



## PORTUGUESE NATIONAL REVIEW ON TAXONOMY AND BIODIVERSITY

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## EXECUTIVE SUMMARY

*“Taxonomy is essential to implementation of the Convention on Biological Diversity (CBD). Taxonomic knowledge is a key input in the management of all types of ecosystems, from marine areas to forests to drylands. It is also a key to effectively addressing alien species, access and benefit-sharing, and the many other cross-cutting issues under the Convention.”* (<http://www.cbd.int/gti/needs.shtml>)

Taxonomy is the science of naming, describing and classifying organisms (all plants, animals and microorganisms of the world), using morphological, behavioural and genetic and biochemical observations to describe and arrange organisms into classifications: kingdom, phylum, class, order, family, genus and species).

It is recognized by all that global biodiversity is being lost at an unprecedented rate as a consequence of human activities, and decisions must be taken now to stop this loss. In order to decide what to do to stop and reverse biodiversity loss we must have the necessary knowledge. Taxonomy provides the species-level information required to better define the biological diversity baseline and assess biodiversity loss, necessary for effective decision-making about the conservation and sustainable use.

*How do decision-makers decide where to establish protected areas if they don't know what is being protected? How can regulators identify and combat harmful invasive species if they cannot distinguish them from native species? How do developing countries ensure that they reap the benefits of the use of their biological diversity, if they don't know the biological diversity that is being used?*  
(<http://www.cbd.int/gti/importance.shtml>)

According to Tillier *et al.* the difficulty to accurately define the biodiversity baseline is due to: incompleteness of existing knowledge about species; low rate of production of new taxonomic knowledge; poor availability of knowledge for analyses. These gaps are the result of the existence of a "taxonomic impediment" to the sound management of biodiversity, characterized by the shortage of trained taxonomists, a lack of new students and an ageing taxonomic workforce.

BIOSTRAT partners were invited to address a number of questions regarding different aspects of the relationship between Taxonomy and Biodiversity in their country, as a contribution to the preparation for the Czech EPBRS (European Platform for Biodiversity Research Strategy) Meeting on “World Biodiversity and European Taxonomy – Strategies in Taxonomy: Research in a Changing World” to be held in Pruhonice between 19<sup>th</sup> and 22<sup>nd</sup> May 2009.

A questionnaire was sent to researchers in universities, research centres, government institutions, companies, NGOs, museums, collections to obtain information on the existing biodiversity expertise and collections and how these were used. Unfortunately, we only obtained 6 answers that are the contribution of eight researchers.

	Name	Institution	Position	Work / Research
1	Leonel Pereira	Department of Botany - UC / IMAR	Assistant Professor	
2	Antonina Santos	Instituto Nacional de Recursos Biológicos, L-IPIMAR	Investigator	Taxonomy and ecology of Crustacean Decapods
3	Cristina Máguas	Centre for Environmental Biology, Faculty of Science, University of Lisbon	Professor, PhD	Lichenology: Ecology, bio-monitorisation
	Cristina Branquinho		Investigator	
	Pedro Pinho		PhD Student	
4	João Cúria	Instituto Nacional de Recursos Biológicos, L-IPIMAR	PhD Student	Environmental impact assessment. Monitoring assessment of coastal and marine environments – Benthic communities
5	Paulo Borges	Department of Agriculture (CITA-A) of the University of the Azores, Portugal	Professor	Research focuses on the study of biodiversity of Azorean arthropods, with emphasis on taxonomy, macroecology, biospeleology and biogeography. In particular, is interested in analysis of processes affecting patterns of species richness of arthropods at different spatial scales.
6	Fátima Teles	Department of Botany, University of Coimbra	Professor	Curator of the Herbarium of University of Coimbra (COI). All answers refer to plants

The information presented in this report is based on data collected from the internet and on the answers given to the questionnaire send at the beginning of March 2009.

In Portugal some taxonomy-based tools are used for biodiversity assessments and policy making, e.g. MACOI database, Portuguese Seaweed Web site, P-MarMAT, Portuguese Marine Macroalgae Assessment Tool, Lichen-diversity based tools, ATLANTIS Tierra database. Some very recent checklists of Portuguese species were identified, including algae, fungi, fauna and flora of the Azores Islands, some red lists, as the Red Book of terrestrial vertebrates from Portugal, or bryophytes from the Iberian Peninsula. Lists of invasive species were also identified, showing some recent activity in the study of Portuguese flora and fauna.

Portugal is a partner in several international projects, not only as a user of the data but as data provider, namely in the GBIF. According to the results of an inquiry carried out during the summer of 2006 in connection with the establishment of the Portuguese node of GBIF, there are approximately 2,4 millions specimens, in 94 collections recorded. Most of them (67%) of the flora domain and only 10% of the records are digitalized in databases (see Table 1).

In the Biodiversity collections' index online we can find 22 biological collections from Portugal, mainly herbariums and entomology (insects and spiders).

From the report presented under the CBD and GTI Portugal didn't have an assessment of taxonomic needs and capacities at the National level.

The Curator of the Herbarium of the University of Coimbra describes a concerning and desperate situation for plant taxonomy in Portugal. The pool of taxonomists is being eroded as they retired, the collections are very poorly staffed, the financial support is nearly zero, the information available to the non-research audience is very little, the remaining specialists are heavily burden and time for education is slim, tools for non-specialists are scarce (no red-list of plant species, no overall distribution of plant species, simple keys, etc). Nevertheless, plant diversity is disappearing fast on the account of regular and devastating summer fires.

Most of the problems are due to a lack of human and financial resources and with the poor visibility and utilisation of the work produced by taxonomists.

In summary, to overcome the existing problems and to improve the taxonomic expertise in Portugal and its use to help stopping the loss of biological biodiversity is necessary:

- To invest more in training and education of new taxonomists.
- To invest more in preparation of checklist and data bases, updating the existing ones.
- To increase the digitalisation of the national biological collections.
- More and better dissemination of the work carried out by the depositaries of the existing national biological collections
- Use of the taxonomists' knowledge and work to support regional planning and conservation of habitats and species.
- Recognise the importance of taxonomy in the production of knowledge needed for prevention and control of invasions and introduction of indigenous / exotic species.

