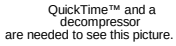
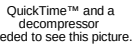


FUTURE TRENDS OF TAXONOMY



21 - 23 January 2008
Carvoeiro (Algarve, Portugal)

The Symposium Programme

Sunday 20/01/2008	
17:00 - 19:00	Symposium registration (Centeanes Room)
Monday 21/01/2008	
9:00 - 9:30	Symposium registration (Centeanes Room)
9:30 - 9:40	**Opening address** (Carvoeiro Room) Simon Tillier (EDIT project leader)
	Technical opportunities (Carvoeiro Room)
9:40 - 10:20	*A renaissance of insect morphology - µ-Ct and other innovative techniques* Rolf G. Beutel
10:20 - 11:00	*Ancient (Museum preserved) tissues and DNA* Matthew Collins
11:00 - 11:40	*Tissue & DNA storage and sharing: BRCs networking* Manuel Morente
11:40 - 12:00	coffee break
12:00 - 12:40	*Field work: the need to scale up and adjust to new constraints* Philippe Bouchet
12:40 - 13:10	*Environmental sequencing* Jeroen Raes
13:10 - 15:00	lunch break
15:00 - 15:40	*Phyloinformatics - integrating everything* Roderic Page
15:40 - 16:20	*Uniting supertrees and supermatrices to derive the Tree of Life* Olaf Bininda-Emonds
16:20 - 17:00	*Developments and threats in taxonomic research: a summary from statements by leading European taxonomists and phylogeneticists* Klaus Klass
17:00 - 17:20	coffee break
17:20 - 19:00	Round Table (Chairman: Alfried P. Vogler)
Tuesday 22/01/2008	
	Conceptual Challenges (Carvoeiro Room)
9:00 - 9:40	*New sequencing techniques* Miguel Alvarez Tejado
9:40 - 10:00	*Zoobank & Zoological Nomenclature* Ellinor Michel
10:00 - 10:20	*Zoological nomenclature: some urgent needs and problems* Alain Dubois
10:20 - 11:00	*From field records to a sustainable taxonomic knowledge base: new approaches and opportunities for efficient biodiversity inventories* Christoph Häuser
11:00 - 11:20	coffee break
11:20 - 12:00	*DNA Taxonomy* Alfried P. Vogler
12:00 - 12:40	*DNA sequences in taxonomy: empirical performance, opportunities, and pitfalls* Rudolf Meier
12:40 - 13:10	*Initiatives for improving systematics: attitudes, impediments and opportunities* Diana Lipscomb
13:10 - 15:00	lunch break
15:00 - 16:30	Round Table (Chairman: Roderic Page)
16:30 - 16:50	coffee break
16:50 - 18:00	Round Table (Chairman: Roderic Page)
Wednesday 23/01/2008	
9:00 - 13:00	Brainstorming (Porches Room) [Closed session with speakers, scientific organizers, project leader and chair of the Future Scoping Group]

abstracts

A renaissance of insect morphology - µ-Ct and other innovative techniques

R. G. Beutel, F. Friedrich & H. Pohl

Institut für Spezielle Zoologie und Evolutionsbiologie, FSU Jena, Germany

The detailed study of internal structures of insects became unpopular in the last decades of the 20th century. However, innovative technological developments have given new impulses to insect anatomy in the last years and the detailed documentation of morphological data has high priority in current phylogenetic projects with a combined approach (e.g., **B**eetle **T**ree **o**f **L**ife). Scanning electronic microscopy (SEM) is extremely useful for surface structures but its potential for the study of soft parts is limited. With the ESEM mode (environmental pressure) it is possible to examine moist or even live specimens and it is also very useful for the documentation of structures of dried museum material. The use of confocal laser scanning microscopy (CLSM) allows a very efficient study of external and internal features of small (or very flat) insects. CLSM is also a very promising tool for the documentation of large series of extracted insect genitalia. An excellent technique for the study of internal features is Micro-computer tomography (µ-CT). It is largely artefact free, the images are perfectly aligned, and it is non-destructive. Image stacks of high quality can be obtained within few hours. The maximum resolution is c. 1 µm. Computer based three dimensional reconstruction and animations are not only a qualitative improvement in morphological investigations, but also very useful for teaching morphology. An optimised application of modern morphological techniques allows a very efficient acquisition of high quality anatomical data and has a great potential to improve systematic and taxonomic studies with a morphological or a combined approach.

Ancient (Museum preserved) tissues and DNA

Matthew Collins

BioArCh, Departments of Biology and Archaeology, University of York, UK

Preserved sequences of DNA (and even proteins) held in museum represent and unique and remarkable store of historically documented, geographically located material for future scholars. However, at the very same time as the costs of accessing this sequence data fall and new techniques hold new promise for other tissues and other biopolymers, the samples are being destroyed by physical and chemical processes, some of which are largely beyond our control.

In this presentation I will consider what we know of the mechanisms that lead to loss of information. We still remain remarkably ignorant of the fates of biologically informative biopolymers, both destructive processes such as chain scission by chemical hydrolysis and constructive processes such as condensation. Furthermore some biomolecules may survive in cryptic (hidden or unexpected) environments of which we still remain ignorant. Using this analysis I will consider future prospects in particular the extent to which new analytical tools will be able to take us beyond traditional areas of research.

Finally, I will discuss the role of modelling of decay processes as a tool for both (i) predicting the likely survival of biopolymers and (ii) as a means of assessing and refining our understanding of both the processes of decay and to identify optimal strategies for recovery of biomolecular information. I will introduce PrediCtoR a tool for predicting the likelihood of successful PCR amplification from ancient tissues, and share ideas for involving the wider research community in developing and improving this prediction tool.

Tissue & DNA storage and sharing: BRCs networking

Manuel M. Morente

Molecular Pathology Programme, CNIO – Spanish National Cancer Research Centre, Spain

Golden era for bioscience

We are living a deep and hopeful transformation in Cancer Research and Cancer Care. This hopeful transformation also applies to every biological research including biodiversity and species taxonomy. The currently available technology for highthrougput analysis of genes and proteins allow us to do:

- A better knowledge of a single species
- A better knowledge of the species evolution relationships

It means a change of paradigm moving from macroscopy (18^{th}-19^{th} century), and microscopy (20^{th} c.) to Molecular profiling (21^{st} c.)
Current technology allows us:

- Vertical Genomics - All Genes, One Species (ie. Human Genome Project)
- Horizontal Genomics - One Read, All Species (ie. Bar-code project)

It means some Emerging Applications of high social value: Parasite and disease vector IDs, Endangered Species Control, QA/QC of cell culture collections, Metazoan entry into Environmental Genomics, etc. This new facilities create new necessities.
Technical developments have renewed the need for high-quality tissue samples, especially when this technology is of increasing social value.

- Large-scale molecular studies with large numbers of cases
- Homogeneous tissue-sampling protocols for multi-centre studies.
- A new mentality for sharing.

Biobanks

Easy access to biological samples of high quality and their associated data is, currently, the main bottleneck for the development of biological sciences research, and Biobanks of excellence are the most suitable tool for resolve this bottleneck
Biological Resource Centers consist of "*service providers and repositories of* ***living cells, genomes of organisms, and information*** *relating to heredity and the functions of the biological systems"*.(OECD Guidelines for the Operation of Biological Resource Centres, 2007). Following this definition biobanks are called to include a wide range of activities and targets, including: Primary specimens, primary annotations, pictures, tissue samples acquisition, fixed and frozen samples, extracted products (DNA, RNA, proteins, etc.), sequences and other analytical data and integrated data bases.

Currently we have labeled data on ~ 1.5 - 3.0 billion specimens in 6000+ natural history collections (sensu lato) worldwide, as well as observational databases (bird counts, etc.). These data have been amassed over ~ 300 years, and therefore have high historical value, but (for the same reason) most are not digital. This means most are not easy to access -- therefore are not accessed. In the "information age" of today, it would be well if all this could be done digitally.

On the other hand an excess of information is time consuming, is cost consuming, is "informatics memory" consuming, is not usually used and is a bad investment. The best solution is interconnectivity of different data bases.

*"BRC must meet the **high standards of quality** and expertise demanded by the international community of scientist and industry for the delivery of biological information and materials"*. (OECD Guidelines for the Operation of Biological Resource Centres, 2007). To be operative it is necessary a good balance between BEST PRACTICES and MINIMAL REQUIREMENTS, but quality management policies ares, always, a mayor issue.
Quality Assurance (QA) or Quality Management System (QMS):

- Minimize errors derived from the lack of protocols.
- Minimize errors derived from the incorrect use of technology and equipments.
- Find and solve weak points in terms of final quality.

Quality Controls are a part of the quality indicators, but the final goal is not QC policy or QMS. Both are instruments.
Quality assurance is fundamental to the successful operation of any biospecimen repository and includes: Written standard operating procedures, Quality indicators and Objectively Quality goals
The QA/QMS should describe procedures to conduct audits. Each Repository should develop written policies and procedures in a standardized written format that should be incorporated into a Standard Operating Procedures (SOP) manual.
Quality Assurance is an alive and progressive issue: "Nothing is so good it can't be made better ".

BRC Networking

BRCs consist of "***service providers*** *and repositories of living cells, genomes of organisms, and information relating to heredity and the functions of the biological systems*". (OECD Guidelines for the Operation of Biological Resource Centres, 2007).
Biobanks exist ever since Natural History Museums store specimens and samples, but the current BRC definition includes…

- Not only tissue storage, but also a series of institutional protocols that allow molecular studies of biological specimens.
- Collection, freezing and storage of neoplastic and normal tissues must be considered a routine in the Natural History Museums and related institutions.
- Not only a biologist's activity but a global institutional facility.
- Homogeneous and suitable protocols for collection, handling, storage and use of frozen samples for research and teaching.
- A professionalisation of the personnel directly working in these units.
- Quality assurance and quality controls
- Co-operative tumor bank networks to allow multicentre and international clinical trials and collaborative studies.
- Being open to share tissue samples with basic and applied researchers…

And networking implies...

- Standardized technical procedures
- A common quality control program
- A well structured coordination office
- Homogeneous ethic requirements
- An open mentality for sharing

Multicentre and multinational PROJECTS are necessary. It means harmonization of Technical procedures, Ethic requirements, International legal frameworks and common

Quality Assurance Policies In order to avoid (o minimize) the intrinsic bias of multicentre & multinational studies.

Field work: the need to scale up and adjust to new constraints

Philippe Bouchet

Muséum national d'Histoire naturelle, Paris, France

We are the first generation of scientists confronted with the challenge of documenting and describing millions of species, while time is running out and many species will become extinct during our lifetime. Other speakers will address the question of how the processes of species recognition and description can be speeded up, but all efforts and initiatives are meaningless if the first phase of the taxonomic work is poorly organized: even before they are evaluated, analyzed and described, taxa must first be sampled and preserved in a manner compatible with modern taxonomical approaches. It is a frequent misconception that species are just lying out there waiting to be collected. Most species are small and rare. Whereas 80% of the species possibly remain undescribed, yet most surveys yield at least 80% of already described species. I argue that this is because many taxonomic discoveries are the serendipitous by-product of field work carried out by other disciplines for other purposes (e.g., conservation surveys, ecosystem studies). Field work conducted specifically for taxonomical purposes essentially remains small-scale and low-tech, and... not infrequently squarely unlawful. This has become untenable in an age where funding bodies and academic institutions expect first-world scientists to abide with regulations (for collecting, export/import, and transport of specimens) and expectations (for capacity building and repatriation of data) of the host countries, and such practices are threatening the future of taxonomy by sending the wrong message to law enforcers, conservationists, and the public at large.
For species discovery to sustainably take place at the scale that is pressed on us by the biodiversity crisis, taxonomists must scale up the way they are conducting field work and must learn how to respond to the new constraints of our time.

Environmental sequencing

Jeroen Raes

EMBL Heidelberg, Germany

New advances in sequencing technologies bring random shotgun sequencing of complete ecosystems within reach of smaller labs, allowing large-scale investigation of the nature and scale of (microbial) biodiversity. However, the complexity of metagenomics data can be overwhelming. Recently, many novel computational tools have been developed to unravel ecosystem properties starting from fragmented sequences. In addition, the so-called 'comparative metagenomics' approaches have allowed the discovery of specific genomic and community adaptations to environmental factors. In my talk, I will discuss progress, but also important pitfalls in computational analysis of large-scale environmental sequencing data.

Points for discussion:

- What is the value (and current thinking) of the species concept in micro-organisms, where lateral gene transfer is rampant and microbial consortia can be seen as 'multicellular' organisms?

Phyloinformatics -- integrating everything

Roderic Page

University of Glasgow, UK

Phyloinformatics, broadly defined, aims to integrate diverse sources of information about organisms within the framework of their phylogeny. This talk will discuss various approaches to integration, including mashups such as iSpecies.org. The key role of identifiers for digital objects is discussed, and examples given of how identifiers for the same organismal names in different databases may be combined. The talk will argue that the best strategy for speeding up integration of biodiversity resources is to adopt a framework similar to CrossRef.org, which underpins the digital publishing industry. It will also argue that the quickest way to harvest information for integration is large scale data mining.

Points for discussion:

- Unique, resolvable identifiers for digital objects
- Services for resolving and linking objects
- Text mining

Uniting supertrees and supermatrices to derive the Tree of Life

Olaf Bininda-Emonds

Institut für Spezielle Zoologie und Evolutionsbiologie, FSU Jena, Germany

In our efforts to derive the Tree of Life, the supertree and supermatrix approaches have been cast as competing strategies for phylogenetic inference. Certainly, the analysis of primary character data (supermatrices) versus that of the trees obtained from those data (supertrees) each has distinct advantages and the methods appear mutually exclusive at first glance. In this talk, I will argue that initial appearances are deceiving in this case: the respective advantages to each method are actually complementary, such that their combination might prove to be the most profitable strategy for a large-scale assault on the Tree of Life. To this end, I initially review the supertree and supermatrix approaches as well as their respective strengths and weaknesses. I then examine how their strengths can be combined in a divide-and-conquer framework to help solve really huge phylogenetic problems. Under this framework, supertrees will evolve into a computational tool to potentially increase the speed (and accuracy?) of large-scale supermatrix analyses rather than being the end product of the phylogenetic analysis. I conclude by exploring the feasibility of a divide-and-conquer strategy and what characteristics are needed for it to represent a real improvement over conventional search strategies.

Points for discussion:

Taxonomy:

- what are the respective roles of morphology and molecules in taxonomy?
- what is feasibility of establishing a common standard for morphological data (as a prelude to setting up a morphological database)?

Tree of Life

- how complete does the Tree of Life need to be?
- does a Tree of Life exist for prokaryotes / how to accommodate groups without a tree?

Bioinformatics and databasing

- establishing global standards / exchange protocols for bioinformatics / phyloinformatic databases
- how to coordinate international efforts to reduce repetition and redundancy?

Developments and Threats in Taxonomic Research: a Summary from Statements by Leading European Taxonomists and Phylogeneticists

Klaus-Dieter Klass

Museum of Zoology Dresden, Germany

As a preparation for this meeting, 20 leading European taxonomists and phylogeneticists were invited to submit a 2-page statement about the situation of taxonomic research in their countries and in general. There are many positive developments, such as the formation of societies representing all systematic disciplines, increasing networking on the European and global levels, continuous improvement of data-basing, use of DNA data in taxonomy, and non-invasive methods of morphological study and gene extraction. However, there are also many threats to taxonomy in the strict sense: The number of permanent positions is declining, contrasting the increasing amount of tasks and methodological aspects of taxonomic work. Taxonomic education at universities has strongly lost ground, resulting in less scientific "upgrowth". There is competition for jobs and (wo)manpower with e.g. molecular phylogenetics. There are financial problems to ensure accessibility of expensive new methods to the majority of taxonomists. Evaluation criteria widely applied throughout science, such as ongoing innovation and the "journal impact factor", massively direct (wo)manpower away from badly needed taxonomic routine work. The taxonomic "amateur" scene is also decreasing and suffers from increasing costs. Another noteworthy development are suggestions of new, more phylogeny-based nomenclatural systems as alternatives to the Linnean one.

Points for discussion:

- How to get rid of the Journal Impact Factor (IF) as a major criterion for assessment of scientific work? What could be a meaningful alternative criterion to the IF, and how could that be developed, disseminated and established?
- How to moderate the innovation criterion and increase funding for long-term routine taxonomic work?
- How to develop programmes for recruitment and initial education of young systematists prior to their study? How to disseminate information about opportunities?

New sequencing techniques

Miguel Alvarez Tejado

KAM Sequencing Iberia, Roche Applied Science, Spain

Deciphering the sequence of DNA has been one of the most important topics in modern biology. For more than 20 years one technology has dominated the field, Sanger technology, with the Human Genome Project being the main driver of this technology. However the Sanger technology is still too costly, time consuming and labor intensive to meet the current demand for DNA sequence information, that is growing in an unexpected speed. Some technologies have broken the barriers and have reached the market. During this talk the 454-Roche sequencing technology will be presented from its fundamentals to applications. Starting with a general overview of the technology (100 times faster than Sanger and up to 100 times more economical) and presenting just a few examples. Of the published applications, because the fields in which is being used is really impressive, including whole genome sequencing, sequence variation studies, comparative genomics and evolution and many more. During the talk the new hurdles these new technologies are introducing in the scientific community and the future developments in speed, efficiency and throughput will be also presented.

Zoobank and Zoological Nomenclature

Ellinor Michel

ICZN Secretariat, NHM London, UK

ZooBank – the concept

- An open-access register for all scientific names of animals
- Formally proposed: Nature 437: 477 (22 September 2005)
- Initiated online (www.zoobank.org) August 2006
- Rapid description of biodiversity facilitated
- Similarities to the Genbank Accession Number system
- Taxonomists as ZooBank builders and primary stakeholders

Why do we need it?

- "Visibility" of animal names and nomenclatural acts
- Completeness of the animal species database
- Code-compliance of all names and acts
- Quality control
- Facilitation of "true" web taxonomy
- Universal availability of descriptions

ZooBank – launched in January 2008!

Points for discussion:

ZooBank & the future of zoological nomenclature:

- Should registration be mandatory?
- How tightly linked with peer-review and taxonomic process?
- Will authors populate ZooBank or will it require assistance from external sources?

