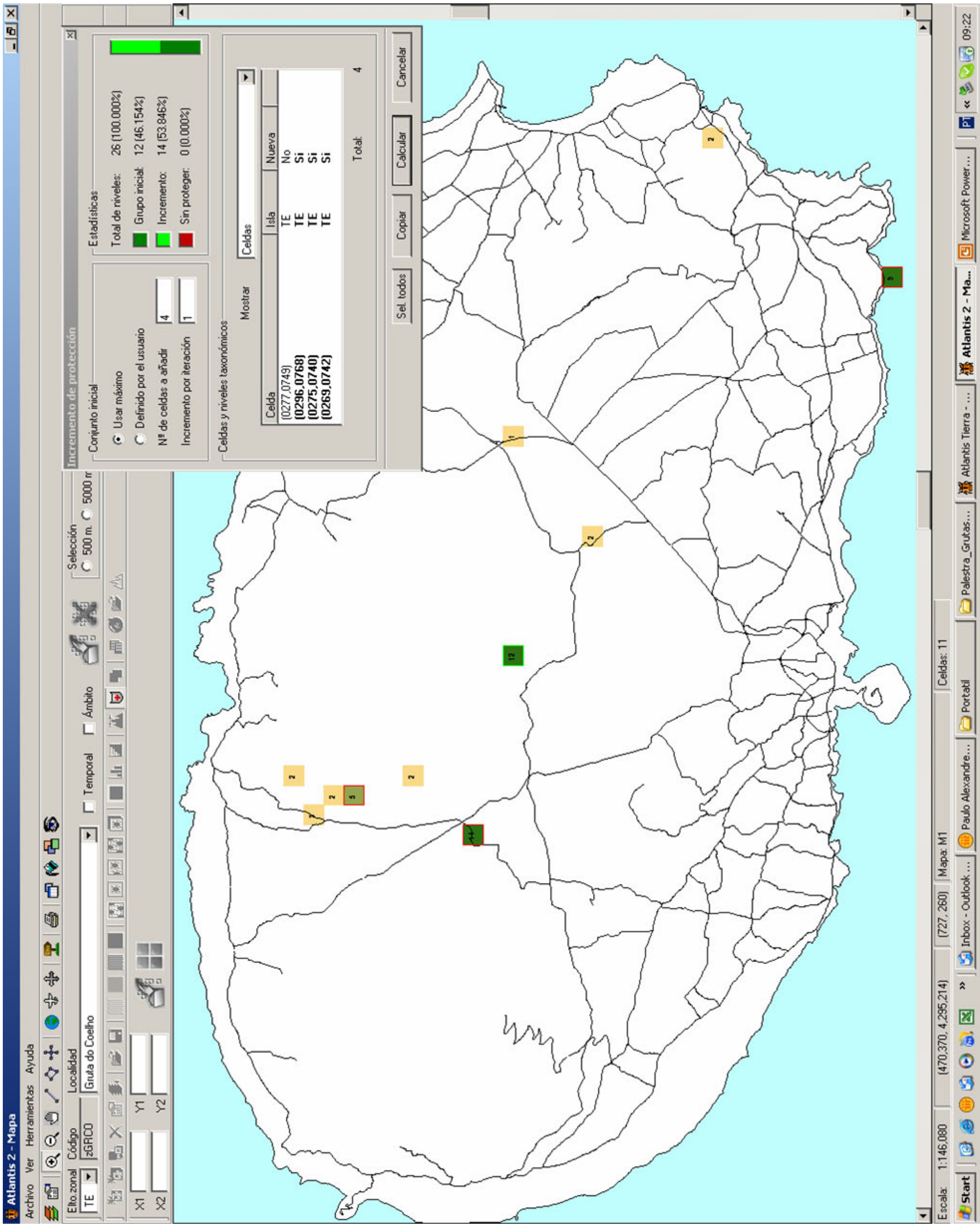

Figure 5. Data analysis window of ATLANTIS Tierra 2.0, in which it is possible to observe the four grid-cells that are necessary to include all the endemic arthropods occurring in caves from Terceira island (see text for further explanations).