## 1 - TAXONOMIC INFORMATION: STRATEGY AND METHODS

### Inventory and Identification: “What is it, and how does it fit among its relatives?”

1.1 Does your country use taxonomy-based tools for biodiversity assessments and policy making? What are these tools?

Mainly online biodiversity database (e.g. MACOI database and Portuguese Seaweed Website) and ecological assessment tool (e.g. P-MarMAT, Portuguese Marine Macroalgae Assessment Tool), used under Water European Framework <sup>(1)</sup>. Taxonomic atlas, books, guides, research papers, reports <sup>(4)</sup>.

The lichen group <sup>(2)</sup> uses lichen-diversity based tools for monitoring: air pollution; forest ecological status; other sources of disturbance; relations between health and environment.

In the Azores, they <sup>(5)</sup> are using the ATLANTIS Tierra database. This software was written in Visual Basic, using a common database environment; it uses the SQL language to develop interrogation queries and has an easy interface with all GIS software. With this database, it is possible to store detailed information about the taxonomy and georeferenced distribution of all species on the surveyed geographical areas of interest ATLANTIS Tierra 2.0 was inspired on “World map distribution analysis software”. Most data is now available online throughout the Azorean Biodiversity Portal.

Portugal has a limited effective governmental policy on plant diversity and conservation. Reserves and Parks are poorly managed. In many instances plant diversity assessments are carried out by biology graduates with little experience on plant identification – especially so when ordered by companies <sup>(6)</sup>.

The project MARBIS-NATURA2000 - Information System for Marine Biodiversity, approved in the context of the Action Plan of the Interministerial Commission for the Sea (2008-2010), which aims to organize and systematize the existent scientific information about marine biodiversity of the oceans under national jurisdiction, including the creation of an integrated information system on marine biodiversity and the establishment of a network of knowledge on marine biodiversity. This work is essential to a higher knowledge of the marine species, habitats and ecosystems in Portugal, and it will constitute an important contribution for the extension of the Natura 2000 network to the marine environment, for the implementation of marine protected areas and for the definition of the planning priorities of the marine space, having in mind to secure the sustainability of the national sea politics in the context of the European Union, securing the maintenance of the good conservation state of the marine biodiversity. This project results from a partnership between the Institute of Nature Conservation and Biodiversidade (ICNB) and the Structure of Mission for the Extension of the Continental Platform (EMEPC), with the support of Galp Energia. Be inserted in the National Strategy for the Sea, and it integrates the Autonomous Regions and all the Ministries with interest and action in aspects connected with the marine biodiversity or the essential systems of support for its maintenance. It also has the collaboration of Marine Biological Association (UK).

Portuguese researchers had participated in the FishBase – A Global Information System on Fishes. FishBase is a relational database with information to cater to different professionals such as research scientists, fisheries managers, zoologists and many more. FishBase on the web contains practically all fish species known to science.

1.2 Does your country have a national species checklist? When it was last revised and updated? Is there any national assessment of which taxonomic groups in particular lack taxonomic information? Did you submit a response to the GTI questionnaire on these issues?

Several works and projects are related with this objective <sup>(1)</sup> (e.g. Portuguese Macroalgae Flora Checklists: MACOI database; Pérez-Ruzafa *et al.*, 2003; Ardré 1970; Araújo *et al.* 2009).

There is a checklist, last update January 2008; There is no evaluation of lacunas; We did not submit a response to the GTI questionnaire <sup>(3)</sup>.

According to <sup>(2)</sup> the country does not have any national species' checklist.

On the other hand <sup>(4)</sup> said that there is no national species checklist; scattered information regarding the taxonomic groups with particular needs concerning taxonomic information; and no response to GTI.

The following lists of species from the Azores and Madeira archipelagos have been recently updated <sup>(5)</sup>:

- A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos (Borges *et al.*, 2008)
- A list of the terrestrial fauna (Mollusca and Arthropoda) and flora (Bryophyta, Pteridophyta and Spermatophyta) from the Azores (Borges *et al.*, 2005).

Both books have already become a key reference for Azorean and Madeira biodiversity research, and it is an important tool for people working in the areas of taxonomy, ecology and nature conservation management <sup>(5)</sup>.

They are presently working on a second edition of the Azorean Book <sup>(5)</sup> "A list of the terrestrial fungi, flora and fauna from the Azores" (Borges *et al.*, in prep).

In the Azores, there is a current effort to survey fewer known species with standardized sampling protocols, namely *Collembola* and *Hymenoptera Parasitica* <sup>(5)</sup>.

The Curator of the University of Coimbra Herbarium said: NOT for plants!! <sup>(6)</sup>

List of birds with regular occurrence in Portugal Continental - <http://birdwatching.spea.pt/ListaEspeciesPt.pdf>

The "Practical Guide for Identification of the Invasive Plants from Portugal Continental" (Marchante *et al.*, 2009) was presented on 28 April 2009. This book aims to disseminate the subject of biological invasions, identifying the main invasive plants from Portugal Continental.

The Decree-Law 565/99, of 21<sup>st</sup> December, established the list of invasive species in Portugal. This list is now being revised.

## Understanding Patterns and Change: “Where is it, what’s happening to it, and where is it going?”

Describe 1-2 flagship projects related to bullet points below and suggest some recommendations useful for meeting as a result from these projects:

1.3 Please outline any national taxonomy-based monitoring or surveys designed to establish the distribution, status and trends of any taxonomic group.

At this moment several monitoring and surveys are in development, some of the theme needed of funding: MACOI project (biodiversity database of Portuguese seaweeds - distribution, occurrence, geographic coordinates, taxonomic groups used: Class, Genus and Species). Other related projects with taxonomic/ecological surveys: RECITAL II (project in implementation phase under Water European Framework) <sup>(1)</sup>.

The lichen group <sup>(3)</sup> uses lichen-diversity based tools for biomonitoring. The information is collected at the regional level (with a 2km sampling grid). Main project in this area is an ongoing project at SW Portugal. At north of Tagus river inventories were made at one location within Natural Park of Serra d’Aires e Candeeiros. To the south, all regions have been evaluated except Algarve.

There are several monitoring actions and surveys concerning marine communities (e.g. Macrobenthos, fish, cephalopods...) aiming to understand the distribution, structure of the communities along time <sup>(4)</sup>.

An excellent example in the Azores is the BALA project (Biodiversity of Arthropods from the Laurisilva of the Azores) (1998-2005), under the coordination of the Azorean Biodiversity Group <sup>(5)</sup>:

Eighteen native forest fragments distributed across seven of the nine islands were sampled in this study, during the summers of 1999 to 2004. Altogether, they represent most of the native forest cover of the Azores, excluding highly fragmented, small patches (less than five hectares), located at low altitudes and/or strongly disturbed by exotic plants or cattle, which were not sampled.