Zoological nomenclature: some urgent needs and problems

Alain Dubois

Muséum national d'Histoire naturelle, Département de Systématique et Evolution, Paris, France

Biology is now facing a new paradigm, which results from the confrontation of the *taxonomic impediment* with the *biodiversity crisis* (Dubois, 2003, 2008*b*). The "grand biological challenge of our age" (Wheeler *et al.*, 2004) is to speed up *considerably* the collection, inventory and description of the living species of our planet before they get extinct. For this work, taxonomy needs to have efficient tools, one of which is the set of nomenclatural Rules that allow having a single, common, simple language for the designation of taxa all over the planet. Different Rules exist for different groups of organisms, but I will focus here on the zoological *Code* (Anonymous, 1999).

The current *Code*, although not "perfect", relies on sound and solid bases that make it fully appropriate to play its role of a long-term reference system for taxonomy. This nomenclatural system has been in force for more than one century and followed in millions of publications, and it has successfully adapted to the successive taxonomic paradigms from the typological "Linnean" thinking to the current "phylogenetic" one. Under the *Code*, allocation of *nomina* to *taxa* relies on an *ostensional* system using *onomatophores* (name-bearing types). This makes the *Code* a *theory-free* nomenclatural system allowing the unambiguous nomination of taxa within any taxonomic system, be it "phylogenetic" or not – in contrast with any possible alternative systems (e.g., the "*Phylocode*") based on *intensional* definitions of nomina that are meaningful only within a given taxonomic paradigm. Nothing would be more detrimental to the "image" of taxonomy among sciences than the long-term parallel persistence of two nomenclatural systems based on incompatible philosophies and entailing profound differences in the way nomina are defined and used (Sluys *et al*., 2004). If acceleration of the taxonomic inventory of the vanishing species of our planet is acknowledged as a primary urgency, all other goals, however "interesting" they may appear from a purely theoretical point of view, cannot have the same priority. Any project of introducing a new nomenclatural system to replace the current one is bound to divert an enormous amount of time, energy and money from the basic aim. For this reason, such a project should not be encouraged. On the contrary, it seems justified for taxonomists to support all suggestions for better nomenclatural Rules under the current *Code*, in order not to upset the current nomenclature of organisms but also to make the *Code* more efficient and less vulnerable to criticism.

A great strength of the *Code* is that most of its Rules are *automatic in use*, thus allowing any two taxonomists on both sides of the planet to establish the same valid nomen for the same taxon without recourse to any committee, board or court. This automatic way of functioning of the *Code* should be even strengthened, particularly in limiting the use of the unclear concept of "usage" (Dubois, 2005*b*) to very specific cases – i.e., to nomina widely used outside the specialised world of taxonomists. Making the *Code* fully automatic, except in rare situations, would require from taxonomists to adopt a less "dramatic" or "passionate" relationship to nomenclature, understanding that nomina are just neutral, "meaningless" labels for the universal and unambiguous designation of taxa under a given taxonomy, not descriptions, theories, stories, or self-glorification of their authors.

In the recent years, the International Commission on Zoological Nomenclature

(ICZN) has largely focused its attention and efforts on the *Zoobank* project. This project is very promising and exciting, but it will not solve all the urgent problems currently facing nomenclature. It also raises a variety of problems of different magnitudes, both theoretical and practical (Dubois, 2007*d*). Whereas the creation in *Zoobank* of a huge nomenclatural database will certainly be a very useful tool at the service of all world's taxonomists, time is certainly not ripe to modify the Rules of availability of nomina by imposing registration of new nomina in *Zoobank*. Availability of nomina should remain attached to paper publication, but voluntary registration of new nomina in *Zoobank* should be strongly encouraged.

On the other hand, several other important changes in the *Code* are needed in the years to come. Most of them are made urgent by the pressure exerted by the projects of alternative nomenclatural systems. These projects often start from real questions and problems, but propose inadequate solutions. Ignoring these questions and problems might encourage a significant number of taxonomists to "leave" the *Code* for these systems, which would have a disastrous effect on the unity and efficiency of taxonomy.

The first problem is that in zoology the *Code* only covers part of the nomenclatural hierarchy as it does not regulate the nomina of taxa at the highest (class, order, etc.) and lowest (variety, form, etc.) ranks. There exists no theoretical justification of this incompleteness, but the latter becomes very problematic in our epoch where many new cladistic analyses are regularly produced and entail important taxonomic changes at all levels. This problem clearly constitutes a strong weakness of the *Code* compared to alternative proposals, and it has become urgent to expand the *Code*'s coverage in order to include all nomina of taxa at all ranks (Dubois, 2005*b*-*d*, 2006*a*-*d*, 2007*a*-*b*). If this is not done, authors will continue to use their "opinions" and "tastes" to coin or choose nomina for higher taxa: the resulting chaos may soon become impossible to manage, except through the use of so-called "usage" which in many cases is simply the use by some "important" authors of their "authority" to promote "their" nomenclature. At a time where taxonomy, through the development of phylogenetic methodologies allowing scientific refutation of hypotheses, has largely got rid of the "argument of authority", it is interesting, but not very positive, to see its resurrection in the field of nomenclature. At the lowest level, unlike in botany, the *Code* forbids the use of additional ranks between subgenus and species-group, and below subspecies. This is also unjustified theorically, but is has the negative consequence that low-level units, disclosed e.g. by phylogeographic analysis, cannot be named and included in official lists or other texts dealing with conservation of threatened taxa.

Several other points of the *Code* require changes, sometimes small, sometimes important. These include the way to quote nomina, with or without the author's name (Ng, 1994 ; Dubois, 2008*a*), the criteria of availability of specific nomina as concerns the deposition of name-bearing types in permanent collections (Dubois & Nemésio, 2007), the distinction between different kinds of subsequent spellings of nomina (Dubois, 1987, 2007*c*), some Rules dealing with secondary homonymy (Dubois, 1995) or familial nomenclature (Dubois, 2005*a*). It has become urgent to clarify the hierarchy between the two competing fundamental principles on which the *Code* currently relies (priority and "usage"), as the current ambiguity is important and harmful (Dubois, 2005*c*: 426). Finally, it would be very useful to modify drastically the presentation of the Rules in the *Code*, as had already been suggested (unsuccessfully) by Dupuis (1984). The argument stating that the *Code*, in each edition, should be modified the least possible in its plan, the numbers of Titles and Articles, and the proper writing of

the Rules, in order not to "disturb" the zoologists who are "used" to the preceding version, does not hold. This plan is not good, and many articles are not clear, as testified by the numerous errors of interpretation, the correction of which requires long useless discussions (Dubois, 2006*d*, 2007*a-c*; Dubois & Nemésio, 2007). An important modification of the plan should be thought of, along the following lines : (1) present first the Principles (as in the botanical code), then the major Rules which result from their implementation, before entering the details, the secondary rules, the exceptions, the examples and the recommendations ; (2) present clearly the Rules in three distinct parts corresponding to the three "floors" of the "nomenclatural house" (Dubois, 2005*a-d*): *availability*, *allocation* and *validity* of nomina ; (3) care for the absence of contradictions between the articles and the *Glossary* ; (4) care to establish an *Index* more complete and explicit than in the current version.

Preparation of such major changes in the *Code* could not be done quickly in a few months and by a limited group of persons. It should involve the contribution of all interested zootaxonomists worldwide, whether or not members of the ICZN, as the *Code* is the collective property of all zootaxonomists who agree to follow its Rules. The final decisions should be taken collectively, democratically, by a vote during a world congress of zoology or using another medium, such as internet. In the end, a drastically modified text, incorporating the changes suggested above, would provide the *Code* with a strength and clarity which would make it an unprecedented tool at the service of all taxonomists who will be involved in the inventory of species in the century to come, which will be crucial for our knowledge of biodiversity.

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From field records to a sustainable taxonomic knowledge base: new approaches and opportunities for efficient biodiversity inventories

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DNA taxonomy

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This talk will outline the principles of DNA taxonomy and recent progress in this field. I will also show how this is useful to other areas of taxonomy, in particular DNA barcoding, molecular systematics and cybertaxonomy. Current research priorities include improved data banking and analysis tools, while collection efforts of poorly studied faunal assemblages are needed to complement our understanding of biological diversity and its evolution. This ties in with the need for renewed efforts to establish a Tree-of-Life research programme at the European level.

Points for discussion:

- Faunal assemblages and biodiversity surveys using DNA taxonomy.
- Development of analytical tools for linking DNA taxonomy and cybertaxonomy data.
- Building a Tree-of-Life research programme.

DNA sequences in taxonomy: empirical performance, opportunities, and pitfalls

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DNA Barcoding and DNA taxonomy continue to attract much interest in biology, but much of the discussion is theoretical in nature. Here, I use 49,841 GenBank COI sequences for 14,058 species of Metazoa and ca. 300 COI sequences for approximately 90 species of Sepsidae to address five questions using empirical data: (1) What are the identification success rates of DNA barcodes across Metazoa and how will rates change as complete barcode databases become available? (2) For how many species is COI diagnostic once intraspecific variability is taken into account? (3) How long should COI barcodes be? (4) Is COI more suitable for species identification than other mitochondrial genes? (5) Can DNA sequences be used to estimate species diversity and/or species limits? The empirical data reveal that even short barcodes (300-400 bps) and barcodes from mitochondrial genes other than COI can yield high identification success rates. However, the latter require near complete species coverage which is difficult to achieve for diverse taxa. Algorithms for clustering sequences can be used to estimate species diversity, but many sequence clusters disagree with the species limits as determined by traditional techniques.

Initiatives for Improving Systematics: Attitudes, Impediments and Opportunities

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The National Science Foundation (NSF) funds most basic systematic research in the United States although some is funded by private foundations (e.g., Sloan Foundation). In the past fifteen years several important new NSF programs have been initiated to improve the quality and quantity of all areas of systematics (taxonomy, species discovery, and phylogenetics). The goals and successes of programs such as PEET (Partnerships for Enhancing Expertise in Taxonomy), AToL (Assembling the Tree of Life), RevSys (Revisionary Systematics), PBI (Planetary Biodiversity Inventories), BS&I (Biotic Surveys and Inventories), as well as the traditional Systematic Biology granting program are admirable but much remains to be done. Changes in technology and improved methods for gathering morphological and molecular information have led to interesting, but controversial, proposals for ways to continue to improve our science (e.g., DNA barcoding, Morphological Ontology). Whether these proposals provide opportunities or impediments to the science of systematics remains to be seen.

an overview of taxonomy in Europe

Current state and main challenges of taxonomic research in Portugal

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Portugal is part of the Iberian Peninsula, which is the richest area of occidental Europe in number of species and endemic species of vertebrates and plants. In addition to this, the archipelagos of Macaronesia (Azores, Selvagens and Madeira) are of particular interest because they hold one of the largest numbers of endemic species of the UE. However, despite this biological interest, problems in taxonomic research are clearly more acute in Portugal than in other European countries. The current state of taxonomic research in Portugal cannot be understood without taking into account the fate of national musei.

The true interest on taxonomy especially in building natural history collections began in the XIX century related to the Portuguese expansion in Africa and South America. Colonization of new territories needed the knowledge of the flora and fauna along with other information on geology and cartography necessary to conquer these vast and far territories. The Museum Bocage founded in 1858 was the institution responsible for this. This Museum sent collectors to the new territories and organized and compiled large samples from the flora and fauna of the new colonies. Many taxonomic works on plants, birds, fishes or reptiles from Africa and Brazil have been produced by Portuguese taxonomists based on these collections. Despite of this interest, the financial support was insufficient to develop within the country a museum equivalent to the high standards of those present at that time in most European countries. In fact the most flourishing period of biological collections lasted only for a very short period. Due to political disinterest, collections soon were left to deteriorate and later in 1978 with the fire of Museum Bocage almost all historical collections disappeared. Most collections existing today are mainly based on recent material of the last half century which began with the new universities and laboratories founded in that period. As a result of this there is no reference national museum or institution with high standards on taxonomic studies as in most European countries.

Today, most important collections are based on plants and micro-organisms while animal collections are very much small and particularly for diverse groups such as insects are still very scarce. The lack of strong tradition on taxonomic studies with limited collections and very reduce literature sources represent major handicaps to develop taxonomic studies. In fact the development of taxonomy in Portugal is far behind other European countries. The main inconveniences to taxonomic studies especially if we take into account animals and particular diverse groups such as insects in my opinion are the following:

- **Financial support and political interest.** This has been the key problem in the past and is also in the present. There has been a high pressure to switch proposals on basic research to more applied technical studies. In fact today there is almost no financial support and interest on taxonomic projects, grants to train new specialists or support to participate in international meetings. Taxonomic studies are considered “old fashion” because it is very difficult to

find financial support and more difficult even to publish results in impact factor journals. An example of the limited political interest is GBIF. Portugal despite of signing the GBIF agreement in 1999, so far the Portuguese node has not been implemented. There are also very limited national sources to apply for financial support. Basically the unique source to apply for support is the Portuguese Foundation for Science and Technology (FCT).

- **Positions to taxonomists**. Positions to taxonomists are absent. Many musea have no curators and many universities have no positions for taxonomists ex. many large universities have no entomologists.

- **Taxonomic institutions.** There is no reference institution (museum) with high standards and long tradition on taxonomic studies. Most existent musea of natural history (4) have few collections which in most cases are not actively studied. Many often they are not properly organized and preserved due to the lack of sufficient curators. The insufficient financial support and political disinterest have been traditionally the two main problems responsible for the abandonment of collections.

- **Limited available collections**. Most collections are small and usually narrow in scope and are deposit at universities and institutes and have no full time staff as curators or technicians. For some diverse groups as insects, curators and collections are almost absent. Usually collections do not include holdings of type material and reference collections are absent for most groups of animals. Due to the absence of appropriate conditions, many specialists when become retired donate their private collections to foreign institutions. In addition to this, many existing collections have not been digitalized and information concerning their holdings is not available on the web. National coordination among institutions with collections is absent.

- **Taxonomic literature**. Very limited taxonomic literature, recent and old can be found in national libraries and even relevant databasis ex. Zoological Record are absent in most institutions or if present are incomplete. Even this scarce taxonomic literature in most cases is not catalogued electronically being very difficult to know the holdings of a particular library. Due to the lack of financial support and political interest, there is also a constant reduction in the number of librarians to attend researcher's demands for copies. The few national publications on taxonomy are not adequately supported and struggle for survivorship.

- **Infrastructures**. Most useful infrastructures ex. scanning microscope, DNA analysis, etc. are often dispersed in many institutions with no tradition on taxonomy. These problems are more relevant for researchers in ultraperiferic areas of greatest diversity as Azores and Madeira, where resources are very scarce and travelling to mainland is insufficiently financed.

- **Universities curricula.** There has been a constantly reduction of taxonomy in university curricula in favour of more fashioned study areas. Due to this and the lack of grants and positions, students become less interested in taxonomic studies. This along with the reduced taxonomic support, difficulties in getting

taxonomic literature, lack of basic studies as floras, faunas, checklists, etc for the whole country, necessary have not help to train new specialists.

Main challenges

1. To stimulate and to support economically taxonomic projects through time especially those which aim the elaboration of main taxonomic works (checklists, catalogues, etc.) on flora and fauna giving especially attention to those that use internet resources and digital means to make the existing knowledge available.

2. To support economically the training of new students in taxonomy and especially to support part of their studies abroad.

3. To gather national collections/institutions focused on taxonomy in a national network and support informatization of biological collections ex. implementation of GBIF and facilitate the collaboration with foreign institutions.

4. To integrate and reshape the aims and scope of the existing collections and make positions to full time curators and technicians supporting economically the training of these and the infrastructures necessary to achieve high standards.

5. To establish a network of national taxonomists and support it economically to organize regular meetings or workshops necessary to propose universities curricula, establishing collaborations with foreign institutions on the study of Iberian flora and fauna particularly with Spain, etc.

6. To support economically the access to on-line taxonomic literature and also the utilization of informatics technologies needed to digitalize library catalogues and to promote collaborative protocols with foreign libraries to obtain copies of journals absent in Portugal.

7. To establish a national observatory or similar on the flora and fauna which maintain informed politicians on the current state of knowledge, needs and problems in order to help them to establish new politics.

Taxonomy in Germany

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Despite the fact that Germany is a nation with a long tradition in taxonomic research and tremendous collection resources, taxonomy as a scientific discipline is in decline and professional taxonomic expertise is in most fields either already lost or "at the verge of extinction".

- While meaningful statistics related to these issues are very limited and little meaningful yet (e.g. G(lobal) T(axonomy) I(nitiative) Germany (www.gti-kontaktstelle.de); Haas & Häuser 2005, ODE 5, Electronic supplement S13), the above point has been widely recognized in discussions and formally disseminated in the background information pages for a nationwide initiative addressing this loss of human resources in taxonomy (www.taxonomie-initiative.de). These discussions have definitely benefited from a union of all biological systematists in the 'Gesellschaft für biologische Systematik' founded in 1997. This German "Pro-Taxonomy Initiative" is a public call to governmental institutions to support taxonomy by establishing a number of new university professorships or chairs focussed on the field of taxonomy, as: 1) there is not a single zoology chair left in Germany focussing in taxonomy; 2) most biologists currently trained in Germany have no advanced taxonomic expertise any longer; 3) training in taxonomy has almost entirely been shifted to the natural history museums; 4) this lack of expertise means that Germany faces the risk of losing expertise to implement international treaties such as CITES and FFH.

Programs such as the US PEET or Tree of Life are not or hardly fundable through the German Science Foundation or other public or private German funding agencies so that in fact only a major initiative funded directly by the government could seek to counterstir the loss of taxonomic expertise by early recruiting students, offer highest quality taxonomic training at universities, and most importantly secure taxonomists positions as well as create new ones.

However, the situation of taxonomy in Germany is complex and not from all aspects 'that' negative. The federal organization of the country resulted in the fact that instead of one central institution we have several smaller museums that are rather spacious, allowing collections to grow, and staffed with technicians and researchers. Some of them received new modern buildings for natural history collections in the last decades, often with air-conditioned collection facilities, a guarantee for good future preservation of specimens. Their almost even distribution over the country's territory is a fact that might have promoted "Amateur" taxonomy which is still comparatively strong in Germany. Here exist already structures on national level, which EDIT invented for Europe. Under this apparent current situation, some more recent developments pose additional threats to the survival of taxonomy:

1) The 'newly' established modern buildings of many collections were designed by architects to often according to unreasonable standards instead of practicability with the result that working costs of these buildings are generally by far higher than institutional research and collection management budgets, pressing strongly on research budget.

