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Taxonomy

From the Greek Taxis = order and Nomos = law

Concept coined by Augustin Pyrame de Candolle (1778-1841)

"Without taxonomy to give shape to the bricks, and systematics to tell us how to put them together, the house of biological science is a meaningless jumble."

Robert May, 1990

The European Distributed Institute of Taxonomy (EDIT) is the collective answer of 26 leading European, North American and Russian institutions to a call of the European Commission, issued in 2004, for a network in « Taxonomy for Biodiversity and Ecosystem Research ».

The project started on 1 March 2006 and will last 5 years.

More information can be found on the EDIT website: <http://www.e-taxonomy.eu/>

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Executive summary

European science is facing a tremendous loss of taxonomic expertise as the succession of retiring qualified taxonomists is hampered by reorientation of work and by cuts in staff. Consequently, the passing-on of taxonomic knowledge and skills to a new generation might be decreasing. To evaluate if adequate training opportunities are currently still available to the new generation of taxonomists, EDIT scored today's education in taxonomy and analysed its strengths and weaknesses. This exercise was needed to meaningfully implement the overall objective of WP 8: establishing a European state-of-the-art school of taxonomy.

The training resources for taxonomy in Europe were assessed through the answers of an online survey, from interviews with people involved in taxonomy, and from existing websites and reports. In total, 201 pertinent sets of information on training courses in taxonomy in Europe and 45 from elsewhere were selected from a total of more than 300 contacts. A complete listing of the inventoried trainings can be found in the EDIT Component 8.1.1 (Report on existing training resources for taxonomy in Europe).

A gap analysis revealed the current status of the training offer in taxonomy in Europe and highlighted the challenges that these training courses have to face in order to meet the standards and needs of the 'twenty-first century' taxonomy. Pertinent issues relate to the accessibility, content, and teaching material of the training courses.

Accessibility of the European training offer

- Information on the training offer in taxonomy is hard to find and fragmented.
- Many training courses are limited to a national audience. This lack of international openness probably finds its origin in traditions and also in time and money investment needed to translate course material.
- An important barrier to the promotion of trainings outside the organising country is the language in which it is held. In this respect, it is encouraging that some training providers adapt the teaching language to the audience.
- A large fraction of the trainings is organised by and in universities. Consequently inscription fees for enrolment must be paid to attend the courses and can prevent the attendance of trainees.
- Courses for technicians and amateurs are underrepresented and/or do not specifically address their problems.
- Most of the training courses are organised at least yearly or on demand. However, half of the trainings on taxonomy last for two weeks or more, hampering the participation of trainees who search for a short and intensive training in taxonomy.

Recommendations

- A central portal for the dissemination of information on trainings in taxonomy is crucially missing. The set up of an online catalogue of courses in taxonomy by EDIT, updateable by concerned parties, can be an essential tool to disseminate the information on the training offer in taxonomy.
- EDIT, in dialogue with training providers and organising institutions can assist for promoting:
 - a wider use of a common language (English in most cases) when a training course is designed in such a way that an international audience may attend it,
 - a system of payment by course instead of the full payment for an entire academic programme.
- EDIT has a key role to play in order to inform future trainees on potential sources of funding, including existing European mobility schemes.
- EDIT should promote trainings intended for the technical staff.
- EDIT should promote the development of intensive and condensed trainings that could attract more participants by demanding less time and funding resources.
- EDIT should seek more collaboration with taxonomic societies since in several taxa a large proportion of new species and new records are achieved by amateurs.

Content and material of the training offer

- Classic teaching methods like lectures and exercise sessions are popular methods in taxonomical training because they are still the most cost effective and easy to implement. Comprehensive e-learning courses are almost inexistent.
- The integration of taxonomy with other disciplines during the trainings is frequent, since taxonomy is a prerequisite to many other research areas (biodiversity assessment, development of conservation strategies, pest management, ...).
- Half of the taxonomic trainings only teach morphological aspects of taxonomy. The other half takes into account both molecular and traditional approaches. Very few courses address taxonomy using only the molecular approach.
- Half of the trainings do not include teaching on the nomenclatural rules.
- Currently, a majority of training courses focus on arthropods, vertebrates and flowering plants, which does not reflect the whole diversity of life.
- The geographical cover of the targeted taxa is strongly biased towards the Palearctic region, although some institutions from countries with former colonies are active in overseas countries.
- Curation practices are an important component of the training offer.
- Skills linked to the use of informatics in taxonomy are largely developed during the trainings.
- Much of the training material (notes, specimens, CD-ROMs, books, etc.) used during training courses is only available to the participants of the training and is not easily distributed by other means.