A total of 6770 samples (3420 pitfall traps and 3350 beating samples) were collected. Samples were sorted and the specimens preserved in 70% alcohol with glycerine. The selection of the arthropod taxa considered in this study was made taking into account the available taxonomists and the taxa which were readily separable by morphological criteria. All Araneae, Opilionida, Pseudoscorpionida, Myriapoda and Insecta (excluding Diptera and Hymenoptera) were assigned to morphospecies through comparison with a reference collection. Various taxonomists checked the assignment to morphospecies, made identifications and supplied additional ecological information.

All specimens and types are deposited in the *Arruda Furtado* entomological collection at the Department of Agrarian Science (University of the Azores).

More details can be found in <sup>(5)</sup>:

- Ranking protected areas in the Azores using standardized sampling of soil epigeal arthropods (Borges *et al.*, 2005).
- Canopy insect herbivores in the Azorean Laurisilva forests: key host plant species in a highly generalist insect community (Ribeiro *et al.*, 2005).

More recently two other projects are also starting <sup>(5)</sup>:

1) PRO-BIO - profiling reliable organisms as bioindicators (An integrated approach for island systems)

Financed by FLAD and currently under the coordination of António Onofre Soares (Centro de Investigação de Recursos Naturais - CIRN/Açores) and with the participation of the Azorean Biodiversity Group, the general aim of this project is the identification of key bioindicator species (i.e. arthropod species in Carabidae, Collembola, Staphylinidae and Araneae) for eight natural and agricultural habitat types (for arboreal and herbaceous land covers):

- Determine if there is a correlation between arthropods (e.g. richness, abundance, and species turnover), land cover and anthropogenic action.
- Survey all strata for a given habitat type using different techniques such as: Pitfall trapping (epigeal fauna); Berlese-Tullgren trapping (micro epigeal fauna); Vaccum (fauna with aerial vagility) and Beating (canopy fauna).
- Attempt to elaborate the genetic profiling of key bioindicators, as a strategy for their conservation. In fact, retaining genetic variation among populations of a key bioindicator may be of critical importance for the maintenance of the adaptive response potential to environmental changes or anthropogenic impacts.

The Azorean Biodiversity Group will be responsible for making a reference collection for all the arthropods and will also participate in the modelling process. All data will be posted in the ATLANTIS database and later will be updated on the Azorean Biodiversity Portal.

2) Consequences of land-use change on Azorean fauna and flora - the 2010 Target

Financed by DRCT (Azorean FCT) and currently under the coordination of Paulo A. V. Borges and Pedro Cardoso of the Azorean Biodiversity Group, the general aim of this project is to provide data and protocols that may be useful for the future evaluation of the Azorean ecosystems.

The focus of the project is not only the natural forests, which are relatively well known presently, but also to expand this knowledge to other land-use/habitat types. This will allow a comprehensive approach to the final objective of halting biodiversity loss in the archipelago by 2010. The project is mainly focused on arthropods and vascular plants, for which reliable data are readily available.

During the months of May, June and July the researchers will visit the islands of Flores, Faial and Santa Maria, for sampling arthropods in different land-use classes. These islands were selected because of the availability of vascular plant data for their entire surface, aiming to:

- a) Model the distribution of the endemic arthropod species using the new data and the already available ATLANTIS data for species and based on climate data (provided by the project CLIMAAT) and land-use maps (provided by the project SUEMAC).
- b) Perform an analysis of what happens to each species with the change in land-use types. Which endemic species are able to survive outside the original natural forest and what unique characteristics do they present?

c) Modelling and explaining the richness of species (overall, endemic, native and introduced) in Azores. To what extent does land-use type determine the richness of the different taxa?

e) Finding indicator taxa for overall richness, endemic richness and irreplaceability of sites. Does any single order or family of arthropods or plants provide a reliable indicator, with high correlation values with overall diversity/irreplaceability?

f) Assessing the correspondence of currently assigned protected areas with high irreplaceability sites. How well high irreplaceability areas are included in the Island Nature Parks and what gaps can be identified in the system?

According to the Curator of the University of Coimbra Herbarium there is NONE, for plants as far as she knows at NATIONAL level <sup>(6)</sup>.

1.4 Is there any coordinated effort in your country regarding bar-coding for identification or the assessment of biodiversity?

There is a Marie Curie Post-Doc doing a project for Azorean Vascular Plants, working at Imperial College (UK) <sup>(5)</sup>.

Not on plants <sup>(6)</sup>.

In 2006 FCT financed the project “Integrating molecular approaches into marine biodiversity research in Portugal: implementing DNA barcoding and investigating phylogeographic patterns”

[http://www.fct.mctes.pt/projectos/pub/2006/painel\\_result/vglobal\\_projecto.asp?idProjecto=69892&idElemConcurso=860](http://www.fct.mctes.pt/projectos/pub/2006/painel_result/vglobal_projecto.asp?idProjecto=69892&idElemConcurso=860).

1.5 Are you aware of any major efforts (or projects) in your country to integrate morphological and molecular taxonomy?

A project regarding the Barcode of Marine Life coordinated in the University of Minho <sup>(2)</sup>.

MarBOL (Barcode of Marine Life) is an international initiative to enhance the capacity of the European researchers to identify marine life by utilizing DNA Barcoding a new technique for that uses a short DNA sequence from a standardized and agreed-upon position in the genome as a molecular diagnostic for species-level identification.

In association with one PhD work, at the Lisbon Botanical Garden <sup>(3)</sup>.

No major projects, only small projects concerning particular taxonomic entities, usually species <sup>(4)</sup>.

There is in the Azores one project doing this for the *Azorean Tarphius* (Coleoptera) and *Hipparchia* (Lepidoptera) under the coordination of the Azorean Biodiversity Group <sup>(5)</sup>.

For plants, there are projects at a generic level. COI is involved in one, the large genus *Vitex* (Lamiaceae) at a world level <sup>(6)</sup>.

## 2 - TAXONOMY AS A BASIS FOR ECOLOGICAL RESEARCH AND SUSTAINABLE MANAGEMENT OF THE BIODIVERSITY

### Ecological Functions and Services: “What does it do, and what does it interact with?”

How does taxonomic research contribute to better understanding of the functions and attributes of species, and to the management of biodiversity?