2) Funding in general is increasingly managed on European level rather than on communal, regional or national level. Under this situation of increased international competition there is a general idea and tendency of synergy among German research

institutions and museums, from networks to entire fusions.[1] This might help to save institutions. Maybe. Risks of these fusions are assured: the loss of the territorially distributed competence and the reduction of personal. 3) In consequence of increased external funding, the high pressure for efficiency and 'high impact' research potentially makes employees of these institutions less focussed on their responsibility to the amateur taxonomist community and the collection development. In fact, typical taxonomist's positions at museums were in the past decade sometimes replaced with scientists whose profile would rather suggest a career at the university or, that these positions were cut due to short institutional budgets. Programs like GBIF had only little effect on this topic.

Since Linnaeus amateurs have been major contributors to taxonomic revisions, museums collection development, faunistic data collections (mapping not plot-like exploration), and red lists. However, taxonomist meetings reveal that hobby taxonomists getting less and older, while very few young amateurs enter the scene, and the experienced ones inevitably get fewer and fewer. To manage earth's biodiversity also with morphology based taxonomy at present and also in the future means:

1) not to keep alive only amateur taxonomy but to keep it a 'mass' science (remember: good taxonomists are needed not only for taxonomy and systematics but also faunistics, nature conservation and ecology)! Since the current decrease of hobby taxonomists is not only the result of lacking interest or less stimulus from the professionals, but also a consequence of the too restrictive nature managing legislation regarding the collection of scientific specimens and the socio-economical situation throughout all Europe in the last decade(s). Thus, also amateurs need chances to get helped by funding to manage the access of museum collections and libraries, and e.g. to be able to effort the growing mailing costs. Museums should be careful in asking desk charges for accessing their collections regarding the long-term effects in the scientific community, excluding maybe not only amateurs but also the developmental countries to develop expertise in taxonomy.

2) to not stop in the elaboration of new original data (DO REVISIONS)! During last decades not only in Germany funding neglected entirely collection based revisionary taxonomy. Funding for e-'taxonomy' has been much more successful in the last years (as it looks modern) but highly skilled taxonomists should not get kept busy in digitising types, references or literature for an imaginary audience for survive.

[1] Note that even Europe's leading, largest and most active natural history museums have at least for some I not many organism groups comparatively weak taxonomic communities in their countries.

My view on the current state and main challenges of taxonomic research in Europe and Spain

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Taxonomy is a hardcore science that underpins most of the research conducted on biodiversity. As a scientific endeavour, the main aims of taxonomy are to delimit, describe, classify and name lineages originated throughout biological evolution. Species are testable hypotheses amenable to further corroboration. Taxonomy has been commonly misinterpreted as an exercise of pure identification by both society and the other scientific disciplines. Identification is merely one operative aspect of taxonomy. Identification tools are deliverables produced by taxonomy yet they do not constitute its main epistemological content. Interestingly, other sciences with stronger technical contents, like molecular biology or genetics, have never been regarded as purely operational procedures. The misinterpretation of taxonomy as identification has had devastating effects for this discipline, compromising its development and placing its future at a stack. For instance, taxonomy has been frequently regarded as a hobby more than a science and hence it has not been valued as an essential resource for society, which has resulted in a chronic lack of public and private funding. The current biodiversity crises, this is the accelerated loss of biodiversity as a consequence of human activity, has put taxonomy back at the front line. Taxonomy is an essential tool for cataloguing life, but the methods traditionally used by taxonomist are unable to cope with the humongous work that lays ahead before important components of biodiversity are gone for ever. The term taxonomic impediment has been coined to describe such limitations. Fortunately, important technical advances like Internet, imaging or molecular tools may seed up taxonomic procedures and fulfil the ultimate goal of cataloguing all life on Earth before it disappears. However, lack of funding is still the major Damocles sword hanging on taxonomy's throat. While the shortage of funding has been already recognized as the major limitation for taxonomic work by most developed countries, the strategies implemented to overcome such limitation differ greatly among these countries. The United States pioneered the recognition of the key role of taxonomy in the verge of the current biodiversity crises, and designed specific funding programs, through the National Science Foundation (NSF), to encourage research on taxonomy. These programs focused primarily on, first, the training of a new generation of taxonomists with ample knowledge in standard principles of taxonomy but also trained on molecular and imaging techniques (the Program Partnerships for Enhancing Expertise in Taxonomy, PEET), and second, on the gathering of new data, either through inventories (Planetary Biodiversity Inventories) or by analytical procedures (Assembling the Tree of Life, AToL). It is important to highlight that most ongoing projects funded by these NSF programs include European based scientists as members of such research teams. Conversely, the European Union has based its funding strategy for taxonomy primarily on Natural History institutions. As an example, the EU-sponsored SYNTHESYS program allows European based researchers to access the resources of Museums and Herbaria across Europe. I certainly agree with the view that Museums and Herbaria are essential depositories of taxonomic information and as such, the funding for their maintenance and development should be guaranteed. Nevertheless, in my opinion, taxonomists constitute the key component of the task force that must face the work of cataloguing all life and, unfortunately, Europe is doing a very poor job in training new

generations of taxonomists. In my view, the problem is not exclusively related to the lack of financial resources, as much as the lack of scientific encouragement for young researchers to undertake a career in taxonomy. Spain represents a good example of the aforementioned problem. The Spanish scientific system has suffered a major revolution during the last decades. One of the most relevant and welcomed changes in the system has been the incorporation of more objective, rigorous and independent procedures for evaluating scientific productivity, which are subsequently used to grant research proposals, fellowships and jobs. In my opinion, however, there has been an overzealous obsession with objectivity, which has resulted in an unbalanced evaluation system that relies almost exclusively on impact factors and citations. In such a system, taxonomy is mercilessly underrated. The cruel reality is that most taxonomic monographs are not published in impact journals, not because of their lack of quality but, most of the times, due to their length and large amount of images. Even worst, one of the suggestions to overcome the taxonomic impediment is to publish species descriptions and reversionary works on the internet to facilitate access and distribution of taxonomic information, which would condemn the author to almost anonymity. On the other hand, taxonomic monographs used to name species or lineages or for identification during research in other scientific disciplines, are frequently not even cited in the final publications. This means that years of taxonomic work could be almost completely dismissed during the evaluation process. Given the current state of affairs, young scientists are force to carefully design their publications in terms of impact factors and citations if they want to maximize the chances to obtain further financial support for the development of their careers. In this system, trying to pursue a career in taxonomy is simply suicidal. In my opinion, taxonomy should not only be considered a priority research line in funding schemes, but specific programs that take into consideration the peculiarities of the taxonomic work during the evaluation of proposals should be implemented. The Fauna Ibérica, arguably one of the major taxonomic projects undertaken in Spain, constitutes an example of how things should not be done. The Fauna Ibérica was conceived as a series of volumes devoted to particular taxonomic groups. It mostly relied on available data from specialists, both professionals and amateurs, but it did very little to encourage the gathering of new data. It was very centralized, so that it left little room for research leaders to organize and design their own work. However, the worst part was that it did not consider the training component at all and hence, an excellent opportunity to guarantee the formation of a new generation of Spanish taxonomists was lost. As a result of all these limitations, among other things, many mega-diverse groups remain to be included in the Fauna Ibérica. Spiders, which are my particular group of interest, are one of them. At present, the only initiatives that aim to summarize current taxonomic knowledge and gather new data on Iberian spiders are encouraged and organized by the *Grupo Ibérico de Aracnología*, a working team formed by professional and amateur arachnologists. None of the ongoing reversionary work on Iberian spiders conducted under the umbrella of the GIA has received specific public financial support.

In my humble opinion, both Spain and the EU should shift their funding strategy for taxonomy and try to mirror those programs developed by the US to encourage taxonomy, especially with regard to new data gathering and training of taxonomists. The situation is not irreversible. Europe, and Spain in particular, have a number of natural history institutions of excellence in taxonomy and systematics, and there is a huge human potential that, given the right scientific encouragement and the adequate funding opportunity could guarantee to fulfil the ultimate goal of cataloguing all life on Eatrth in the next generation.

Future trends of taxonomy

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The area of systematic biology is experiencing a scientific crisis (as meant by Kuhn, 1996), evidenced by the simultaneous use of two distinct nomenclatural systems, namely the Linnaean and the phylogenetic ones (see Cantino & de Queiroz, 2006 and references therein). The former system is the older and the most widely used (*i.e.* has the status of a paradigm), while the second is considered as a paradigm challenger. Another alternative system was proposed recently, namely the cladotypic one (Béthoux, 2007, in press-a, -b).

Under the Linnaean system, ranks are mandatory, and an onomatophore (type-species, type-genus) must be designated for genus and family names. Assignment of species to a genus is mandatory, because species are named *via* a binomen taking the form [genus name] [specific epithet]. In contrast the phylogenetic and cladotypic systems are rank-free, and necessitate definitions of names / taxonomic words. Unlike the phylogenetic system, the cladotypic system is provided with rules governing the species case. It involves uninominal specific epithets preceded by a taxonomic address, which is a list of taxa to which the species can be assigned (see Dayrat et al., 2004).

The nomenclature resulting from the use of the Linnaean system is unsatisfactory. With respect to the cladotypic system, in case of a partly unbalanced topology, the Linnaean system necessitates supernumerary taxonomic words for naming terminal lineages (species) (in prep.). With respect to all alternative systems, in case of monotypy, the Linnaean system necessitates redundant taxonomic words for naming internal lineages (*i.e.* taxa), due to the application of the 'rank principle'. The reliance on onomatophores rather than on definitions results in instability of the meaning of taxonomic words. The use of desinences in accordance to a given rank does not allow taxa hierarchy to be exhaustively retrieved from the taxonomic words only (in prep.). In addition, no rules govern taxonomic words above the family level. Recourse to authority is the only way to reach some level of stability under this system. It can be considered as inadequate.

The phylogenetic system also has drawbacks. First of all, relation-based (node- and branch-based) and apomorphy-based definitions rely on the assumption that a newly erected taxon is not synonym of a previously erected one. However, for that purpose, means of falsification are different for each sort of definitions, therefore the use of both under the same methodological frame is inconsistent. This inconsistency is demonstrated by the fact that it is impossible to determine whether a relation-defined taxonomic word is synonym of an apomorphy-based taxonomic word. In addition, putatively irresolvable cases of synonymy can occur with a nomenclature developed with node-based definitions. If applied to various phylogenetic hypotheses, relation-defined names can designate lineages differing in their diagnostic traits, which clearly qualifies them as different entities (in prep.). As a result, relation-defined names are prone to be polysemic. Node-based definitions are inadequate for defining well-supported taxa which inner phylogeny is poorly known. Branch-based definitions can result in nonsensical taxonomic words (in prep.). Apomorphy-defined taxonomic words also are prone to be polysemic because the formulation of the defining apomorphy can be ambiguous (Gauthier & de Queiroz, 2001; see also Sereno, 1999). Lastly, the system as a whole is inoperative because the species case is not dealt with.

Under the cladotypic system, the number of words necessary and sufficient for naming species and exhaustively describing a topology is minimal. Taxonomic words can be polysemic if it happens that a defining character state is a composite of several states, or character states. If so, emendation is possible and strictly framed. Once emendated, a taxonomic word gains in accuracy. Synonymy cases can be resolved unambiguously. This system might be the most optimal one, but is currently under development.

It is clear that systems alternative to the Linnaean one did not prove their higher efficiency (yet). In particular, the cladotypic system was developed recently, and might have some inherent drawbacks currently unexpected. On the other hand, a growing number of researchers are unsatisfied by the Linnaean system. It is plausible that it will be abandoned at some point.

In this situation of crisis, a strategy for global databasing of taxa cannot be preferred. To my opinion the only relevant decision to be taken regards databasing of species. The generic assignment which is mandatory under the Linnaean system is prone to vary and does not constitute stable information (just like taxonomic addresses). In other words, the binominal species nomenclature is not appropriate for a species database. On the other hand, under all systems, species names are made unambiguous thanks to the reference to (1) the uninominal specific epithet, (2) the name of the creator of the species, and (3) the year of publication of the corresponding contribution. If several homonymous specific epithets designate different species in the same contribution, it is necessary to make reference to (4) the page on which the specific epithet is erected (or the holotype mentioned). If several homonymous specific epithets designate different species are on the same page of a given contribution, it is necessary to make reference to (5) the line on which the specific epithet is erected (or the holotype mentioned). This alternative ‘uninominal’ species nomenclature was developed by Dayrat et al. (2004; see references therein). These data are necessary because they unambiguously make reference to an holotype, which use is mandatory under all systems. To my opinion, the documentation of the five points listed above is a relevant decision to be taken for species databasing. In practice, the specific epithet *should* be decoupled from the genus name in databases.

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Current state and main challenges to the taxonomic research in Spain

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Taxonomy is a European invention, and Europe still contains the world's major taxonomic resources and among the best taxonomists. The majority of the world's type specimens probably occur in European museums. Yet taxonomy is in decline and the virtual lack of training in Western European countries is becoming critical. Taxonomy is fundamental to all of biology, but is now virtually restricted to museums, so that integration with the rest of the scientific community has suffered. Because of very limited government funding or overheads for taxonomy, competitive and cash-strapped European universities and museums increasingly hire in other areas. In contrast, the USA recognizes the scientific and commercial value of taxonomy, and has repeatedly funded major programs in taxonomy and systematics (for instance the Partnership for Enhancing Expertise in Taxonomy program). Basically, it has been predicted that if Europeans do not change their attitude towards taxonomy, in few years we will have to send our students to the USA to learn taxonomy. The principal problem with taxonomy is the low appeal to grant giving bodies and other funding agencies, which have stopped to invest money into this field. Since taxonomy is basic for all field of biology, it has been suggested that this lack of appeal might be a consequence of the way the results of the taxonomic research are presented to society.

Estimates of the total number of species on this planet vary widely, ranging from 3-20 million, and species relationships remain obscure in even the best-known groups. Taxonomic information is scattered widely in small-circulation books and print journals, so that conservationists, biotechnologists, and other users of taxonomy cannot easily access data on or easily count the 1.5-2 million "known" species estimated to have been described. The inadequacy of existing taxonomy informatics has triggered repeated calls for major scientific and public figures for modernization and increased funding. Prof. C. Godfray already suggested that taxonomy had to become accessible to everyone at the click of a mouse if it had to persuade politicians and grant giving bodies to invest on it. Some initiatives like Species 2000 & ITIS "catalogue of life" have the goal to create a validated checklist of all the world's species (plants, animals, fungi and microbes) by 2011. This is being achieved by bringing together an array of global species databases covering each of the major groups of organisms. Therefore, Species 2000 is a "federation" of database organisations working closely with users, taxonomists and sponsoring agencies. Each database covers all known species in the group, using a consistent taxonomic system. The participating databases are widely distributed throughout the world and currently number 47. The existing global species databases presently account for some 50% of the total known species, so substantial investment in new databases will be needed for full coverage of all taxa to be achieved. The information of Species 2000 is used by the Global Biodiversity Information Facility (GBIF) as the taxonomic backbone to its web portal. Another initiative that has started recently is the "Encyclopedia of life", a web based application with the goal of creating a constantly evolving encyclopedia that includes all known data about every living species in the world.

The state of taxonomy in Spain is not different from the state of Taxonomy in many other countries in Europe. The main problem is the lack of funding in this area, which is making Universities and even Natural History Museums to hire in other areas

like Developmental Biology, Ecology, Evolution, etc… This is creating a situation where Taxonomic research *per se* and taxonomists are not being considered as valuable even in Natural History Museums, which should be devoted to the study and curation of the world's biodiversity. In my opinion, the main problem with taxonomic research in Europe in general and in Spain in particular is the lack of funding. If we want taxonomy to become a XXI science we need to invest more money into it; similarly to the PEET program in the USA. If Taxonomy does not have an independent call for funding to areas like for instance evolution, phylogeny and biogeography, it will tend to disappear because all these other areas produce deliverables (publications in much better SCI journals) that are considered more valuable than the deliverables of Taxonomy (publications in low-impact journals).

One solution to the taxonomic impediment that is happening at a global scale, would be to promote a innovative taxonomy across Europe through a specific program like the PEET program in the USA. This would allow the formation of a new breed of taxonomists that, apart of being proficient in taxonomy, they should also be knowledgeable in other areas like molecular biology, modelling, bioinformatics, among others. However, the main goal of any research program like this would always be the taxonomic revision of a particular group.

As stressed above, the lack of visibility of taxonomic research is an important problem, but this can be solved (and in fact is being solved) through web-based applications like the Encyclopedia of life, GBIF and Species2000. Until specific programs devoted to taxonomic research are not developed in Spain, it will not be possible to change people's appreciation about taxonomy and taxonomic research. Although the taxonomic revision of a particular groups should be the main goal of this kind of specific programs in taxonomy, any specific funding for taxonomy should also aim to integrate teams of museum taxonomists with molecular geneticists, evolutionary biologists, bioinformatics, ecologists and biotic change modeller. These multidisciplinary research teams should interact closely and collaborate to form a new generation of taxonomists, with knowledge in many areas of Biology and trained to be able to produce deliverables that are relevant for the community. However, I insist that, like in the PEET program, in this kind of program the main goal should be to produce a complete taxonomic revision of a group using morphology and molecules, and taking advantage of all the new web-based technologies and data bases.

Report on the current state of taxonomic research in Portugal[2]

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In the present report we have analyze the data available in the ISI Web of Science database. We are aware that a vast number of scientific work in the filed of taxonomy is published in journals not cited in this database. However, it was virtually impossible to access a database containing those publications and therefore they were left out of this report. The search was performed within article titles, keywords, and abstracts that contained the word Taxonomy with Portugal in the address field. All available records were scrutinized from 1900 to 2008 (January 5th). There were a total of 197 publications, of which 8 were review articles, one a letter and all other 189 were research articles. All articles were produced Portugal by Portuguese and/or foreign researchers. In any case it is safe to assume that a portion of research that produced the published results was funded by Portuguese institutions, either by direct research funding of projects or by indirect salary payment. Most frequent co-authorship (Figure 1) is headed by neighbour country Spain, followed closely by anglosaxonic countries, USA and England. Countries with only one publication in co-authorship are: Bulgaria, Canada, Chile, Czech Republic, Ireland, Japan, Nepal, Panama, Thailand, Tunisia and Venezuela.