Recommendations

- E-learning courses have a great potential to teach students in taxonomy while avoiding the costs of travel and subsistence. E-learning initiatives should be promoted by **EDIT** (in collaboration with Workpackage 5 - Internet Platform for Cybertaxonomy).
- More efforts should be put into the production of courses dealing with both the morphological and molecular aspects of taxonomy. **EDIT** can assist to put in touch morphological and molecular training programmes that share a pertinent content to integrate the molecular approach into the traditional taxonomy.
- **EDIT** should promote the teaching of nomenclatural rules since this knowledge is crucial to taxonomy.
- More attention should be given to less studied taxonomic groups having a recognised ecological importance. These taxa can be identified in agreement with the assessments realised within the **EDIT** Workpackage 7 - Applying Taxonomy to Conservation.
- **EDIT**, together with active players in taxonomy, has to develop North-South, South-North and South-South exchange programmes to train taxonomists because the largest part of the biodiversity that still needs to be discovered lies in the tropical regions.
- **EDIT** should promote:
 - the importance of curation practices as part of the training offer,
 - trainings using new tools for taxonomic descriptions and revisions (to be linked with Workpackage 6 - Unifying Revisionary Taxonomy).
- **EDIT** should be a major player to improve the accessibility and exchange of training material, in particular the development of online cooperation between training providers.

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1. INTRODUCTION

The present report provides an analysis of the existing training resources for taxonomy collected by the European Distributed Institute of Taxonomy (EDIT, Workpackage 8 - Training and Public Awareness). It is the complement of component 8.1.1 of Workpackage 8, which lists the training offer in taxonomy collected during the survey. This listing is available on request on EDIT's website and on a CD-ROM*.

European science is facing a tremendous loss of taxonomic expertise. Despite the availability of a well developed taxonomic infrastructure, European taxonomic research, including its collection management aspects, increasingly relies on an aging taxonomic community, with permanent staff often over 50 years old and with a significant input by retired researchers and skilled amateurs who frequently have to self-fund their research.

Efforts to find enthusiastic young people with an interest in becoming qualified taxonomists are thwarted by insufficient training opportunities and a lack of long-term professional prospects. To address this problem, education is an essential component of EDIT. The main challenge is to stop the loss of taxonomic expertise, and have this negative trend reversed in 5-10 years from now. EDIT strives to achieve this by increasing the transfer of knowledge and by establishing an integrated European training programme for taxonomy. In parallel, public education will increase the awareness of the vital contribution that taxonomy can make to biodiversity and ecosystem research. EDIT also has a role to play in the promotion of taxonomy to decision makers and funding agencies.

A first step towards the integration of the taxonomic training offer in Europe is to undertake an overview of the current courses and to analyse its strengths and weaknesses. This should be done in the light of opportunities and threats that rest on taxonomical trainings. The present report is an effort to fulfil this need. The current situation of the training resources in taxonomy for Europe is first evaluated. The most important aspects concerning accessibility to the trainings, content of the courses and type of training material are scrutinised. In a second step, a supposed ideal situation of what the offer of courses in taxonomy should be is described. Finally, from current and ideal offer of trainings, proposals are made to improve the future offer of trainings in taxonomy in Europe.

* The CD-ROM containing the 'Report on existing training resources for taxonomy in Europe' is available on request to V. Zintzen (vincent.zintzen@naturalsciences.be).

2. DATA SOURCES

The training resources for taxonomy in Europe were assessed through the answers of an online survey, from interviews, websites and other public documentation. The complete listing of trainings with their details as well as a description of the online questionnaire can be found on EDIT's website and is also available on a CD-ROM*.

The online survey "Assessment on training resources for taxonomy" was designed to collect information on: (1) the identity of the respondents and training organisers, (2) the accessibility to the training, (3) the training content and (4) the training material and teaching aid.

This survey was made available online via SurveyMonkey (<http://www.surveymonkey.com>) from December 2006 until 30 September 2007. A call to fill in the questionnaire was launched *via* the EDIT network and other channels, such as TAXACOM (a mailing list on biological systematics), the European Research on Biodiversity discussion group (EUROBI), DIVERSITAS, Desert*Net, BioNET-INTERNATIONAL, the Global Biodiversity Information Network (GBIF), the Taxonomic Database Working Group (TDWG) and the Global Taxonomy Initiative (GTI) National Focal Points. Moreover, the request was sent to museums, universities, botanical gardens, herbaria, councils, societies and other institutions from about 80 countries.

Additional information on training was gathered from other sources and covered the same main issues as the online survey but was generally less detailed.

The information was filtered to keep only trainings whose main focus is taxonomy. Consequently, this step excluded the bachelor's lectures with programmes only addressing what taxonomy is and all the inconsistent entries. Finally, a total of 201 complete sets of information[§] on training in taxonomy were gathered (145 from online survey and 56 from interviews). Furthermore, 62 contacts with people involved in taxonomical training were made. Since these contacts did not produce any formal information on training, they were not integrated in this report but will be used in the future to complete our expert database.