2.1 Do you know projects involving taxonomists in the understanding of ecological functioning, or the assessment of ecosystem services?

Some e.g. in <sup>(1)</sup> expertise area, Ignacio Bárbara participates in several projects on Portuguese Macroalgae biodiversity and taxonomy; e.g. Leonel Pereira in RECITAL II.

The lichen group <sup>(3)</sup> use lichens-diversity as functional indicators in the following projects:

1. 1997-2003 – Establishing different methodologies for evaluating changes in the air quality of a Cu mine site by using lichens as biomonitors of heavy metals and relate these with changes in ecosystem functioning.
2. 2007-2010 - GISA – Integrated Management of Environment and Health in the Alentejo Litoral Region.
3. 2001-2004 – SINESBIOAR “Implementation of a multidisciplinary tool for the evaluation and management of air quality and the social impacts in the region of Sines”.
4. 1999-2001 - “Atmospheric Pollution and the management and conservation of forest ecosystems in Peninsula de Setubal”
5. 2005-2008 – “Effects of fragmentation on stand structure of *Quercus faginea* forests: key factors influencing water balance”.
6. 2005-2008 – “Contribution of cryptogams to carbon and water fluxes”. Financed by FCT (POCTI/BIA-BDE/60140/2004).
7. 2001-2004 - “European Biodiversity Assessment Tools: Bioassess”. Financed by European Commission (EVK2-CT-1999-00041).
8. 1996-1999 - “Lichens as biomonitors of atmospheric nitrogen deposition”.

Under the Millennium Ecosystem Assessment <sup>(5)</sup> the Azores have contributed with the following publication now in press: Ilhas Oceânicas (Borges *et al.*, in press).

COI is involved in a multidisciplinary project on high altitude grasslands in Portugal in which taxonomists and ecologists work on the understanding of ecological functioning; this project was initiated by taxonomists. HOWEVER, such collaborations are not common in Portugal in the botanical world and, when they occur, there is not a true collaboration between equal partners because ecologists simply require the identification of plants <sup>(6)</sup>.

2.2 What is the contribution of taxonomy in your country to the management of biological invasions?

See Araújo *et al.* 2009 and MACOI website <sup>(1)</sup>.

Lichens taxonomy are not used to the management of biological invasions <sup>(3)</sup>.

The following initiative is the good example for Azores and Madeira <sup>(5)</sup> - Invasive Terrestrial Flora & Fauna of Macaronesia (Silva *et al.*, 2008) (See also online in the Azorean Biodiversity Portal).

COI is aware of projects on invader plant species. Nevertheless, the collection was never consulted for this purpose <sup>(6)</sup>.

The project “INSPECT24 - Introduced marine alien species in Portuguese estuaries and coastal areas: patterns of distribution and abundance, vectors and invading potential” (2009 - 2011) will be lead by Science Faculty Foundation (University of Lisbon) with ICNB, Ports e Maritime Transportation Institute, League to Nature Protection, Évora and Azores Universities as partners. The objective of the Project is to study the occurrence patterns of marine alien species in Portuguese estuaries and coastal zones, to evaluate environmental conditions prone to the establishment potential invasive species and contribute to an increasing of the public awareness on this threat. In the initial phase, all relevant information will be collected, with a consolidation of data and taxonomical validation.

At the same time, the maritime routes including Portuguese harbours will be studied, to support a sampling strategy definition. Campaigns and sampling will be directed to different taxonomic groups, namely phytoplankton, zooplankton, algae and invertebrates in mobile and rocky substrata. Sampling will take place in different coastal and estuarine systems, such as Tagus and Mira, and Sines, Ponta Delgada, Lisbon and Vila Nova de Milfontes marinas and their neighbouring areas, as well as in ballast water tanks of selected ships. An inventory of marine alien species identified in Portuguese water bodies, including whenever possible the following information: valid taxonomy, introduction dates and places, habitat types affected, pathways of introduction e dispersal routes, population numbers, possible impacts and prevention and mitigation measures. Based on the Project findings' proposals on priority areas and species will be presented, to support management. It is also expected to promote cooperation among scientific community, authorities and civil society.

2.3 What is the contribution of taxonomy in your country to efforts to understand the status and trends of key functional groups such as pollinators?

The lichen group <sup>(3)</sup> use lichens functional groups to study key ecological functions such as: water-balance, nitrogen enrichment, climate change.

The following initiative is a good example for Azores and Madeira including not only Pollinators but all the endemic species <sup>(5)</sup> - TOP 100 - As cem espécies ameaçadas prioritárias em termos de gestão na região europeia biogeográfica da Macaronésia (Martín *et al.*, 2008) (See also online in the Azorean Biodiversity Portal).

For example, some plants can be used as bioremediators. COI has never been consulted or involved in such kind research, nor is the curator aware of any collaboration of plant taxonomists in such matters <sup>(6)</sup>.

### **Taxonomy, biodiversity and its conservation: “How to manage it in sustainable way?”**

Describe 1-2 flagship projects related to bullet points below and suggest some recommendations useful for meeting as a result from these projects:

2.4 Are there also non-professional organisations recording biodiversity data collections (e.g. ornithologists) involved in the decision process of land use planning etc.?

Some NGOs are particularly active concerning biodiversity issues, either in land, freshwater and marine habitats <sup>(4)</sup>.

The best example is SPEA (the Portuguese Bird Association) for birds and GESPEA (the Azorean group for the Study of caves) for cave fauna <sup>(5)</sup>.

Not as far as the plant diversity is concerned <sup>(6)</sup>.

2.5 Are there some indicators (or red-list species) either for monitoring Natura 2000 sites or for delimitation and management of nature reserves used in your country?

According to the lichen group <sup>(3)</sup> lichen has not yet been used for that purpose. It is their objective to use N-enrichment indicators for evaluating eutrophication in Natura 2000 areas.

A recent and important example for Azores and Madeira is the following initiative <sup>(5)</sup> - As cem espécies ameaçadas prioritárias em termos de gestão na região europeia biogeográfica da Macaronésia (Martín *et al.*, 2008) (See also online in the Azorean Biodiversity Portal ([www.azoresbiportal.angra.uac.pt/](http://www.azoresbiportal.angra.uac.pt/))).