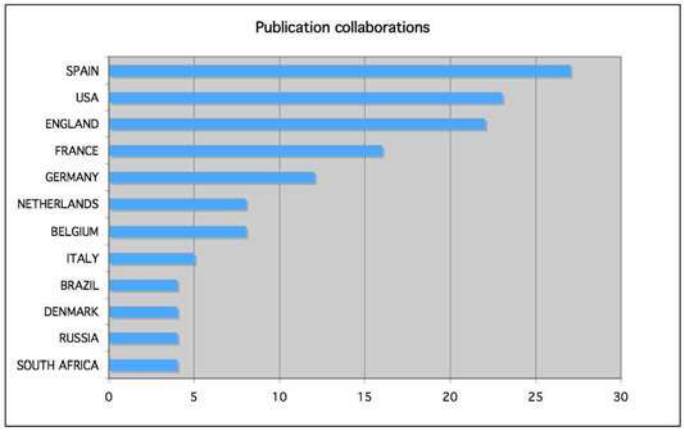

Figure 1. Collaborations between Portuguese institutions and foreign institutions (listed only countries with more than 3 publications).

The top most productive Portuguese Institutions (Figure 2) are universities or their equivalents, to the exception of the Gulbenkian Institute of Science, that appears in 5th place *exequo*. It is interesting that no museum appears in this list. This is probably a reflection of the state of science museums in Portugal.

[2] Disclaimer: This report is solely based on the internationally available scientific production indicators and on my own interpretation of that data given the specific conditions of the country.

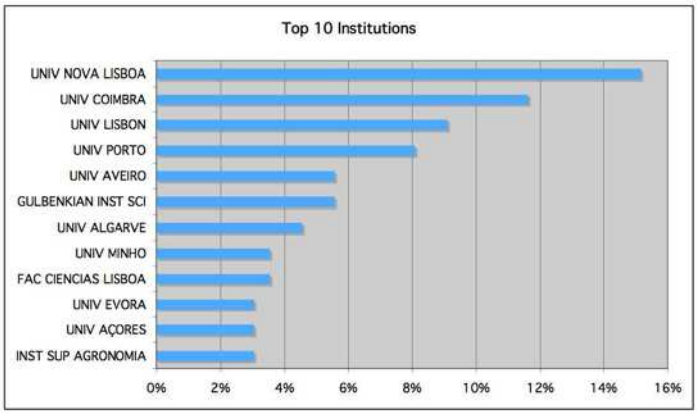

Figure 2. Top most productive institutions in Portugal.

There has been a positive evolution along the time of the scientific production (Figure 3) that mostly took-off in 1999, year that more than doubled the number of papers of the previous year. The increase has been steady, with a slight set back in 2003 and 2004, and with 2 consecutive years very productive (2005-2006).

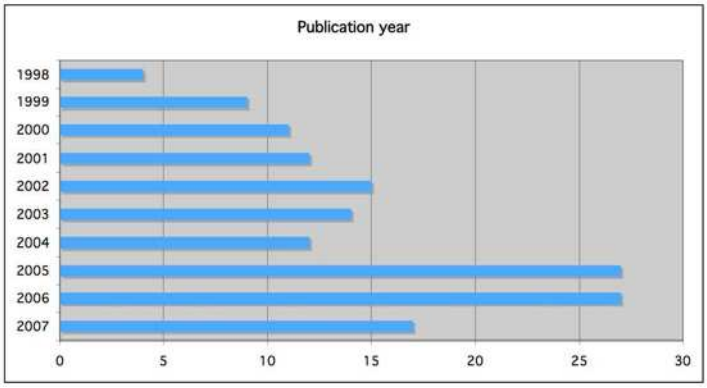

Figure 3. Time evolution of scientific production.

The most representative journals where Portuguese taxonomic science is published are presented in Figure 4.The lead is clearly on journals who deal with microbiology, as is the subject category (Figure 5).

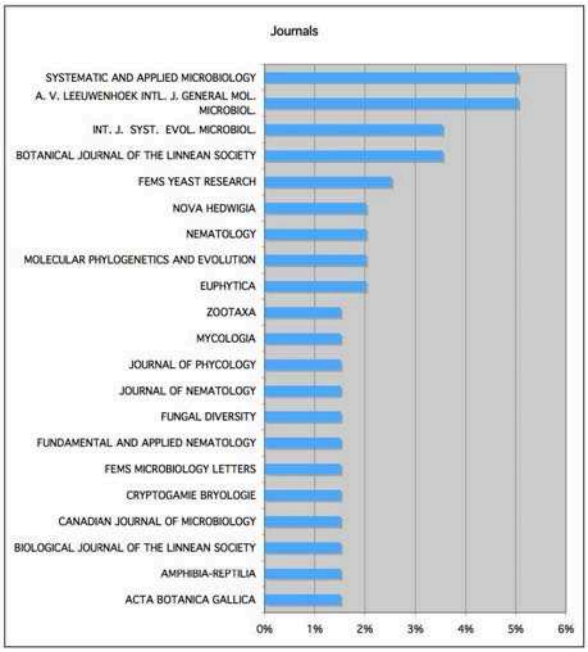

Figure 4. Top publications where Portuguese taxonomic research is published.

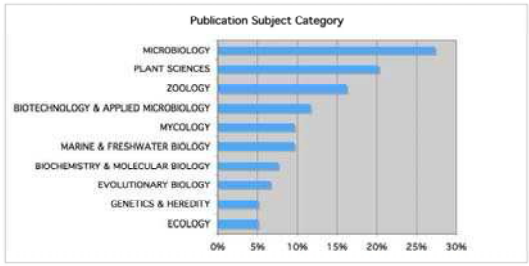

Figure 5. Main publication subjects of Portuguese taxonomic research.

The data here presented, although as stated before, is a fraction of the real work production by Portuguese taxonomists, reflects a number of critical points that are worth while mentioning together with my onw view of the particulars of the Portuguese situation:

a) The museums clearly do not lead the research on taxonomy in Portugal. Although not inferable by this data, it is known that the museums' scientific staff is often aged and renovation has not been a priority and funding is inadequate.

b) The taxonomic research subject that dominates the scientific production in Portugal is microbiology, other subjects do not have a real expression. A detailed examination of the data reveals why this is so: there is one single author that noticeably dominate the publications in this area!

c) Taxonomy is being published in journals that are not in the ISI Citation Index, and therefore the profile of this field is somewhat low.

d) Because of the common perception that taxonomy is not a fashionable subject, authors try to divert their research to other fields such as phylogeny for instance.

e) Although it is not possible to infer directly from this data, the public perception that taxonomy is an out-of-date science does not encourages biology students to choose that field of expertise. Also taxonomic specialized teaching has not been developed or encouraged by Universities.

For this report to be more encompassing, information on the work published elsewhere ISI, on funded projects or even on specialized taxonomy teaching is needed.

Identifying some major problems and their possible solutions

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We are today at the beginning of the century of extinctions (Dubois, 2003). Biology is now confronted with a new paradigm, which results from a double reality: (1) the *taxonomic impediment* (Anonymous, 1994) combined with the *crisis of taxonomy* (Dubois, 2007a,c) – mostly the crisis of *microtaxonomy* or alpha-taxonomy (the discipline in charge of discovering, describing and naming the living species of our planet); (2) the *biodiversity crisis* (Wilson, 1985), which, despite all our (laudable) efforts to limit it, will inevitably result in mass extinctions, especially in the tropical regions of the world. Confronted with this situation, the only appropriate reply would be to speed up considerably the collection, inventory and description of the living species of our planet before they get extinct. However, this message is difficult to pass to our society as a whole: "Funds nominally allocated to taxonomy go largely to reconstruct molecular phylogenies, while thousands of species are threatened by imminent extinction. (...) In the face of the biodiversity crisis, the need for urgency could be no greater. (...) The grand biological challenge of our age is to create a legacy of knowledge for a planet that is soon to be biologically decimated." (Wheeler *et al.*, 2004). Taxonomy is currently "the Cinderella of science" (Padial & De la Riva, 2007), and this occurs just at the time when the need for taxonomy could be no greater. As both phylogenetic reconstruction and conservation biology have much to lose from incomplete or inaccurate taxonomic data or incomplete taxonomic sampling (e.g., Arnold, 1981; Lecointre *et al*., 1993; Dubois, 2000), disinterest or neglect for this problem from the part of researchers involved in these fields may appear surprising, but it is a reality (further discussion would be too long here, but this phenomenon is not incomprehensible).

In the recent years, the international community has taken some important steps to try and solve the crisis of taxonomy. These are briefly reviewed in the introductory text of this symposium. Although I agree that all the technical progresses are important, I disagree on their relative importance compared to another factor, which is the shortage in permanent professional positions of taxonomists. It is striking that all of these proposals and projects are based on a *technical* approach of problems, but that none focuses on the *human factor*. Techniques, computers and DNA will never replace men: no web-based taxonomy, no barcoding or other molecular approaches will significantly increase our knowledge of biodiversity if we remain as little numerous as we are today. As aptly pointed out by de Carvalho *et al.* (2005), relying only upon technical developments sounds in part like looking for "miracle solutions" that would avoid having to go to the field and collect specimens, study them carefully in the laboratory, compare them with collections, describe them and publish their descriptions, and produce regularly taxonomic revisions and monographs. A complementary (not contradictory) approach to this question requires to take full account of the human factor. To speak frankly, we should face facts and realize that our societies (and especially those of Europe and North America) are prone to invest money (in the expectation of benefits) into technologies, material equipments and products, but not into salaries. This "fascination by the tool" is common to all sciences nowadays.

However, what we *primarily* need to describe the vanishing species of the globe is not molecular phylogenies or online databases, but above all *manpower*, i.e., permanent positions for well-trained professionals, *brains and arms* to do the daily field and laboratory work in all countries of the world, well-supported museums and healthy specialized publications printing yearly thousands of pages and figures: "systematics needs theoretical training, more professionals, a lasting commitment to collections, and recognition as a robust science by peers and policy-makers, without which taxonomy itself may fall victim to extinction" (de Carvalho *et al.* 2005). According to Wilson (2004), there are at present about 6000 working taxonomists worldwide, i.e., "a tiny slice of the biological community as a whole", and their discipline is "one of the weakest and most underfounded". The current trend for a bibliometric "evaluation" of research and for emphasizing so-called "excellence" (mostly measured by "impact factors", by the number of industrial patents deposited or by the amount of money obtained by a researcher) goes strongly against an increase of support to taxonomy. The least that members of our small community can do is to identify properly their priorities, and to devote most of their time and energy to these priorities.

Most of the unknown biodiversity is in the intertropical zone of the planet, where institutions and scientists are few, have little money and cannot do much. Furthermore, especially after the Rio de Janeiro Conference, it has become increasingly difficult to collect specimens there for study. The biologists of our century, and above all of the present and next coming generations, will be the last ones in the history of the planet to have the opportunity to collect, study and store (for current but also for future study) specimens and tissues of millions of species that will have turned extinct before the end of this century. These species should be considered a collective patrimony of mankind, and open to study by all competent taxonomists worldwide, not the private property of States or local communities.

If collecting and describing the vanishing biodiversity of our planet is reckoned as the primary priority for systematics and all comparative biology (including evolutionary biology), then a number of consequences follow, concerning our strategy for the coming years and decades. In my opinion, five goals deserve to be especially highlighted:

1. Properly identify the taxonomic and geographical priorities

Particular attention should be given to the identification of the least studied taxonomic groups and of the areas of the planet where most of the to-be-discovered species live, and where extinctions can be expected to be the most severe in the coming period. The latter will no doubt include the intertropical rain forests and all the identified "biodiversity hotspots", but also some marine zones and mountain areas. This is an important prerequisite for rational decisions about the taxa and areas that should be afforded priority for taxonomic exploration of the planet. Otherwise, "traditions" and "opportunities" will continue to guide these works and we may miss the real urgencies. For example, except in some very special habitats or for a few taxonomic groups, Europe and Northern America are certainly not part of the priority areas. As another example, the focus of systematic research on mammals and birds which is still in order in many research institutions of the world is a nonsense, and time should soon come where this "tradition" is abandoned and other priorities defined.

2. Increase considerably the number of taxonomists, especially in countries of "the South"

A strong effort should be made to seek financial support for the training of taxonomists, for their recruitement as professionals, for field work and collection of specimens and tissues, for their proper storing in well-organized, long-term funded and curated collections. If we are really to make up for lost time and collect and describe a major proportion of the world's biodiversity before it is extinct, professional positions of taxonomists should be created *by hundreds or thousands* before it is too late. This effort should be especially important in the areas pointed to above, mostly in the intertropical zone. It is crucial that the countries of "the South" quickly develop a real expertise, not only on biodiversity management and conservation, but also, and in fact primarily, on taxonomic study of their own fauna and flora. The help from specialists of "the North" will remain important, but colleagues from these countries should soon become able to work by themselves at the same level of quality as in "the North". Despite the impression sometimes given by co-authorship of many papers published nowadays, we are still very far from this goal.

A dramatic increase in the number of professional taxonomists of the magnitude suggested above may appear totally unrealistic today, and it will certainly remain so if the community of taxonomists does not even speak and struggle for it. However, our societies have repeatedly proved able to invest gigantic amounts of money into projects that probably appeared as unrealistic a few years or decades before, such as developing the military and civil nuclear research and industry, the aeronautics and space research and industry, or sequencing the human genome. Is it more important for mankind to look for life in other planet systems or to increase our knowledge of the life forms on our planet before many of them have disappeared? It should be the duty of those who speak in the name of the community of taxonomists to argue everywhere possible, and as convincingly as possible, in favour of a much accelerated exploration of the vanishing biodiversity of our planet in the coming decade, which indeed requires the creation of hundreds or thousands of professional positions.

3. Allow for collection of specimens by taxonomists over the whole planet

The community of taxonomists should make all efforts to send a strong message to the States, administrations, NGOs, and *especially* to all actors in the "conservation biology" and "ecology" communities regarding the *absolute need* for collection of specimens for a proper, repeatable, long-term scientific taxonomic study or organisms. This requires changing the minds and, consequently, the juridical texts, regarding the "value" of biodiversity, its being the "property" of the States where it occurs, or so "endangered" that it should not be properly studied anymore. We need to engage a strong fight against all barriers to the collection of specimens for the taxonomic study of biodiversity that have flourished in the recent years (roughly since the Rio de Janeiro conference). Taxonomists and conservation biologists should become real "allies" in this important endeavour, not "enemies" as they currently often are (Dubois, 2003; Dubois & Nemésio, 2007). Who really thinks one can seriously "protect" and "conserve" what we still do not know. The restrictive lists of extinct and endangered species regularly published by IUCN, WWF and other bodies are pathetic, in that they simply ignore (and cannot do but ignore) the status of millions of species that have still not be collected and recognized by taxonomy.

4. Modify the evaluation of taxonomic research

We should also send a clear and strong message supporting "taxonomy as a fundamental discipline" (Wilson, 2004) to the governments and all research policy-makers of the world, and especially of Europe and North-America. It is crucial to obtain

a change in the way taxonomic research is evaluated and funded in our countries. Relying on "impact factors" and other bibliometric indicators which are indeed fully inappropriate for taxonomy (Ellis, 2002) – and very questionably appropriate for other research fields (Lawrence, 2007) – will always result in the need for taxonomists seeking funding to invest an important part of their research activity in other disciplines (including evolutionary biology and phylogenetics) at the expense of their taxonomic work proper. We need to impose a system of evaluation of taxonomy that relies on the *quality of taxonomic works themselves*, not in the ability of taxonomists to do some other kind of research.

5. Improve the *Code* before it is wiped out by another nomenclatural system

Zoological taxa are designated by Latin scientific names or *nomina*, most of which are regulated by the *Code*. These nomina, some of which have been in use since 1758, are of utmost importance for all biologists and users of biological data as they are the labels or keys that allow finding all the information accumulated over centuries about the taxa. If we agree that our primary goal should be to accelerate the collection, study, description and storing of as many biological specimens and species of our planet as possible before they get extinct, it should be clear that all other goals, however "interesting" they may appear from a purely theoretical point of view, do not have the same priority. In this respect, any project of introducing a new nomenclatural system (e.g., the "*Phylocode*") to replace the current one is bound to divert an enormous amount of time, energy and money from the basic aim, and to keep busy many taxonomists that really have more urgent works to do. For this reason, it would appear irresponsible, if not "criminal", to support such a project. On the contrary, it seems justified for taxonomists to support all suggestions made to have better Rules of Nomenclature under the current *Code*, in order not to upset the current nomenclature of organisms but also to make the *Code* more efficient and less vulnerable to the criticisms of the supporters of alternative nomenclatural systems. No nomenclatural system will ever be "perfect", but this is of relative importance as nomenclature is not a science but a technique, a tool used to help taxonomy to store and retrieve the information about taxa. A good nomenclatural system is one that has several properties (Dubois 2005a) allowing it to be efficient as a tool for universal communication among zoologists, to help them describing and naming validly new taxa, and not being a brake to this. Among these properties, it is important that the system be *as automatic in use as possible* and does not require endless discussions and votes among "specialists" to decide which nomen should be used for a taxon – and this is provided by the Rule of Priority. The recent emphasis put on so-called "usage" in the recent versions of the *Code* not only goes against this simple approach, but also revives a respect for "authorities" which has fortunately become weaker in science in the recent decades. For example, evolutionary biology has progressively become largely detached from the so-called "argument by authority" (*argumentum ad verecundiam*), and it is strange that at the same time zoological nomenclature partly reverts from a "*de jure*" set of Rules to a "*de facto*" attitude, with support for the *a posteriori* validation of the mistakes of some authors: this largely weakens the value of the *Code* as a strong reference in the eyes of many zoologists.

In the recent years, the International Commission on Zoological Nomenclature has largely focused its attention and efforts on the *Zoobank* project, which is certainly very interesting and useful, but is one more example of the "fascination by the tool" discussed above, and which raises a variety of problems that are not discussed here. Besides, this project will not be as useful as it might if, because the *Code* still has many

internal problems, a majority of zoologists decided to turn to alternative nomenclatural proposals and to abandon the *Code*! Among many other problems that are not mentioned here, an important one is that this text currently does not regulate the nomina of taxa at the highest (class, order, etc.) and lowest (variety, form, etc.) ranks, which clearly constitutes a weakness of this system compared to alternative proposals: it would be most useful to expand the *Code*'s coverage in order to include all nomina of taxa at all ranks (Dubois, 2005a-b, 2006a-d, 2007a-b).