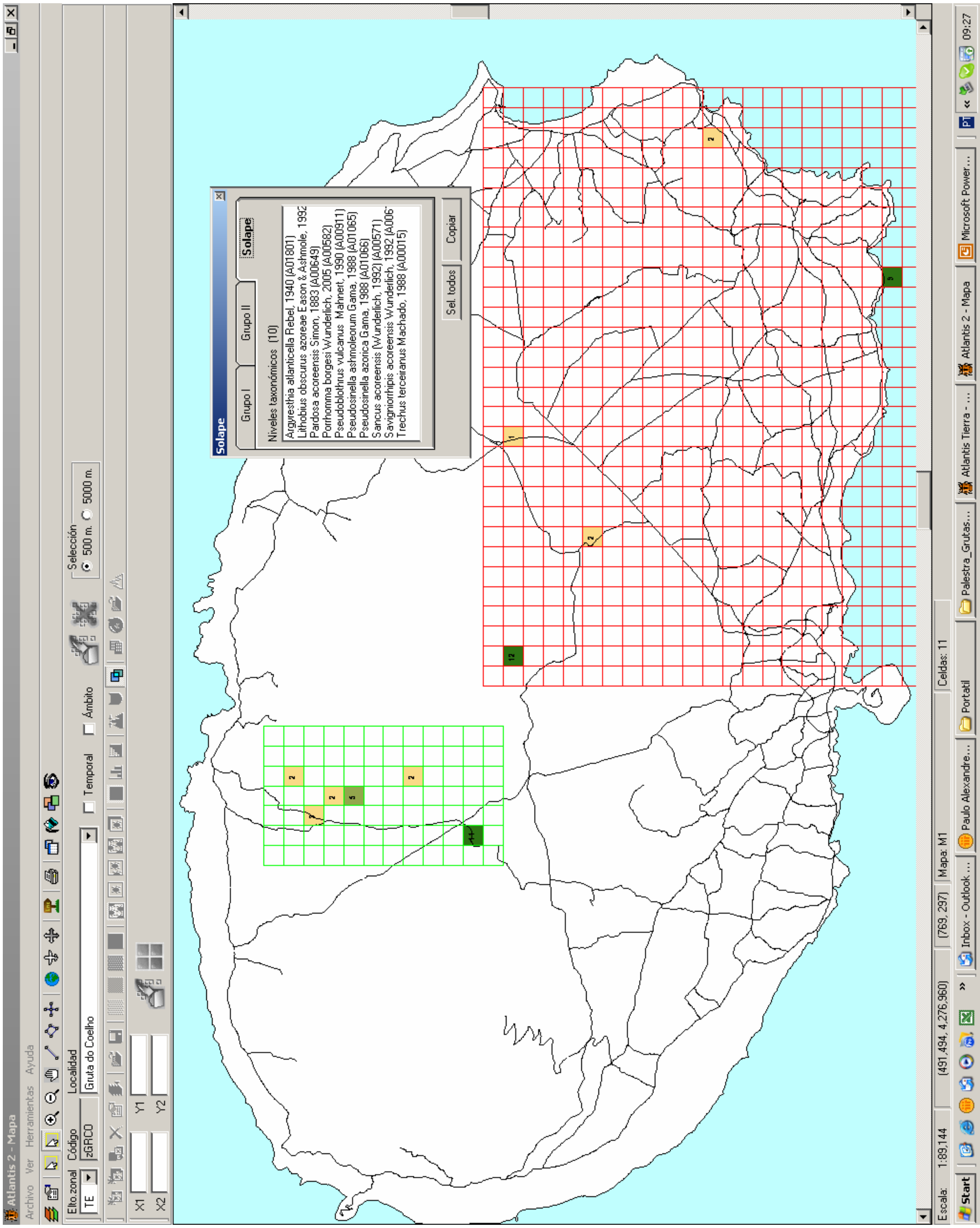

Figure 6. Data analysis window of ATLANTIS Tierra 2.0, in which it is possible to observe the list of endemic arthropods that occur in two distinct cave systems at Terceira island (see text for further explanations).

Tierra 2.0 uses the heuristic suboptimal simple-greedy reserve-selection algorithm: first, the grid-cell with the highest species richness is selected. Then, these species are ignored and the grid-cell with the highest complement of species (that is, the most species not represented in the previous selected grid-cell), and so on, until all species are represented at least once. One good example of the application of the complementarity procedure is showed in Fig. 5, in which only four out of the eleven grid-cells with caves are necessary to protect the 26 endemic arthropod species occurring in the caves of this island. Those four grid-cells are signalized with a green dark border (the first selected grid-cell) and with a reddish dark border (the three other selected grid-cells). Therefore, with only four caves well managed we may protect all the endemic arthropod species know to occur in caves at Terceira Island (Azores). However, we should call attention to the fact that the complementarity procedure could be made more complex asking for the minimum set of caves that combined have at least each species represented twice, therefore assuring that species are protected in more than one place.

Another important facility available in ATLANTIS Tierra 2.0 is related with the investigation of the species composition in different areas of a region. For instance, we could have the list of species that are common in two different cave systems (Fig. 6). We could also get the list of species for each cave system and by exclusion obtain the lists of species that are exclusive to each cave system.

Conclusion

There is some urgency in the conservation of the diverse community of mosses and liverworts (Bryophyta) as well as of the rich cave adapted arthropods occurring in the Azorean lava tubes and volcanic pits. The general pattern that emerges is that ATLANTIS Tierra 2.0 will be an important tool not only for the Azorean Government in managing the territory and designing natural protected areas, but also for research in de areas of applied ecology and conservation.

Using the ATLANTIS Tierra 2.0 new tool we will be better equipped to answer the following important questions: a) Where are the current "hotspot caves" of biodiversity in the Azores?; b) How many new caves need to be selected as specially protected areas in order to conserve the rarest endemic taxa?; c) Is there congruence between the patterns of richness and distribution of invertebrates and bryophytes?; d) Are environmental variables good surrogates of species distributions?

Acknowledgements

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