There is ANY red-list of plant species in Portugal – this is a quite extraordinary state of affairs! <sup>(6)</sup>

In 2006, the Vertebrates of Portugal Red Book (eds: Cabral *et al.*, 2006) coordinated by the ICNB and developed in narrow collaboration with the national scientific community was ended. This list updated the former Mammals, Birds, Reptiles and Amphibious Red book (1990) and Fresh Water and Migratory Fishes Red Book (1991).

Regarding the Marine and Estuarine Fishes the red book existent in Portugal is from 1993, so the information available is not updated.

The Red List of bryophytes of the Iberian Peninsula, Portugal, Spain and Andorra (Sergio *et al.*, 2006) was revised and updated in 2006.

Regarding the Flora of Portugal Red List, the first phase of the works will be finished with the conclusion of the reference list of species to be classified, under the partnership established with the Association of Fitossociologia ALFA.

2.6 Which taxonomy-related research (standardized taxonomic metadata, delivery of checklist building tools, building expertise network) in developing non-European biodiversity-rich countries is supported by policy-makers from your country based on your national expertise and experience?

The best example in the Azores is the Azorean Biodiversity Portal ([www.azoresbiportal.angra.uac.pt/](http://www.azoresbiportal.angra.uac.pt/)) <sup>(5)</sup>.

2.7 Is there a National Needs Assessment of GTI in your country? If yes, what are your specific needs, e.g. for conservation, protected areas, CITES/customs, dealing with invasive species etc?

Portugal doesn't have a National Needs Assessment of GTI. In fact, Portugal didn't submit the Report on the Implementation of the Global Taxonomy Initiative Programme of Work - Report on GTI (<http://www.cbd.int/doc/programmes/cro-cut/gti/gti-needs-summary-en.pdf>).

Also, according to the Portuguese Third National Report on CBD (<http://www.cbd.int/doc/world/pt/pt-nr-03-en.pdf>), Portugal didn't make an assessment of taxonomic needs and capacities at the national level for the implementation of the Convention (annex to the decision VI/8).

### 3 - TAXONOMY, POTENTIAL USERS AND CAPACITY BUILDING OF EXPERTS

#### Open Access to Information: “How to find out about it?”

How does taxonomic information get from where it resides to where it is needed elsewhere in the world?

3.1 To what extent is taxonomic research in your country contributing to international biodiversity initiatives and projects (e.g. GTI, GBIF, PESI, EOL)

The MACOI database will be linked, in the future, to the GBIF Portuguese node <sup>(1)</sup>.

According to <sup>(2)</sup> taxonomic research it is not contributing.

Probably, those initiatives and projects may use national species' checklists, retrieved from scientific publications <sup>(4)</sup>.

The Portuguese Spiders database (<http://www.ennor.org/catalogue.php>) is already associated with GBIF. Data provider for GBIF (Global Biodiversity Information Facility) responsible of the project “Iberian Spider Catalogue” <sup>(5)</sup>.

None on plants <sup>(6)</sup>.

Five Portuguese biological collections can be found in the GBIF data portal (<http://data.gbif.org/>):

Botanic Garden, National Museum of Natural History, University of Lisbon

#### **1. Bryophyte collection**

Occurrences records indexed: 21380

Number of records shared by provider: 21380

Number of species: 607

Number of taxa: 984

#### **2. Lichen collection**

Occurrences records indexed: 1.997

Number of records shared by provider: 2.761

Number of species: 242

Number of taxa: 325

ACOI - Coimbra Collection of Algae - University of Coimbra

#### **3. Coimbra Collection of Algae**

Occurrences records indexed: 1.601

Number of records shared by provider: 1.601

Number of species: 781

Number of taxa: 1.081

Micoteca da Universidade do Minho

#### **4. Micoteca da Universidade do Minho Collection**

Occurrences records indexed: 251

Number of records shared by provider: 251

Number of species: 124

Number of taxa: 226

Instituto de Investigação Científica Tropical

## 5. Herbarium collection

Occurrences records indexed: 3.023

Number of records shared by provider: 3.026

Number of species: 1.537

Number of taxa: 2.276

3.2 What is the state of the art in biodiversity informatics in your country? e.g. etaxonomy and e-science tools)

In development but needed of funding <sup>(1)</sup>.

No work has been done with lichens <sup>(3)</sup>.

Several labs in institutes and universities use bioinformatic tools for research, namely concerning genetic data. Most of the research facilities have computers and internet access <sup>(4)</sup>.

The best example in the Azores is the Azorean Biodiversity Portal ([www.azoresbiportal.angra.uac.pt/](http://www.azoresbiportal.angra.uac.pt/)) <sup>(5)</sup>

In 2006 FCT (Portuguese Foundation for Science and Technology) financed 5 projects (641.000 €) for network qualification and organization of biological collections ([http://www.fct.mctes.pt/projectos/pub/2006/Painel\\_Result/default2.asp?idElemConcurso=928](http://www.fct.mctes.pt/projectos/pub/2006/Painel_Result/default2.asp?idElemConcurso=928)). This subject was withdrawn in the call of 2009.

The projects approved in 2006 were:

- IMBAMBA - Implementing Biodiversity Data Access and Management of Botanical Collections in Angola (Instituto de Investigação Científica e Tropical)
- Willkomm Herbarium: historical collection online (Faculdade de Ciências e Tecnologia - Universidade de Coimbra), housed in the Herbarium of Coimbra University
- Determining the role of dirigent proteins during grapevine/Uncinula necator interactions (Instituto de Tecnologia Química e Biológica)
- Algoteca de Coimbra (ACOI): a unique collection of microalgae (Faculdade de Ciências e Tecnologia - Universidade de Coimbra)
- Recovering the past, recording the present, and preparing the future of zoological collections in Portugal (Fundação da Faculdade de Ciências - Faculdade de Ciências da Universidade de Lisboa)

According to the results of the Biocase inquiry carried out during the summer of 2006, based on the 94 collections recorded there are approximately 2,4 millions specimens, most of them (67%) of the flora domain, only 10% of the records are digitalized in databases (see Table 2) ([http://biomonitor.ist.utl.pt/gbif/media/outros/PlanoAccaoGBIF\\_PT.pdf](http://biomonitor.ist.utl.pt/gbif/media/outros/PlanoAccaoGBIF_PT.pdf)).