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Systematics in France: We have the conceptual and technical means and we need to reinvest our thematic field

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In the western world, Systematics is an old science. Its development predates the idea of evolution, even it became the main body of evolutionary biology in the 19th century. For that reason already, most research topics in Systematics deal with the pre-evolutionary correspondance with classification when they should first deal with evolutionary biology (O'Hara, 1992). In this "relatively modern" (19th century!) evolutionary framework, classification is a wonderful by-product of Systematics aimed at comparative evolutionary biology. This by-product is made available to the whole scientific community and society through taxonomy which is the part of Systematics which permit to make the original data – the species - known, accessible and data-based in a much better and more sophisticated way than any other equivalent system in other sciences (compare taxonomy, codes of nomenclature, types, collection vouchers, etc. with Genbank or Embl for genomics without rules, vouchers or permanent revision procedure …)

In these issues, it should be remembered that concepts should not be confused with basic technical issues: a very good system even if not yet web-based or fully interactive could still be preferred to stylish but poorly conceived systems.

In this context, the evolution of Systematics in France was not very original. During the 20th century, Systematics has become progressively marginal in the national and very centralized academic system. When some large national research institutions have been created after the Second World War, mainly the CNRS (Central National de la Recherche Scientifique) but also the IRD, INRA, BRGM, INSERM, etc., their brilliant development took over the resources for scientific research in France. For the record, CNRS employs today more than 20 000 persons whose 8000 are highly-skilled scientists with life positions mostly in universities. The evaluation comittees of CNRS power many crucial decisions regarding French science policy. CNRS and other large national research institutions considered systematics as a decaying and obsolete research field by comparison with population biology, ecology and genetics, not to speak about cell biology, cytogenetics and the growing molecular biology and genomics which were the truly dominant disciplines in life sciences. At the best, these institutions accepted the idea of a weak support for maintaining basic taxonomy as an engineering activity limited to providing names and identifications.

As a matter of consequence, systematics has disappeared from many laboratories in universities and other places and survived only in a few centers, owing to some permanent local structures (such the collections and associated laboratories in the Muséum national d'Histoire naturelle in Paris) or to rare but vivid individuals (e.g., CBGP from INRA-IRD in Montpellier). In the 80ies, the situation changed with the international involvement in biodiversity studies and the corresponding initiatives (such as Systematics Agenda 2000, for example). Also, the development of algorithmic and molecular phylogenetics has featured a revival of the discipline which permitted

some teams to emerge and to be evaluated at the national level. More recently, the rise of the community of systematists in the world, the correlated increase in impact factors of systematics journals, together with the further development of biodiversity issues in the world has prompted again this positive evolution. Several large labs granted by large institutions of research (mainly CNRS) have emerged or grown in Lyon, Montpellier, or Paris which focus largely on systematics, especially by using molecular phylogenetics or developing comparative algorithmics in the framework of evolutionary biology.

At the same time, places where traditional systematics survived in the mean time were somewhat embedded in a slow and difficult evolution but finally connected to large institutions of research. They keep moving slowly and do not fully explore yet the potential array of research topics that their competence would allow. Paradoxically, the local structures that permitted these places to keep systematics truly alive (e.g., large collections) forbid them to move fast enough or even constrain them to justify more their research in terms of service and engineering than in terms of evolutionary biology.

The challenge of such a situation is twinfold. On the one hand, places of traditional systematics must place themselves in the framework of evolutionary biology. They must establish strong and sophisticated connections with other disciplines such as population biology, behavioral sciences, genomics, and so forth. They must also keep at the same time their competence in taxonomy, nomenclature, or morphological phylogenetics that make them original and necessary. This is crucial in two ways. This is a vanishing and very useful competence and as such, it should be kept alive. But this is also the way to establish connections with the remainder of the evolutionary biology. To study evolution, you need to study organisms that behave, reproduce and to consider them in a functional perspective for which the study of morphology is invaluable.
On the other hand, good labs of evolutionary biology should be enhanced to recruit systematists. Obviously, this can only be made on a voluntary basis, by showing these labs how powerful young widely competent systematists can be. At the present day, systematists complain they conduct heavy taxonomic work which is not appreciated enough (low IF, etc.). This situation will solve by itself when systematics will become fully connected again with the remainder of biology, and especially of evolutionary biology.

Reinvesting our thematic field – evolutionary biology – will be a cumbersome task so much cultural inertia is heavy in each community but the future of systematics is at this cost. At an international and mainly extra-european level, this has already begun and the first effects of this change are fortunately patent.

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Trends in taxonomy today

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Taxonomy is the science of the description and classification of organisms, essential in theoretical and applied biology. About 1.7 million species have been named since Linnaeus and it is estimated that only around 5-10% of the world's biota has been described so far, and, obviously, taxonomy plays the major role in this sense. However, taxonomy is in crisis (funding for taxonomy is inadequate, there is a lack of taxonomists, the recruitment of young scientists into taxonomy and systematics is extremely low, the impact factor of taxonomical journals is very low, and taxonomists have not been able to get the society and other disciplines concerned about the importance of taxonomy. Fortunately, during the last years, several progresses are emerging. The general interest about biodiversity conservation, the advances of internet and web pages, the progress in molecular techniques, the development of statistics in phylogeny, and the new taxonomic funding initiatives and global projects are giving some light: taxonomy is getting fashionable again and topics like Phylocode and Bar Coding are among the most controversial and discussed subjects in taxonomy today.

(1) Taxonomy, the classification of living things, is essential in theoretical and applied biology (agriculture and forestry, biological control, public health, wild life management, mineral prospecting through the datation of rocks by their enclosed fauna and flora, national defence, environmental problems, soil fertility, commerce, etc.). However, this discipline is presently in crisis: there is a lack of funding for taxonomy, the number of taxonomists is dramatically decreasing and taxonomical studies have a low impact factor.
(2) Fortunately, the emerging interest for biodiversity and conservation is representing an input of oxygen for taxonomy. It is estimated than more than 90% of the world species are still unknown and undescribed, and even new animal phyla are still being described. We are attending the extinction of hundred of species, most of them still undescribed. Obviously, taxonomy plays a major role in the sense of biological conservation. Parataxonomy, consisting in sorting out the specimens to recognizable taxonomic units (RTUs) is being proposed as a useful tool in assessing biodiversity evaluations.
(3) Can the web contribute to improve the traditional 'bad concept' of taxonomy? Some authors insist on the need of taxonomy to accommodate to the new technologies, considering that taxonomy is made for the web since it is information-rich and often requires copious illustrations. These authors advocate by an encyclopaedia of life and by a unitary taxonomy; all taxonomic information about each group (descriptions, photographs, illustrations, keys) would be on the web and new information could be added, each group being under the administration of an expert. On the other hand, several other scientists have not received the new approach with so much optimism.
(4) Fortunately, the number of new projects and funding initiatives for supporting taxonomy are recently increasing, at global scale (e.g. Species 2000, Integrated Taxonomic Information System, the Global Biodiversity Information Facility, All Species Foundation, Tree of Life), or more regional scale (e.g. Fauna Europaea in Europe, Fauna Iberica in Spain or Swedish Taxonomy Initiative in Sweden). Two programmes, the Partnerships for Enhacing Expertise in Taxonomy (PEET)

developed in USA, and SYNTHESYS, supported by the European Community, are two interesting funding initiatives which should serve like models for future; these programmes are destined to train new taxonomists and to provide facilities and resources to the taxonomists which already exist.

(5) The emphasis on phylogenetic perspectives in biology began in the 1960s and 1970s, with the accumulation of new phylogenetic data (especially from molecular biology), the development of explicit and objective methods for phylogenetic inference, and the construction of computer hardware and software sufficient to the task of applying the new methods to the new data. In this sense, bayesian inference of phylogeny brings a new perspective to a number of outstanding issues in evolutionary biology. Both, morphological and molecular approaches should be the two sides of the same coin in taxonomy. And not only morphology and genetics must contribute, but also behavioural, ecological, biochemical and physiological data should be considered.

(6) DNA barcoding is now being proposed as a way to catalogue life. This new technology makes use of short but specific DNA tags, or "barcodes" to distinguish one species from another. It uses a small part of the mitochondrial genome, 650 to 750 bases of the cytochrome c oxidase I gene (COI) to provide a unique fingerprint for each species. Despite the potential benefits of DNA barcoding to both the practitioners and users of taxonomy, it has been controversial in some scientific circles. A few scientists have even characterized DNA barcoding as being "anti-taxonomy".

(7) The new proposed nomenclature system, known as "Phylocode" has also brought controversy among scientists. This new naming system is based more explicitly on evolutionary relationships and, instead of being grouped into ranks, such as genus, family and order, organisms are assembled into "clades", defined as any set of organisms with a common ancestor. Although "Phylocode" is strongly supported by many scientists, this system has also some weak points (e.g. the number of taxon names would dramatically increase, all valid names currently being used should have to be defined and registered, and, taking into account that the phylogenetic relationships are not clear for many taxa yet, the establishing of this new system right now would increase the confusion instead of clarifying the situation)

(8) Taxonomy is now in an important point of its long way trajectory and we must decide to go into one direction or another. New approaches have emerged and technological progress is demanding, sometimes without understanding. There are many topics under debate and many different points of view. Several authors are proposing challenges to transform taxonomy such as establish a federation of taxonomy societies and institutions, increase kinds and levels of outreach and education, undertake species inventories, expand identification tool chest, etc. This is, obviously, positive since the excellent news is that the interest in taxonomy is reawakening. But we must be careful and not lose our way, we must join our efforts to have clear objectives to show them to others, specially those who can provide funding. Taxonomy needs time and money to face the crisis, but we must first know how to use them and for what. We must go to the Renaissance and not to the Tower of Babel. To understand the world around us, we must understand all the species which live with us on it, and until now we only know the 5-10% of them. We must focus our efforts convincing about the importance of taxonomy as a basic science for understanding our lives, the skeleton of hundreds of disciplines. And phylogenetics, DNA progress, the web, the new statistic methods should be the tools to support taxonomy not the weapons to eventually kill it. Taxonomy is taxonomy, and must survive as taxonomy for ever.

Considerations on the status of the taxonomy in Italy

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In Italy, hundreds of expert taxonomists operate in research centers of universities, museums and botanical gardens. Considering the last 20-30 years up nowadays, many research groups actively participate to taxonomic and systematic researches at national and international levels. The universities host several groups of excellence working on several groups of organisms using traditional morphological approach and cladistics and molecular analyses. There are experts of the larger and/or more significant zoological and botanical taxa, but also of those considered “minor” taxa. The research of Italian taxonomists realized several interesting projects, to cite is the involvement of more than 65 Italians to the project “Fauna Europaea”, and the important series of volumes of “Flora d’Italia” (Flora of Italy), whose updated supplements are serially published, and of “Fauna d’Italia” (Fauna of Italy), in which new monographic volumes are still published. Among the "minor" taxa, I would like to cite the example of tardigrades, in which I am involved. Italy is the country with the largest tradition on tardigrade systematics and three important research centers are currently present.

Italian taxonomists are “moving into the web” and several online databases on different taxa are available. Even though the use of web has to be certainly increased in taxonomic activities, some important experiences are already available. In particular two examples are important: the “ITALIC” and the “Ckmap” projects. The ITALIC (Information System on Italian Lichens) is an information system on Italian lichens searchable on line, which organizes information from four main databases, a general checklist of lichens, a morpho-anatomical database, herbaria, and regional checklists, and from an iconographic archive, and an archive of predictive distributional maps. The Ckmap project, on which several institutions collaborate, as Universities, Museums and private citizen expert in taxonomy, has produced a checklist of the Italian fauna. For the first time in Europe this project allows the complete inventory of the animal species of a whole country. Up to date, the total number of species listed is approximately 58000.

The large and/or well organized Italian museums too are important research centers for taxonomy. Collaborations with other research centers (e.g. Universities, Museums, local administrations) are more and more frequent and established. For example, other than to collaborate with universities in scientific projects, Museums host students and can offer to them job opportunities. In the last years, some Museums are organizing new modern laboratories integrating the classic morphological taxonomy with molecular biology, biochemistry and electron microscopy techniques. In Italy, university museums are usually rich of important collections but they are rarely adequately funded by the university institutions. For this reason, often they do not have specialized staff able to look after the museums and above all to perform taxonomic researches. This situation is widespread with rare exceptions.
Other than the personal permanently employed in Museums and Botanical Gardens, the collaborators are a fundamental component for the taxonomic and faunal/floristic works of these institutions. Collaborators are usually private citizen, researchers of high scientific level, that actively operate on field.

In spite of the important achievements and of the large work in progress, Italy suffers of the so called “taxonomy crisis”. The reasons of this crisis are probably common to other countries. About the Italian condition, this crisis can be due to several factors related to the low consideration of the role of taxonomy in the scientific community.

Taxonomic researches rarely are founded by public and private institutions, especially if not applied or finalized to human interests. In Italy, university researchers can (taxonomists could) obtain national funds applying for the “Project of relevant national interest” granted by the Italian Ministry of University and Research. If we analyze the more than 800 funded projects in the last 5 years in the biological area, we realized that only 23 of them involved in some way experts in taxonomy. Possible explanations can be several, but I do not believe that no good projects have been presented to the commissions. These projects are judged by other scientists belonging to other research fields that often show little regard for the work of taxonomists. As a result, the applications for the projects are always less and less due to the low confidence of taxonomists in the success of their applications.
This lead the researchers in taxonomy to shift their interests to more remunerated research fields with higher opportunities of grants and career. In this situation, it is difficult to create research groups in taxonomy, and it is often inevitable that when experts get in retirement there are not taxonomists able to continue their work. In this way we lose a lot of experience!

Taxonomy work requires long theoretical and practical trainings other than knowledge in several biological fields. In most cases the guide of an expert results essential. Discovering, describing, and classifying species as well as other related activities (e.g. redescription, synonym identification and so on.....) require time and constancy. When knowledge and experiences are lost, it is difficult for a scientist to begin to study a taxonomic group.

The new generations of pragmatic students are rarely attracted by taxonomic researches mainly because the students do not see job opportunities. For this reason, it should be very important to inform students on the need of taxonomic work and on its role in several biology fields. This task is even more difficult because in the Italian universities the hours available for teaching courses, as zoological and botanical systematics, are continuously reduced. In most cases, the Faculties consider these topics “antique”, not useful for students and not strategic for society.

Nowadays, alpha-taxonomy risks to be no more considered an autonomous field of biology. Taxonomy is seen as the "Cinderella" of science, and its findings have to be on the service of other research fields as molecular biology, ecology, etc.. Almost no scientific journals with Impact Factor accept to publish descriptions of species. Therefore, many taxonomic and faunal/floristic papers are published in journals edited by Italian Museums or Scientific Societies that are difficult to be found and often are written in Italian. Since the number of articles in scientific journals with IF is often used as criterion to evaluate career progression and to assign research grants, the researchers are discouraged to publish papers on taxonomy.

In Italy, the scientist colleagues often image taxonomy as an old discipline. This could be related to the delay in applying the emerging technologies to taxonomy, to the typological concept of species still used, to the fact that some taxonomic paper are pure not critical descriptions without discussion, and to the idea of an integrative taxonomy rarely applied. Nevertheless, modern approaches are widely used by Italian taxonomists, such as cladistics and molecular analyses, to find phylogenetic relationships, to define taxa, or to discover cryptic species. These approaches, together

with traditional morphology, are currently applied and represent ordinary tools for most of us.

Few Italian institutions participate to DNA Barcode of Life projects but several laboratories already use this approach and their number is rapidly increasing. Botany was moving even slowly with respect to zoology in the use of these new techniques applied to taxonomy, but the new generations of researchers are creating excellent laboratories of biosystematics and the gap will be probably reduced soon. Attention should be devoted to the reduction of researchers that work on field or on herbarium because even if DNA Barcode methods are a breakthrough for identification, they will not supplant the need of a diagnosis of species and the identifications of the apomorphies characterizing the evolutionary lines.

In general, small research groups are working on barcode and there is no a real co-ordination or common projects. Meetings are scheduled for the next year to create working groups, to begin discussions, exchange of experiences and researchers, and to propose ample research projects for obtaining national and international funds. I think this initiative will produce interesting developments for this discipline that need a common vision, and to univocally communicate its aspirations.

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For more information on Italian Museums see:

Latella L. 2007. Il Museo: luogo di collezione e ricerca. Riflessioni sull'importanza della tassonomia. In *Il Museo Naturalistico Archeologico di Vicenza a 150 anni dalla sua fondazione - collezioni e ricerca* (ed. Dal Lago A). Vicenza. (in press).

Perspectives and Future Trends in Taxonomy

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The arrangement of taxa and the establishment of the similarities between them (Taxonomy) are essential linchpins for all other studies in Biological Diversity. As Wilson (2002) summarises: Taxonomy is not a single specialization that stands on its own, but is a lateral study "encompassing the full sweep of life", whereas the rest of biology is a vertical study of biological organisation within a very few species, and both disciplines have to be combined to achieve a full study of Biological Diversity. Taxonomy should be considered a holistic, multidisciplinary study that embraces species discovery, identification both by alpha taxonomy and molecular methods/barcodes, phylogenetics and systematics. Yet, in the past thirty years, Taxonomy has been the least favoured of all biological studies. It is a popularly held view that taxonomists have not moved with the times; but in order to modernise and use new tools and strategies, appropriate funding is essential. The funding available has not been directed to Taxonomy, but to trendy new areas of research such as molecular phylogenetics.