EDIT is a European project focusing on training courses organised by European institutions. However, the survey was open to a broad audience with an interest in taxonomy and we consequently received information on courses organised outside Europe. Forty-five (45) sets of information on training in taxonomy were collected and 27 contacts were made. This information will be presented apart from the European results, at the end of this report.

Despite the large effort invested to reach people involved in taxonomic training, gaps in the results from the survey and interviews still exist. A few countries (Belgium, Slovakia, UK, Netherlands and Denmark) contributed largely to the effort while information on other countries ranges from incomplete to lacking. Figure 1 illustrates this fact by showing the density of responses by European countries. The number of answers received from outside Europe is, as expected, much lower. The gap analysis is limited by the fact that it is based on survey respondents only. Actual expertise may be much more extensive.

*The CD-ROM containing the 'Report on existing training resources for taxonomy in Europe' is available on request to V. Zintzen (vincent.zintzen@naturalsciences.be).

[§] The 'Report on existing training resources for taxonomy' (component 8.1.1) has 203 complete sets of information. Some answers were received too late to be incorporated in the analysis.

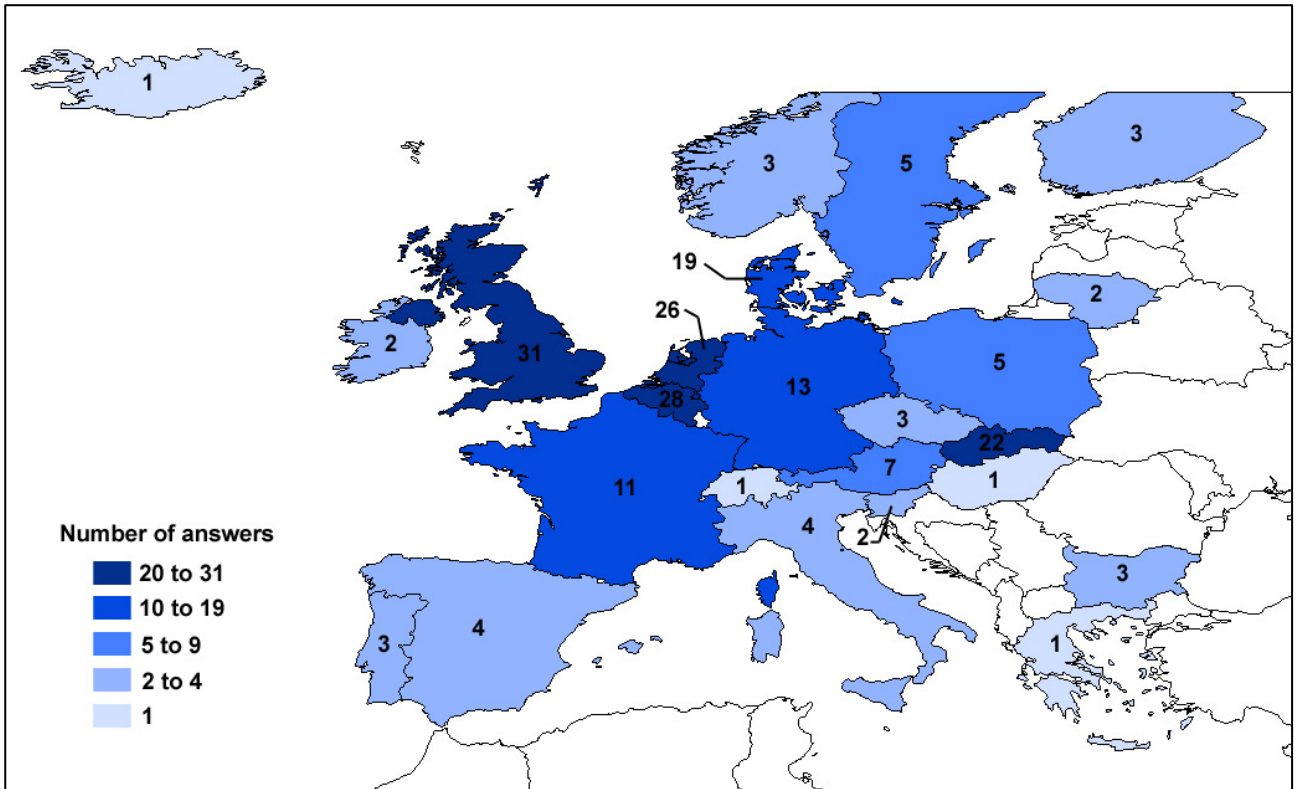


Figure 1. Geographical distribution of answers collected on training in taxonomy in Europe.