Table 2 – Number of biological collections recorded on national institutions, digitalised data and percentage, as resulted of the Biocase inquiry carried out during the Summer of 2006 ([http://biomonitor.ist.utl.pt/gbif/media/outros/PlanoAccaoGBIF\\_PT.pdf](http://biomonitor.ist.utl.pt/gbif/media/outros/PlanoAccaoGBIF_PT.pdf)).

	Nº collections	Nº specimens	Digitalised data	% digitalised data
Animal	28	762051	61489	8,00%
Flora	52	1628091	162161	10,00%
Microbial	14	19250	9151	48,00%
Total	94	2409392	232521	10,00%

In 2007 the action plan for the establishment of the GIBIF Portuguese node (called Portuguese Infrastructures of Biological Diversity Information – GBIF.PT) was presented for appreciation to the Portuguese Science, Technology and High Education (MCTES) in 2007.

In the Biodiversity collections index online we can find information about 22 biological collections from Portugal, mainly herbariums and entomology (insects and spiders).

Table 3 – Portuguese biological collections in the Biodiversity collections index.

	Kind of Collection	Taxonomic Scope	Geographic Scope
Centro de Zoologia do I.I.C.T. - Entomology	Entomology (Insects/Spiders)	Mainly vascular plants and fungi.	Portugal, including Azores and Madeira, Spain, northern Africa, Europe, and North America.
Estação Agronómica Nacional Herbário	Herbarium	Mainly vascular plants and fungi.	Portugal, including Azores and Madeira, Spain, northern Africa, Europe, and North America.
Instituto de Investigação Científica Tropical Herbário	Herbarium	Vascular plants.	Tropical Africa, especially Mozambique, Angola, Guinea-Bissau, Cape Verde Islands, and São Tomé and Príncipe.
Instituto Nacional de Investigação Agrária Herbário	Herbarium	Vascular plants and bryophytes.	Portugal, Azores and Madeira.
Instituto Nun'Alvres Herbário	Herbarium	Bryophytes; lichens of Portugal.	Worldwide, especially of Portugal, Madeira, and Azores.
Instituto Superior de Agronomia Herbário João de Carvalho e Vasconcellos	Herbarium	Vascular plants.	Europe, especially Portugal, Madeira, and Azores.
Jardim Botânico da Madeira Herbário	Herbarium		Madeira, Porto Santo, Desertas, and Salvagens (Salvage Islands).
Ministério da Educação Herbário	Herbarium	Fungi	Portugal
Museu Carlos Machado Herbarium - Açores	Herbarium		Worldwide, especially Azores.
Museu Municipal do Funchal Herbário	Herbarium	Mainly vascular plants and algae.	Macaronesia; Madeira, Porto Santo, Desertas, and Selvagens; some Azores and Canary Islands.
Museu Nacional de História Natural Herbário	Herbarium	All groups	Worldwide, especially Portugal, Azores, Madeira, and Selvagens Islands; Angola; Mozambique; São Tomé and Príncipe Islands; Guinea-Bissau; Cape Verde Islands; Timor Island; India.
National Station for Plant Breeding Herbarium	Herbarium	Vascular plants.	Mainly Portugal, including Madeira.
Sociedade de Geografia de Lisboa Herbário	Herbarium		
Universidade de Aveiro Herbário	Herbarium		Portugal
Universidade de Coimbra, Museu de História Natural	Entomology (Insects/Spiders)	All orders of insects, but best represented by Lepidoptera and Coleoptera.	
Universidade de Évora Herbário	Herbarium		Southern Portugal.
Universidade de Lisboa - Entomology	Entomology (Insects/Spiders)		
Universidade de Trás-os-Montes e Alto Douro Herbário	Herbarium		Portugal, especially Trás-os-Montes and Alto Douro region.
Universidade do Porto Herbário	Entomology (Insects/Spiders)		
Universidade dos Açores Herbarium	Herbarium		Flora of Macaronesia, especially Azores.
University of Coimbra Herbarium	Herbarium	All groups	Worldwide, especially Portugal and tropical Africa.
Universidade do Porto Herbário	Herbarium		Mainly Portugal.

3.3 Has there been a national assessment of best practices for taxonomic data quality and validation?

There are no National guidelines, but the lichen group represents Portugal for the construction of the European Guidelines for lichen diversity assessment <sup>(3)</sup>.

NOT for plants <sup>(6)</sup>.

3.4 Do you have any national guidelines on how to approach the proof of absence?

See previous answer <sup>(3)</sup>.

NOT for plants <sup>(6)</sup>.

3.5 What are the taxonomic standards used in the databases (TDWG, Darwin core, COL, PESI, etc.)?

MACOI database use Darwin core 2 <sup>(1)</sup>

Darwin core <sup>(2)</sup>

Databases used for plants have been very much personal choices, at least some with no taxonomic standards. The Herbarium of the University of Coimbra (COI) uses SPECIFY, developed by the University of Kansas, and it complies with all the taxonomic standards required by GBIF (TDWG, Darwin core, etc). <sup>(6)</sup>

3.6 Could you identify the major digitization efforts for biodiversity data (e.g. collections, observations, species checklists)?

Digitization of the historical herbarium COI - Phycological Collection and was recently submitted, for financing, a project to FCT (Portuguese Foundation for Science and Technology) <sup>(1)</sup>. COI has c. 800.000 specimens and has digitized 45.884 specimens now <sup>(6)</sup>.

Collections and observations of marine crustaceans <sup>(2)</sup>.

Work done at the Botanical Garden of the University of Lisbon <sup>(3)</sup>.

For the Macaronesia there is an important initiative, the ATLANTIS, which generated the list of species of all the archipelagos <sup>(5)</sup>:

This effort was started by the Canarian Conservation Bureau with the project BIOTA-Canarias, and resulted in the publication of a detailed list of terrestrial and marine biodiversity of the Canary Islands (Izquierdo *et al.*, 2001, 2004; Moro *et al.*, 2003). Later the idea was expanded to the other Macaronesian archipelagos (the Cape Verde Islands, Madeira-Selvagens and the Azores) through two INTERREG IIIB projects called ATLÂNTICO and BIONATURA (2004-2008).

As a consequence of the cooperation between the Canarian, the Azorean and Madeira governments, three more lists of species appeared recently for Cape Verde (Arechavaleta *et al.*, 2005), Azores (Borges *et al.*, 2005) and Madeira-Selvagens (Borges *et al.*, 2008).