Taxonomy lays the foundations for the Tree of Life, which is a requisite database for studies in ecology and conservation. Taxonomy underpins studies in evolutionary biology and ecology, which are directly applied responses to climate and environmental changes (May 2002). Like exploration into unknown outer space, taxonomy is an exploration of the still largely undiscovered Biodiversity of Life. We do not know what is out there, and there is still a great deal of flora and fauna to be discovered. It is evident now that traditional taxonomic practices are indeed inadequate for species identification, and that molecular techniques can unravel a host of hidden taxa which cannot be deciphered by alpha taxonomy. However, before molecular taxonomic tools are applied, initial identification by traditional methods needs to be carried out by a Taxonomist. What has all too often happened is that molecular phylogenetics have been studied without any of the biological aspects of the said taxa, and this has led to many "false draws and blind alleys" (Godfrey & Knapp 2003) in the analysis of data, as has happened in a group I know well – Strepsiptera. For instance, if two morphologically identical specimens are sequenced and show different molecular characterization, questions such as: whether they come from the same habitat, are sibling/incipient/ hybridizing species, and (if a parasite) do they parasitize the same species of host need to be addressed. These are crucial biological questions vital for ecologists, conservationists and policy makers alike. Otherwise, the molecular data are meaningless, and molecular phylogenetics divorced from traditional Taxonomy is indeed an improvised study. Taxonomy is therefore not a dead-end, but the beginning of a larger study of Biological Diversity which has an endless number of users and end-users. Combining morphological and molecular data is thus vital, and ecological geneticists and evolutionary biologists have to work in close collaboration with Taxonomists, as their work compliments each others'. Without the historical background-knowledge of interesting anatomical structure and behaviour, the study of molecular phylogenetics will be of no interest to biologists (Wheeler 2002), and unless there is investment in comparative morphology coupled with ethology and ecology, there will soon be little to explain with molecular phylogenetics (to where most of the funding at present is directed).

It takes years of experience to become a competent Taxonomist, but positions have been lost in institutions and funding is being directed for research to reconstruct phylogenies in a way that "improves neither formal classification nor the application of scientific names" (Wheeler 2002). DNA barcodes are good tools for species identification and help recognize species whose existence is already hypothesised on the basis of complex characters; but are a poor approach to species discovery and description. Bar codes also work for only certain groups of taxa and not for others such as Strepsiptera (unpublished).

Most importantly, there has to be collaboration between taxonomists, molecular phylogenetists and computer programmers. The big failure in the progress and advancement of Taxonomy so far has been that many taxonomists tend to work alone. Instead, taxonomists should be in the centre of all activities concerning species identification, be it by the use of molecular methods for comparisons with other similar taxa and their evolutionary relationships (phylogenetics and systematics), or the gathering of all data for use by the wider public via the web which provides globally a single point of information which will be freely available to everyone, from amateur entomologists to policy makers.

The US has been addressing the taxonomic crisis by aiding different funding programmes for several years, but this has still not happened in Europe. In 2002 Wilson estimated that there are about 6,000 taxonomists and that twice that number, with an equal number of assistants, would be needed to complete the Tree of Life in one generation. May (2002), however, disputes this time scale, even if revolutionary methods are devised for capturing new species. He says that there is so much material to be collected and discovered that there are not enough people to carry out this exercise. The widely-held view that the greatest number of unknown taxa are among the prokaryotes is mistaken. Even among Eukaryotes there are numerous undiscivered taxa in the form of cryptic species, as we are finding out in my study group, Strepsiptera. We could not have known this without active and thorough sampling, which is being carried out throughout the world. The activities of a field naturalist are critical, and whatever the merits of instant identification with DNA analysis, handheld keys and numerous other trendy approaches: if there are no people collecting, discovering and recognizing taxa all the modern devices will be a waste of time and money (Raven 2002). The Taxonomist plays a critical and vital role in species discovery, identification and description for the molecular biologist. Furthermore, active field collection and discovery of new species will give us a clearer picture of the biodiversity between different geographic areas, habitats and continents. Field biological collection is an area which funding bodies ignore, especially in Europe, whereas in the US there are NSF initiatives specially set aside for this activity.

The last 15 years have seen biologists and policy makers in Europe wringing their hands in horror at the demise of Taxonomy. The very same people (in many cases) sit on funding committees but have done little or nothing for this cause. The US, however, has moved on, and there are several large scale multidisciplinary collaborative projects underway. I have joined a number of these teams, and we are actively collecting and discovering new species which I would otherwise have not been able do. In Europe we need urgent funding for new technologies to improve Taxonomy, not to replace it. .

Current state and main challenges of taxonomic research in Poland

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I would like to start with introducing the Polish Taxonomical Society. Firstly, because its main board and founders are professors of the Department of Biodiversity and Evolutionary Taxonomy, a place of my job. Secondly, because the Society groups the most of currently publishing Polish taxonomists not only working on invertebrates but also on vertebrates, plants, fungi and protist. They represent over 20 polish scientific centers: Warsaw University, Jagiellonian University, Gdańsk University, University of Łódź, University of Wrocław, University of Opole, Silesian University, University of Szczecin, Adam Mickiewicz University, Mikołaj Kopernik University, University of Warmia and Mazury, University of Podlasie, Maria Curie-Sklodowska University, University of Bialystok, Institute of Systematics and Evolution of Animals PAS, Museum and Institute of Zoology PAS, Nencki Institute of Experimental Biology PAS, Institute of Oceanology PAS, Wrocław University of Environmental and Life Sciences, Warsaw Agricultural Academy, Medical Universities.

The PTS (www.biol.uni.wroc.pl/cassidae/pttaxtitle.html) was established in 1991 in Wroclaw by polish taxonomists working on invertebrates. Now it gathers about 70 active taxonomists, amateurs and professionals which met each year on conference concerning results of their studies, discussing new molecular techniques, important problems of taxonomy (for example: “Universal classification of organisms - a challenge for classic and molecular taxonomy”, “Systematic unit – morphological and genetical aspects”, “Perspectives of progress of Polish taxonomy in the 21st century”).

There are still some disagreements among molecular taxonomy, classical taxonomy, phylogenetic biology and biodiversity. One of the main tasks of conferences organised by PTS is integration of molecular and classic studies on classification, taxonomy, inspiration for common projects. This tendency and cooperation between scientific centres is well seen in studies of young taxonomists, mostly PhD students – modern taxonomical studies, based on different data, including DNA and other – molecular, biological characters**.** On the other hand, separating of faculties of natural sciences from biotechnology, stronger specialization and limited courses of classical taxonomy and evolutionary biology on both specializations make education of future taxonomists insufficient. **Most of them have to aquire sufficient knowledge and practice on their own. Courses on theoretical and practical taxonomy are designed as additional ones and they are carried out only when a certain number of students sign for them.** Lack of courses on professional scientific English even at PhD studies is also significant.

The statute of the PTS is resembling task of EDIT in a smaller, mainly Polish, scale: support scientific research on invertebrate taxonomy, store scientific collections, organize scientific library, create a new scientific journal devoted to various aspects of invertebrate taxonomy. The Society published quarterly journal “Genus - The International Journal of Invertebrate Taxonomy” (www.biol.uni.wroc.pl/cassidae/ genus.html) and monographic books on invertebrate taxonomy. It is published since 1990 and sponsored by the State Committee for Scientific Research. It is found on list of journals monitoring by ISI Journal Citation Report. List of polish journals monitoring by ISI, in which taxonomists published, include about 30 titles.

One of the main problems, causing most of taxonomists in Poland frustrated, is system of evaluation of research activity and distribution of funds among institutions and

research teams making by KBN - the State Committee for Scientific Research, the major central governmental source of funds for research. The main cryterium of evaluation of scientists is system of evaluation of journals made by the Ministry of Science and Higher Education. Number of points depends on their presence in Journal Citation Index and their "impact factor". Difficulties in comparison of parameters of such evaluation in different sciences are not taken into account by decision making bodies. This system of evaluation underestimate large monographs and reviews – the most journals have limits on the length of papers or on number of large paper. To speed publishing by systematics, web-based journal "Zootaxa" was established in 2001 but our country's scientific policy neglected this journal (with IF=0.612) giving only 2 points as for journals without impact factor.

Another problem is places of job. Numerous taxonomists in Poland are amateurs or phD students without possibilities of work in the country in near future. Moreover, salary of university/ scientist/teacher is only on the level of the average monthly wage and salary (2700 PLN= 750€ brutto) and is not motivating. Further problem is connected with next level of polish academic career, evaluation of academic staff: defense of thesis presented to qualify as assistant professor, which practically means waste of time for procedure, despite of continuing researches.

I mentioned the Polish Taxonomical Society, so I must quote also the Polish Botanical Society (PTB), with 7 journals and own library in Warsaw (over 50000 volumes), the Polish Society of Microbiology, the Polish Entomological Society. Taxonomy is integral part of evolutionary biology so the National Seminars on Evolutionary Biology must be mentioned (www.eko.uj.edu.pl/eseb). Seminars are organized four times a year by Institute of Environmental Sciences, European Community Centre of Excellence of the Jagiellonian University under auspicies of Comitee of Evolutionary Biology of Polish Academy od Sciences. These Seminars gathered over 100 researchers, PhD students and undregraduate students from entire Poland. Other important taxonomical events which have taken place in Poland recently are: the 10th Congress of the European Society for Evolutionary Biology (was held at the Jagiellonian University**,** Cracow) in 2005, the16th Meeting of the International Society for Evolutionary Protistology (organized by Department of Biodiversity and Evolutionary Taxonomy at University of Wrocław) in 2006.

One of the task and taxonomic activities is describing biodiversity, making inventories of taxa in specific areas or ecosystems, check lists and catalogues. Butterflies and moths are one of the most prominent group among invertebrates. They make a good subject for evaluation of habitat condition. A distributional checklist of the Lepidoptera of Poland planned for 2010 is a next step (A distributional atlas of butterflies in Poland 1986-1995) to summarize the distribution of butterflies in Poland. The same project is almost completed for dragonflies (Odonata).

One of the most impressive catalogue is "Catalogue of Polish Fauna" (Polish Academy of Sciences) consisting 23 volumes with data on species distribution and complete faunistic and systematics bibliography of Polish Coleoptera, finished in 2006. It is one of the most complete regional database for the most abundant group of animals. After 30 years nearly twice increase of number of coleopteorologists publications is observed. Some taxonomists are working on the Natura 2000 Networking Programme. This important project for European biodiversity conservation is not completed yet, after four years of conflicts between state authorities and nongovernment organisations. Nevertheless some first inventory works in Special Areas of Conservation (SAC) were completed and management plans are under construction.

Unfortunately, this important activity is neglected in evaluation of scientific achievement.

Future trends of taxonomy

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In present times taxonomic (and phylogenetic) research faces numerous challenges, and there is enormous innovation. There are new methods of observing, comparing, and analysing characters, some of them non-invasive both concerning molecular and morphological techniques. New kinds of characters are becoming introduced into taxonomic work; most importantly, DNA sequences are increasingly explored for purposes of species distinction. The building of comprehensive databases, preferably based on global coordination, has come to full swing. The challenges inherent in the further development and coordination of these novel aspects are frequently discussed. Besides these issues, I view three major general problems for taxonomic work: (1) There is a shortage of comprehensive, revisionary taxonomic work, and a lack of standardisation in the description of taxa. Considerable improvement is not in sight, because (2) routine-work is left behind by an exaggerated, unbalanced promotion of innovation (enhanced by current research policies and assessment criteria), and because (3) there is a decrease of permanent positions in taxonomy combined with a shortage in well-educated scientific "upgrowth".

(1) Lack of comprehensive taxonomic contributions and of standardised taxon descriptions

Regarding species-rich taxa (such as insects), comprehensive treatments are available only for a very small proportion of the subgroups. Therefore – unless there is a specialist at hand – for the vast majority of specimens found outside North America, Europe, Russia, and Japan, identification usually needs a time-consuming study of much original literature produced over centuries. In addition, especially older descriptions are often too brief as to be informative, and even recent descriptions of related species are often too heterogeneous for a clear comparison. Consequently, an examination of "reliably" identified material or types is frequently indispensible for identification.
The huge gaps in taxonomic knowledge can only be filled by a great amount of taxonomic routine-work (morphological and to some extent molecular). Preferably this should be large-scale revisionary work, coordinated among the current experts of a taxon, and with a sufficiently long period of time available. One should remember that most of the literature today widely used for species identification is the outcome of decades of continuous taxonomic work by one or more specialists. This outcome is to a great proportion based on long-term experience with some taxon – a factor that cannot be replaced by any methodological improvement.

Creating standardised species descriptions for family-level taxa, agreed upon by the current experts, could optimise such efforts (by maximising comparability), with a list of characters to be considered, clear definitions of character conditions, and standards of pictorial documentation. Such standardisation would eventually also facilitate the building of databases for taxa, as well as phylogenetic analyses. This also means that in order to arrive at some homogeneity of descriptions across, e.g., the species of a family, some stability in taxonomic practice is needed; of course such stability must be set on a high level.

(2) Taxonomy and research policies

Three factors are currently counter-productive to enhancing comprehensive taxonomic work:

(A) The first is quite trivial: the strong decline in recent years of permanent research positions that have been a major basis for long-term taxonomic routine work, especially at natural history museums. Many of the positions were filled with purely molecular researchers, or ITs, or were simply abandoned.

(B) Current policies of funding institutions (national and EU based) widely propagate "innovation" as a major criterion for grant applications. While thoughtful innovation is welcome, this policy is prone to effecting a diversification of taxonomic methodology that may not be warranted to that extent, and it is in conflict with the demand of standardisation and stability. Furthermore, while particular methods are "en vogue" and a source of innovation, related work is financially supported, but once their use has become routine, support decreases. Thus, routine morphology-based taxonomic work is hardly ever supported. And support will probably also break down in case of DNA-based taxonomic work as soon as the methodology has reached some stability and work has become routine. There is thus a fundamental conflict between current funding policies and the basic needs of taxonomic work.

(C) The current, widely distributed use of journal impact factors (IF) in the evaluation of particular researchers and institutes is also counter-productive. Impact is at average much higher for journals publishing papers with molecular and/or phylogenetic content than for journals focused on contributions with routine taxonomic content. (One should remember that the IF measures nothing but the average citation rate of a journal, while for several reasons it is non-sensical to derive any conclusions from it on the quality of some particular publication.) While nothing is wrong with publications on important general topics being highly ranked, and many colleagues focussing on phylogenetic and molecular research, the current usage of the IF has the consequence that young researchers (who need to apply for funding) as well as full scientists (who will be evaluated according to impact and funding) are massively drawn away from comprehensive taxonomic routine work. In other words, there is hardly any researcher who in present times could dare to dedicate 5 years to a taxonomic revision of some genus comprising 300 species, because then his IF will be too meagre for the next application or evaluation.

Hiring molecular systematists or ITs, innovation as such, and phylogenetic work are important aspects of Systematic Biology. Nonetheless, these aspects have led to a strong decrease of (wo)manpower for taxonomic routine work, and the number of taxa no longer covered by any competent specialist worldwide has steadily increased.

(3) Recruitment and early training in Systematic Biology

In order to support taxonomic research in the future I consider it most important to increase the number of both permanent positions (see above) and competent young systematists. Regarding the latter point, one approach could be as follows:

Most taxonomists and phylogeneticists have developed their strong interest in this field during very young ages, often before they started their study at a university. However, there are hardly any opportunities to support start-up training at that age (ca. 15–20). Furthermore, at the universities Systematic Biology has at average experienced a significant decrease during the last decades, whereby related education of interested students and the recruitment of further students for this field have run short. This situation leaves a vacuum of almost 10 years, where the offer of special training could strongly improve forthcoming skills and competence of systematic biologists, and also

increase their number. Therefore, at the Museum of Zoology Dresden a model for early training has been practised since several years. Candidates from highschool conduct a simple research project in Systematic Entomology, resulting in a publication. After the "Abitur" they have the opportunity to conduct one year of entomological work at the museum, with some 70% scientific work and 30% collection work (frame: "Volonteer Ecological Year", financially supported by the EU, 280 € per month, but only run on a regional basis).

I would consider it substantial progress if there could be grants for work at such an early stage (especially after the "Abitur") on a more regular basis, controlled by the scientific community, and with some over-regional approach and selection of candidates. This would ideally be installed at natural history museums.

Plant Taxonomy in Spain: a personal reflection

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From my point of view, plant Taxonomy in Spain, as in the rest of the international scientific community, is currently experiencing a period of deep changes, as a result of the application of the new methods of phylogenetic analyses based on molecular markers. The use of this new approach in the botany field has aroused certain controversy in the scientific community, characterized by the existence of two opposed and even irreconcilable currents under the opinion of some researchers, namely classic or morphological taxonomy (α-taxonomy) and molecular systematics. In my opinion this dialectic is merely apparent, because research has shown in numerous instances that both types of methodologies are equally valid and complementary. It would be desirable to favour a trend towards a progressive integration of both currents, since it could strengthen scientific results with respect to those coming from studies based exclusively on morphological or molecular markers. The use of a larger number of independent markers (morphology, anatomy, cytogenetics, palynology, DNA sequences or fingerprinting patterns) results fundamental to verify evolutive hypotheses with greater degree of confidence. However, treatments of the same group of organisms based on different kind of data usually exhibit a mixture of congruences and incongruences. Fortunately, at present, it is noticeable a general fashion towards the integration of both currents in the Spanish community of plant taxonomists. The reconstruction of phylogenetic hypotheses based on molecular markers is more and more being accepted as a valuable tool to reinforce and contrast traditional taxonomic studies and to tackle different systematic, biogeographic and evolutive questions. In addition, this integration trend is promoting a bringing together to plant Taxonomy of specialists in other fields, with the subsequent scientific exchange and enrichment that it involves. For instance, the existence of common evolutive patterns between distinct species (macroevolution) and populations of the same species (microevolution) is encouraging the interaction between population geneticists and molecular systematists.

In general, scientists who support the first current (α-taxonomy) are the heirs of the Spanish traditional taxonomic school, mainly based on morphological data, and therefore have sometimes shown reticences to incorporate the new techniques based on molecular characters. Until the end of the 20th century, this school has traditionally put little interest in the study of the main evolutive mechanisms in plants, like hybridization, polyploidy and allopatric speciation. Instead, most research was carried out on the description of new taxa and plant communities, sometimes of doubtful value. Nowadays this fact has its reflection in the large amount of local taxa which usually swell the synonymy of a given species. Between the causes of this scientific inflation, which has been taken to extreme by some phytosociologists, lay the interest to increase the value of a publication or the revalorization of local populations for conservation purposes. Likewise, the peculiarity of the ICBN (International Code of Botanical Nomenclature) for which the name of the author is placed after that of the described taxon, has led to many situations of new species described merely for personal interest. Obviously these attitudes, far from an objective scientific spirit, have had a negative influence over plant classic Taxonomy, causing its disrepute and obscuring its valuable contributions.

On the other hand, some cladists consider molecular characters as a panacea to solve systematic problems. In this context, classic Taxonomy has been sometimes considered as a science submitted to a high degree of subjectivity, which made important contributions in the past but currently in decadence by the bursting in of molecular tecniques. Some of these researchers have frequently joined plant Taxonomy from other fields like molecular biology and often lack specific training in Botany.