This cooperation, that included more than 200 taxonomists, now we know that the number of unique endemic species and subspecies of terrestrial organisms (fungi, plants and animals) in these islands is now estimated to be around 420 for the Azores (Borges *et al.*, 2005), 1419 for Madeira (Borges *et al.*, 2008) and 3672 for the Canary Islands (Izquierdo *et al.*, 2004). With such a diversity of unique species many of them under threat (Martin *et al.*, 2008) it was critical to develop a project to highlight such importance. With such an endeavour the diversity of life will come out from the grey taxonomic literature, herbaria and private collections and put available for all the public! A group of biologists and ecologists the University of the Azores cooperated in gathering their forces to make possible this project. The “Azorean Biodiversity Portal – ABP” ([www.azoresbioportal.angra.uac.pt/](http://www.azoresbioportal.angra.uac.pt/)) is the most remarkable product of such cooperation.

A software, called ATLANTIS Tierra 2.0, was developed for biodiversity data storage. This software was written in Visual Basic, using a common database environment; it uses the SQL language to develop interrogation queries and has an easy interface with all GIS software. With this database, it is possible to store detailed information about the taxonomy and georeferenced distribution of all species on the surveyed geographical areas of interest. ATLANTIS Tierra 2.0 was inspired on “Worldmap distribution analysis software”. It has several important tools, namely a taxonomic tool and a conservation management analysis tool that allows the calculation of species richness, their rarity or complementarity (displays the minimum number of cells required to ensure that each species in the dataset is represented at least once) in all 500x500 m cells of a particular island or, in any special area in one island. The ATLANTIS database was successfully developed in the Canary Islands, Cape Verde and in the Azores, and is still in development in the Madeira archipelago.

3.7 Is there any effort in your country to make taxonomic information especially identification services easily accessible and useful to practitioners?

Please look at the previous answer <sup>(1)</sup>.

The best example is the new tools for the identification of Azorean Spiders available in the Azorean Biodiversity Portal ([www.azoresbioportal.angra.uac.pt/](http://www.azoresbioportal.angra.uac.pt/)) <sup>(5)</sup> - Images of Azorean Spiders with details for male and female identification v. 3.0. (Mendonça & Borges, 2009).

No. COI is the second largest Herbarium in the Iberian Peninsula, it has c. 800.000 specimens and, apart from the curator, it has 1 member of staff. This means COI is not enough staffed (1) to train or help practitioners, (2) to carry out Floras accounts, the tools for the identification of plants. <sup>(6)</sup>

### Capacity Building in Biodiversity-rich Countries and Worldwide

What is the state of training and education in systematics and are there any gaps in capacity?

3.8 Are there any policy initiatives in your country to orient capacity building in taxonomy?

There are NO policies as such. At COI the curator is the lecturer of Plant Diversity, and she uses the Herbarium to orient capacity building in plant taxonomy, as well as field trips. <sup>(6)</sup>

In Madeira, training programmes on marine taxonomy have been carried out, mainly by the University of Madeira, targeted for graduated, MSc and PhD students. MSc and PhD projects have been developed at University of Madeira, often in collaboration with local institutions, focused on MPAs, threatened and/or endangered marine species (including birds, cetaceans, monk seal and turtles), and other marine resources (phytoplankton, fish stocks). Some genetic monitoring is carried out in some *Pterodroma* species populations, marine turtles and cetaceans. Involved institutions: Regional Fisheries Directorship, Funchal Marine Biology Station, Whale Museum, Funchal Municipality Museum, University of Madeira (<http://www.cbd.int/doc/world/pt/pt-nr-vmc-en.pdf>).

3.9 Are there any sources of finance or policy actions in your country dedicated to applied taxonomy (e.g. identification tools, training for parataxonomists, i.e. field-trained biodiversity collection and inventory specialists recruited from local areas)?

No, there are any policy actions dedicated to applied taxonomy in Portugal <sup>(6)</sup>.

Some investments are being made in plant and animal germplasm banks. For example, in Madeira the construction of infrastructures to house herbarium collections as well as laboratories for taxonomic and systematic studies is planned. However, there is a lack of funds and continuity in these investments, and most natural history museums and botanical gardens struggle with the lack of funding and human resources (Portuguese CBD Third National Report, 2007).

There are some projects but not at the national level or with national coordination. There is collaboration between research centers, Universities and NGO that helps in coordination of courses of taxonomy. As examples we detach in Azores the Project INTERREG IIIB (2000-2006) Atlantic “*Listagem de espécies de fauna e flora terrestres dos Açores*”; Project INTERREG III Aquamac “*Técnicas e Métodos para a Gestão Sustentável da Água na Macaronésia*”. Some technical and academic training programmes in marine species' taxonomy have been recently carried out, utilizing the oceanic research vessel NORUEGA, in collaboration between IPIMAR and Portuguese universities, with graduated, master and PhD students (Portuguese CBD Third National Report, 2007).

The Centre of Marine and Environmental Research (CIMAR) contributes for the Taxonomic Clearing System from MarBEF (Marine Biodiversity and Ecosystem Functioning - EU Network) which uses available taxonomic expertise across the MarBEF community to provide fast responses to taxonomic questions and help to enhance taxonomic expertise in Europe (<http://www.marbef.org/>). MarBEF is also responsible for the database of European Marine Species and for the European part of OBIS (Ocean Biogeography Information System - <http://www.iobis.org/>) that has records from 63 000 species.

CIMAR is also involved with “PROPE taxon - Web Accessible Taxonomic Expertise in MarBEF” providing an e-Platform for the European Taxonomists (<http://www.medobis.org/prope/index.php>).

Some work is being done in the context of ICES working groups, namely International Bottom Trawl Survey Working Group. ICES use the Interagency Taxonomic Information System (<http://www.itis.usda.gov>) rtuguese CBD Thispecies'onat Report, 2007).

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## ANNEX 1

Complete list of collections and respective number of records, percentage of digitalised data and number of digitalised records per year ([http://biomonitor.ist.utl.pt/gbif/media/outros/PlanoAccaoGBIF\\_PT.pdf](http://biomonitor.ist.utl.pt/gbif/media/outros/PlanoAccaoGBIF_PT.pdf))

Organization	Collection	Nº specimens	% Digitalised data	Digitalised data / year
INIAP	EAN-Cárias e Pistácias	1611	0	0
UM	Aves Marinhas BTAMCP	93	70	80
UM	Fauna Cavernícola CFCP	EC	EC	EC
UM	Mamíferos Marinhos BTMMCP	280	70	50
UM	Nemátodes CNDB	500	0	0
UM	Especies Vegetais CCVDB	45	0	0
UM	Microrganismos CMDB	3500	100	TOT
ISA	Herbário João de Carvalho e Vasconcellos	100000	13	100
ISA	Jardim Botânico da Ajuda	4000	5	10
INIAP	Amostras de plantas de arroz	-	-	-
INIAP	Herbário da EAN	100000	-	-
Min. Agricult.	Ampelográfica do Douro	-	-	-
Min. Agricult.	Ampelográfica de Vidago	-	-	-
INIAP	Germoplasma de arroz	1415	-	20
IICT	Herbário LISC	300000	2	2000
IICT	Entomoteca	6278	100	TOT
IICT	Cafeeiros e agentes patogénicos	3500	25	-
IICT	Jardim Tropical - Plantas Vivas	V	EP	0
IICT	Jardim Tropical - Herbário	ED	EP	0
IICT	Jardim Tropical - Sementes	V	100	0
IICT	Jardim Tropical - Xiloteca	4082	15	V
IICT	Xiloteca e Laminoteca	8200	9	TNE
IICT	Zoologia	70000	0	-
UTAD	Cultivares de Castanheiro	93	-	-
UTAD	Culturas de Microbiologia Ambiental	1600	15	-
UE	Herbário	5000	-	400
UTAD	Histologia e histopatologia Animal	-	-	-
INIAP	Banco de Germoplasma/Genética	4000	99	TNE
UTAD	Microrganismos em cultura	300	10	-
UTAD	Herbário HVR	1800	99	TNE
FCUP	Herbário	75000	80	1500
FCUP	Microrganismos	500	0	EC
UTAD	Fungi	1400	70	250
AVG	Oceanográfica de D. Carlos	3000	10	-
INIAP	Phaseolus vulgaris	600	30	150
INETI	Culturas de Microrganismos Industriais (CCMI)	1030	80	20
UC	Portuguesa de Bactérias (CPC)	4000	-	300
INIAP	Ampelográfica Nacional	730	100	TOT
UALG	Biodiversidade nas Pescas no Sul de Portugal	700	-	-
UL	Herbário LISU	250000	15	10000
UC	Algoteca de Coimbra (ACOI)	4000	40	-
INIAP	Micoteca	300	-	TNE
INSA	Micoteca (MINSAs)	1803	50	150
UM	Micoteca	397	80	50
UTAD	Lepidópteros	2500	0	-
UALG	Herbário	3000	0	-
ISA	Culturas	2500	0	0
GOVREGAÇOR	Flora Natural dos Açores	-	-	-
ES				
INSA	Culturas Microalgas Dra. Estela Sousa e Silva	190	75	15
UP	Coleção Geral	3800	100	-
UP	Biel (Insectos)	1200	0	-
UP	Castro (Moluscos)	1000	0	-
UP	Corrêa de Barros (Insectos, Coleópteros)	30000	0	-
UP	Braga Júnior (Insectos Amér. Sul)	50000	0	-
UP	Braga Júnior (Anfíbios, Répteis, Aves e Mamíferos AS)	2716	50	-
UP	Augusto Nobre (Moluscos de Portugal)	2000	75	-
UP	Mª Amélia Cruz (Lepidópteros Port)	6000	75	-
UP	Reis Júnior (Aves de Portugal)	400	-	-
INIAP	Fruteiras	-	0	0
ICN	Luis Gonzaga do Nascimento	500	90	V
INIAP	Oliveiras (TextoLivre)	17	-	0
UC	Herbário (COI) - Criptogamia	50000	0	0
UC	Herbário (COI) - Seminário	5000	0	0
UC	Herbário (COI) - Exsicata	5000	0	0
UC	Herbário (COI) - Histórico de Willkomm	10000	0	0
UC	Herbário (COI) - Col. Port. Vascular	150000	11	16000
UC	Herbário (COI) - Geral Vascular	230000	-	-

UC	Herbário (COI) - Carpológica	5000	0	0
UC	Herbário (COI) - Africana Vascular	180000	5	2300
INIAP	Estirpes Bactérias Fixadoras de Azoto (Rhizobium)	200	0	15
GOVREGMAD	Herbário	23194	25	2000
ESAB	Herbário	7500	75	500
EVN	Microrganismos Enológicos	1150	90	TNE
UA	Herbário	15000	10	0
INIA	Leguminosas	5154	-	100-150
INIA	Forrageiras	-	-	-
INIA	Pratenses	-	-	-
INIAP	Herbário	35000	-	-
DRATM	Pereiras Regionais	-	-	-
ESAB	Entomológica	20000	10	-
INIAP	Vegetais	1300	80	10-100
INIAP	Herbário	35000	30	0
INETI	Paleontológica	500000	5	V
INIAP	Cultivares de Oliveira	50	-	-
INIAP	Sementário	500	-	-
INIAP	Micoteca/Culturas	280	100	10
INIAP	Entomoteca de Ecossistemas Florestais	16984	50	10
INIAP	Micoteca/Herbário	2700	30	30
ESAB	Micoteca/Herbário	700	40	100
MNHN	Ictiologia	35000	10	800
MNHN	Herpetologia	1500	70	300
MNHN	Aves	2600	0	0
MNHN	Mamalogia	5000	60	V
MNHN	Invertebrados	-	50	1170

**Legend**

EC – In construction

ED - In determination

EP – In Preparation

TNE – All the new entries

V - Variable

- - No information

TOT - Totally digitalised

**Institutions**

AVG - Aquário Vasco da Gama

ESAB - Escola Superior Agrária de Beja

FCUP - Faculdade de Ciências da Universidade do Porto

GOVREGMAD - Governo Regional da Madeira

ICNB - Instituto da Conservação da Natureza e da Biodiversidade

IICT - Instituto de Investigação Científica Tropical

INETI - Instituto Nacional de Engenharia, Tecnologia e Inovação

INIAP - Instituto Nacional de Investigação Agrária e das Pescas

INSA - Instituto Nacional de Saúde Dr. Ricardo Jorge

ISA - Instituto Superior de Agronomia

MNHN - Museu Nacional de História Natural, Universidade de Lisboa

UA - Universidade de Aveiro

UALG - Universidade do Algarve

UC - Universidade de Coimbra

UE - Universidade de Évora

UM - Universidade do Minho

UTAD - Universidade de Trás-os-Montes e Alto Douro