Weaknesses of both currents when taken to extreme positions have repeatedly come out into the open. On one hand, some highly artificial classifications have been long accepted which do not reflect the natural evolution of the organisms under study; on the other hand, the extremely reductionist treatment of a species as a series of molecular characters (i.e. DNA sequences), has led to numerous misidentifications in molecular phylogenies and to a excessively abstract view of Taxonomy. In some of these cases the researchers seem not to know the studied plants since they do not take into account their phenotypic characteristics.

An additional significant trend in the present development of plant Taxonomy in Spain is the opening to international cooperation and the creation of stable research groups. Traditionally the progress of this science was carried out by a few botanists who worked alone or in small closed groups. Nowadays that former individualistic Taxonomy has given way to a general trend of formation of research groups in numerous universities and other scientific centres. These groups are characterised by more dynamic teams and by a growing scientific exchange with other national and international groups, boosted by the improvement of communication media (i.e. internet, e-mail). Some outcomes of this process are joint pubications, stays abroad of researchers and the design of more solid and exhaustive sampling strategies. This work philosophy of cooperation between groups has turned out to be very positive for the progress of plant Taxonomy in Spain, and constitutes a cornerstone in the integration of the two currents above mentioned. In addition, it is speeding up the implantation of the tecniques of phylogenetic analyses, whose penetration in Spain would have otherwise probably slowed down because of the burden of our individualistic tradition.

Taxonomy on the rise - the current state and main challenges of taxonomic research in Sweden

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Taxonomy on the rise

In 2007 Sweden celebrated the 300th birthday of Carl von Linné (Carolus Linnaeus, 1707-1778), the father of taxonomy who invented the universal system to describe, identify, and classify organisms. With his *Systema naturae* that was published in its first edition 1735, Linné started the discovery of biodiversity. Today it has been recognized beyond the circles of the biological community that his work is far from being finished. The fact that only a minute part of the actual diversity on the planet is described while simultaneously a vast amount of species are threatened or disappearing has revitalized taxonomy as a high priority scientific discipline for the coming century. It has also become clear that unknown species are left to be discovered in very well known regions of the world such as northern Europe. The number of described multicellular species in Sweden for example has gone up from 38.000 to over 50.000 in the past 35 years (Gärdenfors et al. 2003). At the same time it has been realized that the larger part of the described flora and fauna of Sweden (>65%) is very poorly known in their biology, especially with respect to their life history and ecological significance. In order to promote species knowledge - scientifically and in the public, the Swedish government launched an exemplary project in 2002 with the ambitious goal of describing the complete flora and fauna of its country (Miller 2005). The *Swedish Taxonomy Initiative* (STI - http://www.artdata.slu.se/svenskaartprojektet/svenskaartprojektet_eng.asp) is a 20 year assignment and makes Sweden the first country in the world that attempts to carry out a complete inventory of its entire multicellular life. In this large scale survey several goals are pursued, and the discovery of new species is certainly one of them. However, also the intense study of poorly known taxa has a high priority, as well as the development of human recourses and infrastructure in the field of taxonomy.

The agenda of the Swedish Taxonomy Initiative follows three main steps (Fig. 1), and begins with biological inventories, followed by taxonomic research and the presentation of the taxonomic records in a national *Encyclopedia of the Swedish Flora and Fauna* (http://www.nationalnyckeln.se/english/). Five years after the start of the project many large inventories have successfully been established, collecting biological material all over the country. One example is the Swedish Malaise Trap Project that revises the hymenopteran and dipteran fauna. After more than three years this project has assembled an estimate of 40 million insects from across Sweden while preliminary results suggests that more than 1000 species have been found new to Sweden, of which more than 400 species are even new to science. Another example is the Pandalina expedition that carries out an inventory of the marine fauna along the entire Swedish west coast between 2006 and 2009. Also here the preliminary results report a large number of new records for Swedish waters and also new species for science (especially among the microscopic fauna).

All samples collected during the inventories of the STI are curated by the natural history museums of Sweden and from here they are distributed to the taxonomic experts that further process the material. In addition to the primary purpose for species descriptions, taxonomic revisions, and biogeographical records, many of

the samples are used for other purposes and hypothesis based research, like ecological and phylogenetic projects (Dunn et al 2008), population genetics, as well as barcoding (Bourlat et al 2007). Another major goal of the marine inventory survey is the compilation of a reliable red-list, which has not existed before. The density and distribution of marine species is usually very difficult to trace over time and endangered species have to date been accounted only superficially.

All taxonomic records gathered during the venture of the STI will be made available via a public online-database, the *Artportalen* (www.artportalen.se). This taxonomic register is already running with a large number of taxa and exchanges regularly information with upcoming and established super-regional databases (e.g. MarBEF, GBIF, LifeWatch).

A major ambition of the *Swedish Taxonomy Initiative* is furthermore drawing public attention towards the Swedish biodiversity recourses and wake interest in our animal diversity. For this reason the *Encyclopedia of the Swedish Flora and Fauna* displays taxonomic and systematic information in careful balance with popular-scientific presentation of organisms and colorful illustrations (Fig. 2). The idea with this book series is to produce more than 100 volumes over the next 20 years, and after the first five years we can report 5 volumes already published (mosses, beetles, myriapods, and butterflies) while more than 20 volumes being under construction.

Within the STI workshops and courses are organized in subjects related to systematics and taxonomy for researches and PhD-students. For example in autumn 2007 an international workshop dealing with meiofauna was held while in spring and summer 2008 a number of advanced PhD-courses for taxonomy methods (including electronic methods in taxonomy such as DELTA - http://delta-intkey.com) are scheduled.

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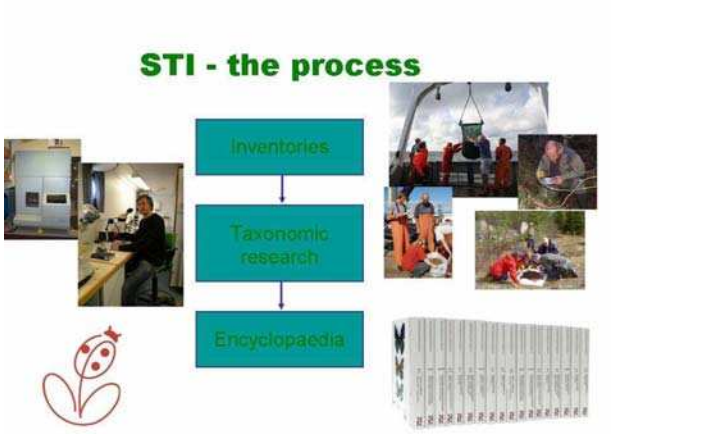

Fig. 1 The research agenda of the *Swedish Taxonomy Initiative*. In the first step inventories are carried out collecting with the goal of collecting either certain taxa or all multicellular organisms of a certain environment. In the second step all collected material is stored at the Swedish national museums and distributed for taxonomic research. As the third step a popular-scientific book series is currently under construction - *The Encyclopedia of the Swedish Flora and Fauna*.

Fig. 2 Book series *The Encyclopedia of the Swedish Flora and Fauna*.

Fig 3 Surveys on the Swedish west coast.

Current state and main challenges of taxonomic research in Sweden

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Sweden has, by tradition, a strong tradition in the field of taxonomy. Carl von Linné, of course well-known, but also people like Elias Fries (mycology), and a number of zoologists have made groundbreaking contributions in their respective organismal fields. Taxonomic research has maintained a relatively high level and the considerable natural history collections in the country have also had decent support. Since about five years, the Swedish government supports "the Swedish taxonomy initiative", aiming at within a 20-year period produces semi-popular taxonomic descriptions and determination keys to all multicellular organisms occurring in Sweden. So, one might think that the current state of taxonomy and its future is brighter than ever? Well, in my opinion, the potential is large, but the outcome will depend on a number of very important strategic decisions.

Before discussing the particular points I wish to make, let me first briefly define the distinctions between the fields of nomenclature, taxonomy, and systematics. Nomenclature simply apply a set of naming rules to a classification of organisms that is given by taxonomic research. Nomenclature is part of taxonomy, which also entails description of the features (morphological, anatomical, cytological, molecular, behavioural, physiological, phylogenetic, chorological, etc) of the organismal groups (taxa). Knowledge of these features is often by governed by systematic research on a particular taxonomic group. Systematic research may or may not include taxonomic classification. In contrast to e.g. physiologists or ecologists, the systematists major focus is the variation within the particular taxonomic group under study, rather than trying to extrapolate the features of a model (organism or system) generally.

Under the evolutionary paradigm, most taxonomist's take for granted that the taxonomic classification produced should reflect evolutionary relationships. The formalism behind this varies, and is sometimes the subject of heated controversy. To keep taxonomy as research discipline in the fore-front of modern evolutionary biology, it is extremely important that that taxonomy rests on a solid scientific framework, and that it is a vital and developing scientific field of biology.

Important natural history collections are part of some Swedish universities (i.e. the herbarium at Göteborg University, the museums at Lund University, and the Museum of Evolution, Uppsala University). Funding of other institutions varies, the Swedish Museum of Natural History in Stockholm serves under the governmental department of Culture, the botanical garden in Stockholm jointly under the Royal Swedish Academy of Science and Stockholm university, whereas the Botanical Garden and the Museum of Natural History in Göteborg both serves under the regional Government. The relative importance of research, public relations, and biodiversity information storage varies among the departments, but they have all in common that they are very important sources of information for biodiversity research, including systematics and taxonomy. Although the Swedish taxonomy initiative is a good funding source presently, the problem of long-term funding is not resolved. In my view, it is important that these institutions define the cost that can be defined as belonging to curation, exchange and maintenance of the natural history collections. This should be a national/international responsibility. An organisation consisting of these institutions is presently working with this as one of its goals.

As for the scientific development of systematics and taxonomy, it is important the the museums and the universities are tightly integrated. In Sweden, I believe that taxonomic research, in an international comparison, occupies (or at least occupied) a relatively high proportion of university based research. There is an unfortunate tendency that this about to change, though. Strong academic environments should be identified, where systematic research and the local natural history collections forms the core, interacting tightly with other areas of evolutionary biology.

Specifically, the following areas should be given high priority:

-Development of a conceptual framework that makes sense in the evolutionary theoretical framework.

-Strong integration with relevant cutting edge research in neighbouring areas in biology

-Development of efficient bioinformatics tools that handle both “traditional” taxonomic data as well as molecular and phylogenetic information. In particular, tools that make the taxonomists routine work easier and enhance dissemination of results (publication) should be developed.

Zoological taxonomy in Spain: a brief perspective

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I doubt that anyone would consider Spain among the countries with strong tradition and investment in zoological taxonomy. Although some Spanish zoologists from the nineteenth and early twenty Centuries, as Jiménez de la Espada and Eduardo Boscá (amphibians), Ignacio Bolívar and Mariano de la Paz Graells (insects) or Angel Cabrera (mammals), contributed to the excellence of Spanish taxonomy with their works on the Iberian, African, and Neotropical faunas, most Biodiversity of the Spanish homeland territories and colonies was described by other Europeans.

The history and perspectives of the National Museum of Natural History in Madrid can be used to illustrate the scarce interest in promoting zoological taxonomy in Spain. It is worth to note that this museum represents the most important Spanish institution created by zoological taxonomists for zoological taxonomists. It was born in the Eighteen Century as the Natural History Cabinet. A great building was envisioned to house the Cabinet's collections. Unfortunately, once it was built, royal desires destined the edifice to exhibit paintings and sculptures in what is now internationally known as Museo del Prado. Another magnificent building was then built as the Arts and Science Palace. The Natural History Cabinet was able to find a corner there. This was the last location for the Cabinet, which later transformed in the National Museum of Natural History. However, only a small part the large building was destined to the Museum. This situation lasts to date. The Museum only occupies a small fraction of the building, the largest portion (even the main entrance) being filled by the School of Industrial Engineering. In the early 1990s, modern trends in museology led to the dismantling of the traditional zoological exhibition in the Museum. The main consequence is that there is no large permanent exhibition on taxonomy in Spain and, therefore, hampering one of the principal ways of communicating taxonomy to society. In short, Spain lacks a Museum of Natural History comparable to museums in other European countries.

Besides this particular situation, my general impression is that taxonomy in Spain is not going through a healthier state. Zoological departments at the universities tend to prioritize research projects on ecology and genetics, while taxonomy is the business of a handful of independent and isolated invertebrate taxonomists. Moreover, students of biology and university researchers tend to be more interested in vertebrates than invertebrates. Thus, since most taxonomic work has been done in Spanish vertebrates, the dominant feeling among them is that most taxonomic work has been done. The research lines are therefore focused on other topics because taxonomy is taken for granted. This rebounds in the topics taught at the classrooms and, further, on the perception of students about which are and which are not the hot topics in biology. Additionally, most students are much more attracted by the vision of "real" scientist evoked by laboratories or complex statistical analyses, than by that of counting appendices of hundred of preserved specimens under binoculars. In summary, neither university docents nor alumni are interested in taxonomy.

Nevertheless, I think that the general ostracism of taxonomy (also in Spain) is the result of its reluctance to incorporate conceptual changes and new methodological procedures. Compare the conceptual stasis of taxonomy with the enormous conceptual, methodological and technical development of phylogenetics in the last 50 years.

Phylogeneticists have incorporated different kinds of characters, methods, models and statistical tests in their studies, and have fully accepted the conceptual implications of evolutionary theory. The modern conceptual and technical framework of phylogenetics attracts much more personal and economic resources than taxonomy. Phylogenetics has thus become a much more lucrative and successful program than taxonomy, which is reflected in, for example, the highest impact factor of the journals where phylogenies can be published. This scenario has caused a serious problem. Resources initially destined to taxonomy are now being deviated towards tree reconstructions, mainly due to the broad confusion by non-taxonomists between phylogenies and classification. Furthermore, applicants to the scarce positions in taxonomy are commonly required to have skills and a considerable publication record in phylogenetics, even if these publications do not include description of taxa or proposal of new classifications.

Despite this negative panorama, I consider that taxonomy still has an unprecedented opportunity to be reborn from its ashes and attract the interest of students and scientists, which would place it in consonance with its relevance for society. The apparition of popular books about the Biodiversity crisis (e.g., The Diversity of Life) helped students and researchers to be aware of the urgent need of taxonomic exploration. Although this is an important step, I think that to reach the level of prestige and acceptation of other sciences, taxonomists need to rebuild taxonomy. As phylogeneticists did, taxonomists need to accept all the implications derived from evolutionary theory, and to rethink their procedures (even those strictly nomenclatural) in light of the conceptual and methodological development of areas of knowledge as phylogenetics, population biology, ecology or genetics. Only then would taxonomy become a much more empirical, competitive and attractive science.

Zootaxonomy and taxonomic paleontology in Hungary – A status report

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Hungarian zootaxonomists struggle with ambivalent feelings. Their self-esteem is boosted by the pride to continue the rich traditions of some 200 years of zootaxonomy in Hungary. Yet there is widespread frustration that the discipline is underrepresented and underfunded within biology and science as a whole, exacerbated by an inferiority complex in comparison with the infrastructure and opportunities available in western countries. This report is largely based on a recently published thematic set of papers [1] that provides a review of zootaxonomic research and infrastructure in Hungary. I attempt to summarize their key findings and supplement it with a brief analysis of taxonomic paleontology in my country.

To understand current activities, it is helpful to review the recent history of the discipline. Over 30 years ago started a series of large research projects devoted to faunal studies of national parks in Hungary (Hortobágy, Aggtelek, etc.) [2]. The first long-term monitoring study was completed on Bátorliget Nature Reserve by 1991. The first modern, comprehensive zootaxonomic textbook was published in Hungarian in 1996 [3]. The approach of a new millenium catalyzed summary volumes and checklists on various taxonomic groups (e.g. Palaearctic Diptera, Millipedes of Hungary, oribatid mites of Hungary, Microlepidoptera). A new monograph series (Pedozoologia Hungarica) has been devoted to previously neglected soil dweller groups (e.g. earthworms, mites, nematodes).

Hungarian taxonomists strive to live up to the reputation built up by several generations of their predecessors. Traditional strengths include expertise in various groups of insects and mammals. Apart from an obvious focus on Hungary and the entire Carpathian Basin, Palaearctic faunas in general are important research targets. However, much of the international reputation of Hungarian taxonomy is earned by specialists who are leading world-wide experts of their respective faunal groups. Much current research is devoted to Southeast Asia. To cite another, recent historical example, the bulk of pioneering studies on the Mongolian entomofauna was carried out or coordinated by Hungarian taxonomists. The Department of Zoology of the Hungarian Natural History Museum has traditionally played a key role in collecting campaigns and taxonomic work in exotic areas. Hungarian taxonomists are pedant in distinguishing themselves from systematists. Indeed, pure taxonomic research far outweighs systematics in Hungary. Hungarian taxonomists appear somewhat slow in embracing modern molecular, DNA-based approaches and are keen to insist that traditional morphologic expertise is irreplaceable and should be maintained. The recent opening of a DNA laboratory in the Hungarian Natural History Museum at least provides the necessary basic infrastructure for molecular taxonomic work. It remains to be seen how fast or slow a change in attitude will happen, sooner or later surely allowing molecular taxonomy to gain a foothold in Hungary.

Specimen-based taxonomic research utilizes collections. The prime zoological collection in the country is kept in the Hungarian Natural History Museum, which is ranked among the top ten such collections in Europe. The zoological collection consists of more than 7 million specimens or lots, 90 % of which are insects [4]. Its

most important part is the beetle collection (nearly 3 million specimens) which is regarded as the world's best collection for certain families. Another measure of significance is that the zoological collection houses nearly 70 thousand type specimens. Apart from the Budapest museum, several regional museums have significant (but more than an order of magnitude smaller) zoological collections. There are two main Hungarian journals which publish primary zootaxonomic literature and both of them are edited in the Hungarian Natural History Museum. Acta Zoologica Hungarica is indexed in the SCI, whereas the Annales Historico-Naturale Musei Nationalis Hungarici celebrates its 100th volume in 2008.

An overview of the institutional infrastructure and a census of professional zoologists was compiled on the basis of a new edition of the directory of zoologists and a customized questionnaire [5]. The number of zoologists has remained fairly stable around 450 over the past 20 years. An estimated 20% of them (i.e. ~90 scientists) are regarded as zootaxonomists. All zoologist staff members are spread among some 100 institutions. Taxonomists work dominantly in museums (first and foremost in the Hungarian Natural History Museum), university departments, and national park services. The demographics of zoologists is satisfactory, with a slight deficit in the 40–50 age group. There are some 60 young zoologists in the under 30 age group but a large percentage of them are PhD students. The future health of the profession will depend on whether they will find employment within the field.

With regard to the future of the discipline, maintaining adequate university education is crucial. The PhD students mostly attend the University of Budapest or U of Debrecen, where Zootaxonomy, ecology and hidrobiology, and Biodiversity streams exist, respectively, within the Biology PhD School [6]. The undergraduate programs are currently undergoing a major „Bologna-style" reform, where the previously well-established 5-year diploma program is replaced by a 3-year BSc followed by a 2-year MSc program. The latter one will be phased in as the first BSc students are expected to graduate in 2009. In Hungary 8 universities offer a BSc program in biology. The number of students admitted has risen sharply in the last 15 years, following a similar general trend in Hungarian higher education. Zootaxonomy remains a first and second year course with slightly reduced credit values and class time, split nearly evenly between lectures and labs, followed by a field school at the end of Year 2.

In this review, I have subjectively omitted botanical taxonomy, simply for lack of time to compile the relevant information. Instead, I briefly touch upon paleontological taxonomy, where I have some first hand experience. Paleontology is a much smaller field than zoology, not only in Hungary. The annual Hungarian Paleontology Conference is attended on average by 50–70 professionals and students, representing an estimated 65–75 % of the entire field. The largest research base is again the Hungarian Natural History Museum, where the Department of Paleontology is complemented by a Research Group largely funded by the Hungarian Academy of Sciences. The Eötvös University of Budapest has a stand-alone Paleontology Department, but the Hungarian Geological Institute, previously a key place for paleo research, has been downsized to a degree at which paleontological research has been decimated. The paleontological community is further segmented by research areas to vertebrate and invertebrate paleontologists, micropaleontologists, and paleobotanists. Some currently (and traditionally) strong research topics include Mesozoic radiolarians, bivalves, cephalopods, brachiopods, Cenozoic foraminifers, molluscs, crustaceans, mammals and plants. The geographic focus is the Carpathian Basin, only a few experts work regularly on material from outside Europe. The approach is generally traditional, expert-based and morphologically oriented. Much of the current basic

taxonomic work is only little different from the well-established 19th century-style. Even the use of morphometrics in taxonomy remains largely ignored by most Hungarian paleontologists. The taxonomic output is published mostly in national and regional journals and monograph series. I shall end on a positive note, though, by mentioning the increasing share of international, cooperative research among the projects by Hungarian paleontologists. I work on raising the awareness that there is much interest in taxonomic paleontology as supplier of raw data for analysis of trends in past biodiversity through deep time. We shall see increasing Hungarian contribution to international database projects, such as the Paleobiology Database.

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The current state and challenges of taxonomic research in Germany

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Germany has a long taxonomic tradition and specialists for a wide range of taxonomic groups. Particularly in natural history museums, active taxonomic research is thriving, often coupled today with the aim to address larger evolutionary questions. On the methodological side, molecular systematics is steadily progressing, though there has been a luke-warm response to DNA-taxonomy or DNA-barcoding so far, with few notable exceptions. Taxonomy in Germany has the potential to be a thriving science, thus, were it not for pressing problems in two different areas:

(1) While natural history museums continue to be hotspots of taxonomists, the situation at the universities has become very different. Very few if any chairs in zoology e.g. are being held by taxonomists after a long continuous decline. Rather, there is a notable tendency towards choosing molecular biologists for vacant positions. In effect, taxonomic teaching has all but vanished and what is left is endangered. The natural history museums remain the only steady source of taxonomic expertise, thus. While most of the museums at least have links with universities, their efforts cannot replace the lack of taxonomic education provided by the latter. Consequently, students of biology are often hardly exposed to taxonomy at all and if they are, cannot fail to perceive that its prospects at present are far less promising than they are e.g. for genetics. If this trend continues, it will inevitably lead to a severe lack of taxonomists in the future.

(2) Taxonomy is obviously collection based and in total the German natural history museums probably hold one of the three largest national collections in the world. This rich heritage does not translate into sufficient funding for maintaining and using these collections, though. While some of the larger museums have secured a more steady source of funding through federal money recently, others still face a shortage of funds or in at least one case even closure. Consequently, curator positions for example remain vacant or are quietly cut away. In addition, curators in Germany traditionally have to do both research and be collection managers at the same time, a double role that is not promoting excellence in either task under the best of circumstances and certainly not if insufficient funding is an additional problem.

The major challenge for the future of taxonomic research in Germany will be to successfully address the threat of an extinction of taxonomic expertise due to its virtual elimination from the university curriculae. A new initiative to install ten well-equipped professorships in taxonomy at German universities (http://www.taxonomie-initiative.de) may prove a promising start to overcome the perceived unattractiveness of an apparently old-fashioned discipline – which is, slightly ironically, at the same time hailed as a megascience of the 21st century by some.

On the collection side, progress has been made e.g. through initiatives like GBIF, which has lead in some case to the first in-depth cataloguing of type specimens in major museums through the funding of extra staff. The key here again is to spend more ressources particularly on skilled personnel to manage the collections efficiently, open up research time (not only) for curators and last but not least increase the attractiveness of the field for students.

A future for taxonomy

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Which taxonomy?

These are challenging times for taxonomists. On the one hand, taxonomy (*sensu lato*) is going through a deep crisis, as opportunities and resources are evaporating. Indeed, taxonomists increasingly have to compete for funding and career opportunities with researchers from other disciplines that are perceived as having a higher societal or scientific relevance. On the other hand, the appearance of novel methodologies and of the world wide web has created a setting in which fascinating tools and unprecedented information dissemination and retrieval possibilities are possible. If taxonomy as a discipline is to survive the bottleneck, then it will have to evolve, by adaptation to the needs and expectations of society.

The challenges and opportunities created by the availability of new techniques makes that fundamental taxonomic questions can now be tackled using an unprecedented range of methods, morphological, ecological, or molecular. This promising new approach has the potential to deliver fundamentally new paradigms on diversity and evolution. Taxonomic research that embraces any relevant available technique, and is well embedded in a conceptual framework, should be able to compete with other scientific disciplines, both in the pursuit of research resources and the publication of results in high-ranking journals, and, consequently, in the creation of career opportunities. However, combining the available tools successfully is of a complexity that requires an interdisciplinary approach, hence prohibitive to the lone taxonomist.

The line of fundamental research is unlikely to yield the taxonomic products ecologists, managers and policy persons require, like species- and geographic information databases, communication and identification tools (whether morphological or molecular), well-curated natural history collections, and training of identification skills. A different adaptation is required to answer this need: that of taxonomists developing applied tools, tailored to the needs of users.

Building a future

So, the pressures on taxonomy appear to be disruptive. On the one hand, fundamental taxonomic research results in the high-level publications that scientists need to build a career upon; applied taxonomic research delivers the taxonomic tools and products most needed by users. These two diverging paths will probably become mutually exclusive under the present culture of conducting and evaluating science, and especially the second, applied branch of taxonomy appears to be critically endangered. The products and services delivered by applied taxonomic research are no match compared to the outcome of other research disciplines including fundamental taxonomic research, if evaluated using contemporary techniques, viz. comparison of journal impact factors and citation indexes. An applied branch of taxonomy can only flourish, and be expected to deliver, if both taxonomists and users adhere to some basic economical principles, that is, that clear conditions exist regarding products and services, offered against a realistic price. Pragmatically, this requires taxonomists who don’t get sidetracked from their contracts (see Evenhuis 2007, Flowers 2007), and

users who understand that what they pay for is what they get (e.g., see Gotelli 2004). Institutes and funding agencies that choose to support such research should act consistently, and apply appropriate evaluation criteria for the selection of personnel and projects.

Many taxonomists will probably argue that the two lines of taxonomic research sketched above fail to focus on the activity that is now most associated with people's perception of taxonomy, viz. the description of (new) taxa. Indeed, I see this activity as only a step, albeit an important one, in the taxonomic process, but not as the Holy Grail. It should be borne in mind that this activity has been going on for centuries and that we are nowhere near the ends of it. Also, amateurs, in many cases, are doing a great job at it. Considering these elements, it is unrealistic to expect that funding agencies will put resources to the disposal of an activity that can easily be perceived as a being equivalent to a bottomless pit.

Concluding thoughts

In order to enable taxonomy to adapt in the way as described above, a change of attitude will be required by both taxonomists and users. It is likely that this change of attitude in taxonomists will be established through a process of selection. As far as users are concerned, it is unlikely that any change of attitude will happen. Competition for funding is such that budgets for taxonomic support included in ecological or other research proposals will most probably be the first to be axed. Also, there is hardly an incentive to, for example, ecologists to improve on taxonomy, as quality control by peer review generally fails to evaluate this aspect.

Clearly, the picture I draft of the future of taxonomy is bleak. Fortunately, governments worldwide have realised, in the Convention on Biological Diversity, that the taxonomic crisis is having an adverse effect on sustainable management and conservation of biodiversity, and has initiated a Global Taxonomy Initiative to tackle the taxonomic impediment. Initiatives like, the Assembling the Tree of Life (AToL: http://atol.sdsc.edu/), Partnership for Enhancing Expertise in Taxonomy (PEET: http://www.nhm.ku.edu/peet/), and, of course, the European Distributed Institute of Taxonomy (EDIT: http://www.e-taxonomy.eu/), and others, are setting a stage. I hope that in Belgium, we will see a significant initiative promoting taxonomy, both in natural history institutes and universities, in the future.

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Current state and main challenges of taxonomy in Finland

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The current state of taxonomy in Finland is by European standards in quite good shape. There are several museums with adequate collections and taxonomic work is relatively well-funded. Taxonomists with permanent positions in museums and universities are able to work on taxonomic problems of their choice, without being forced to work on groups of organisms that are of immediate economic interest to humans. This is reflected in the high standards of publications in taxonomy and systematics coming from Finland. There are also large numbers of amateur taxonomists describing new species of their favourite group, mostly doing good quality work and publishing descriptions in accessible journals.

However, the taxonomic work done in Finland is very traditional and there is resistance to new methods and ideas. Many taxonomists with permanent positions are part of the older generation and the number of permanent positions is quite limited, meaning that turnover is quite slow. This in turn means that many new ideas in the field of taxonomy are not readily accepted by the established researchers and it is viewed as the clichéd old-fashioned, dusty profession by students. The small number of available positions also means that the field of taxonomy is not very attractive for students. The main challenges for taxonomy in Finland are to introduce the new methods being developed and to make taxonomy an attractive field of research for potentially interested students.

DNA taxonomy in Finland: the use of DNA in taxonomy is mainly seen as a passing fad by many established taxonomists in Finland. This is reinforced by the amateurs who do not have the resources or technical knowledge to use molecular methods in their work. Clearly the use of DNA as a source of characters is not appreciated in Finland and this is not helped by the large costs of acquiring such information relative to traditional methods. A sequencing center devoted to generating molecular data for taxonomic purposes would be necessary to allow nonspecialists access to such data at minimum cost. One serious consequence of the scepticism towards DNA taxonomy is that no museum in Finland has invested in storing specimens for DNA-based work, despite active collecting trips around the world. Another consequence is that no Finnish museums are part of the Consortium for the Barcode of Life.

Internet based taxonomy in Finland: the internet is seen as too ephemeral to be a reliable repository for species descriptions. There appears to be very little interest in exploring the possibilities of the internet among many professional taxonomists. There does not even appear to be interest in placing collection information on the internet, even though some museums do have databases of their collections (e.g. University of Oulu Zoological Museum).

Finnish taxonomy is poised on the edge of transition. Younger generation and some older generation taxonomists are already implementing new methods in taxonomy, and a number of museum jobs will become available in the next few years as many taxonomists reach the age of retirement. This means there is much potential for Finnish taxonomy to change from traditional to progressive.

Current state and challenges in Swiss systematics and taxonomy

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The biodiversity of Switzerland is among the richest in Europe, and new species are described on a regular basis. Forty-seven museums, 11 botanical and 8 zoological gardens hold biological collections, unified under 'MeDaCollect', a meta-database and partner of the EU Project BioCASE. Despite the fact that the potential user has to be fluent in either French or German, this database facilitates worldwide access to around 41 million specimens. According to a recently published Nature article, 345'000 type specimens, material that named an estimated quarter of all described species, are housed in Swiss collections (Agosti et al 2003). This is an astonishingly high number, especially considering the fact that Switzerland is not yet a full member of the Global Biodiversity Information Facility (GBIF).

As the taxonomic expertise to deal with this wealth of specimens is vanishing, the Swiss Academy of Sciences launched specific platforms to face this problem, namely the 'Task Force Systematik und Taxonomie' (daugther of the 'Global Biodiversity Information Facility Switzerland') and the 'Swiss Forum of Biodiversity'. In this context a memorandum on the future of Swiss systematics was published, describing how this discipline on the edge of dying out could find its way back to academic institutes, international science, and lecture halls. The very detailed management plan, developed by 25 mostly Swiss authors, shows not only how severe the state of Systematica Helvetica is, but also to what great extent Swiss systematists and taxonomists are interested themselves in getting this discipline back on its feet.

Current situation in Botany (not including mycology) and Zoology

As in many other European countries, the problem is manifold: budgets for natural history collections at museum and botanical gardens have been reduced, and the use of the money available has been shifted from managing collections to designing easy to digest exhibitions, while teaching biodiversity, taxonomy, and systematics has dramatically decreased, as has the number of taxonomists working on Swiss desktops. As more and more of these experts leave their offices for retirement, their positions are either filled with specialists foreign to the field or dissolved altogether.

Although Botany can be seen as the taxonomically most active research area in Switzerland, no particular efforts are made by the politicians to improve the current difficult (financial) situation. The recent retirement of two of the most authoritative experts in the field and their replacement by experts foreign to systematics and taxonomy is just an example of the present state of affairs. As professors in Systematic Botany leave, courses in systematics are cut back, and the existence of botanical gardens and herbaria is threatened. For example, a national petition was necessary in 2007 to "save" the botanical garden of Neuchâtel, whose funding support was not renewed by the University. Unfortunately, such events are not the exception, but the sad rule!

And this also holds true for zoological collections, as the process of financing publicly accessible exhibits rather than the curation of existing collections has already devoured some of the smaller museums (Swiss Academy of Sciences 2007). Professors

of systematic zoology have by now entirely disappeared from the teaching boards of Swiss universities, and there seems to be no trend to change this.

As systematics is unanimously considered to be the foundation for most organismic sciences, the question remains: why are we killing the goose that lays the golden eggs?

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List of available research grants, initiatives and organisations in the area of taxonomy and systematics, with indication of Swiss participation

1) Research Grants

USA-NSF programs for taxonomy and sytematics
AToL (Assembling the Tree of Life) http://atol.sdsc.edu/
PEET (Partnership for Enhancing Expertise in Taxonomy) http://www.nhm.ku.edu/peet/
PBI (Planetary Biodiversity Inventory) http://nsf.gov/funding/pgm_summ.jsp?pims_id=5343

Nothing comparable in EU or Switzerland

2) Worldwide or EU initiatives and Swiss participation

a) BioCASE: search for metadata (institutions and collections). http://www.biocase.org/ Switzerland is not listed (see Search for metadata (institutions and collections)).
b) SYNTHESYS: http://www.synthesys.info/index.htm
Switzerland is not part
c) GBIF: http://www.gbif.org/
Switzerland is associated country (http://www.gbif.ch/) but judging from their web page the Swiss GBIF node is not very active.
d) CTAF Consortium of European Taxonomic Facilities http://www.cetaf.org/
The only Swiss members are: Muséum d'Historie Naturelle de la Ville de Genève and Conservatoire et Jardin Botaniques de la Ville de Genève
e) EDIT Network of excellence. http://www.e-taxonomy.eu/
Any Swiss institution involved?
f) ENBI (European Network for Biodiversity Information) is the EU's contribution to the Global Biodiversity Information Facility (GBIF) http://www.enbi.info/forums/enbi/index.php
Swiss Biodiversity Forum listed as member, but no Swiss research institution.

MeDaCollect', a meta-database for biological collections
http://medacollect.biodiversity.ch/index_d.html
Swiss initiative that lists all collections, but you can't search for species and accession numbers.

3) Organization within Switzerland

The Swiss Biodiversity Forum of the Swiss Academy of Sciences is the competence center for biodiversity research in Switzerland. http://www.biodiversity.ch/
Swiss taxonomists and systematists are organised under the Swiss Systematic Society. (http://www.swiss-systematics.ch/e/about/)

Taxonomy in Poland

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Taxonomical researches in Poland have a long tradition especially the taxonomy of vascular plants and animals. Polish taxonomical scientific institutes (Museum and Institute of Zoology Polish Academy of Sciences, W. Szafer Institute of Botany Polish Academy of Sciences) are active participants of an international initiatives concerning taxonomy (EDIT, CBOL). There are several societies grouping in Poland actively working specialists in different fields of systematic (mycology, zoology, botany, phycology). Each society organizes annual symposiums, scientific seminaries and meetings where taxonomists present the results of they work and have occasion to discuss. I know only one society in Poland grouping only taxonomists – it is The Polish Taxonomical Society. It was founded in 1991 by a group of young Polish taxonomists working on various groups of invertebrates. These 25-30 persons during several years met on scientific seminaries organized at the Department of Zoology, Agricultural University in Wrocław.

Polish taxonomists begin using the modern molecular methods for systematic studies and taxonomic revisions of different groups of organisms. The DNA sequences and "DNA barcodes" data in combination with other taxonomic data (morphological, biochemical, physiological features) currently have been used by my research group to designate epitypes and neotypes for euglenoid's species (*Monomorphina pyrum* – Kosmala at al. 2007; *Phacus orbicularis, Phacus pleuronectes, Phacus hamelii* - Kosmala at al. 2007); for designation a new taxa (*Monomorphina pseudopyrum*) and taxonomical reclassifications (Zakryś 2002, Kosmala at al. 2005).

The challenge for Polish taxonomy is the same like in other countries – using the molecular tools, as a standard methods, for discovering existing relationships among organisms and proper interpretation of phylogeny trees constructed on the molecular data which wouldn't be in contradiction with other data (morphological, biochemical, physiological, ecological).

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