3. TRAINING RESOURCES FOR TAXONOMY: WHAT IS THE SITUATION IN EUROPE?

The following results are based on the analysis of the European data collected through the online questionnaire and from personal interviews, websites and other public documentation.

3.1. Accessibility

3.1.1. Targeted geographical audience

The largest part of the training courses in taxonomy (39%) targets a national audience only (Fig. 2). However, many are open to an international public (28%). A small proportion of trainings is specifically designed for a European audience only (4%). Additionally, some respondents mention that the international dimension of their trainings is targeting specific regions of the world (mainly developing countries) because they are part of collaboration programmes with these areas.

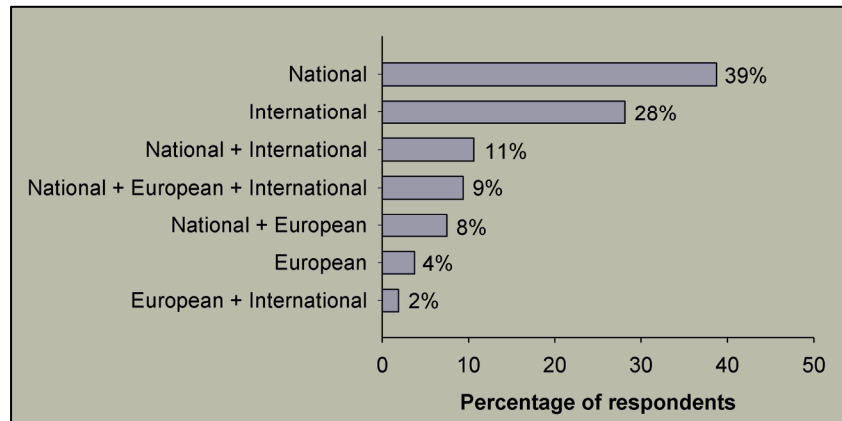


Figure 2. Targeted geographical audience.

3.1.2. Language

Trainings can be held in one language, alternately in different languages or in several languages at the same time. Most of the trainings (53%, Fig. 3) are held in the official language(s) of the organising institution. This percentage includes the trainings held in English in the UK. However a significant fraction of the trainings is specifically organised in English, even if it is not the language of the host country (22%) and English is used in replacement or in addition to the local languages if needed (24% of the trainings). In Scandinavian countries, the tendency is to use English even if only one foreign student attends the training.

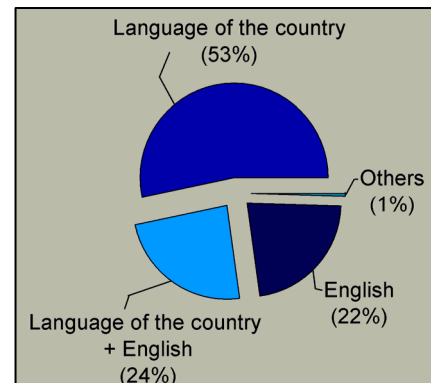


Figure 3. Language of instruction. 'Others' states for a single training held in Spanish and Italian.

3.1.3. Financial aspects of attendance

Since most of the trainings are organised by universities or in cooperation with them, the participants need to pay an enrolment fee for the academic year (Fig. 4). 67% of the trainings involve these costs of attendance. Some respondents mention that individual courses can be followed and paid for separately in universities. 20% of the trainings have an inscription fee and 13% are free. The fact that some training is marked as 'free', does not mean that these trainings can be held without any funding. In most cases, it implies that the organisers of the course have another source of funding instead of a contribution of the participants, for instance a grant from the government or funding agencies.

Costs of attendance could only be given for short-term trainings (<2 weeks) and reach an average of 105 EUR/day/person (s.d.: ±97 EUR, N=31). That does not include travel expenses.

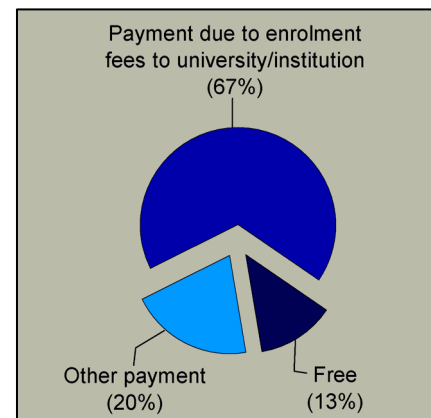


Figure 4. Financial aspects of attendance.

3.1.4. Level of trainings and target audience

Trainings are predominantly held by the academic world (88%), leaving only 12% to non-academic courses.

67% of the trainings are offered at university level (undergraduates, master, PhD and postgraduates) (Fig. 5). Specialists, professionals and technicians are admitted to 23% of the trainings. Very few courses are specifically organised for amateur taxonomists (4%), high school students (4%) or the general public (1%). It should be noted that many trainings are organised for a broad audience rather than for a single type of participants.

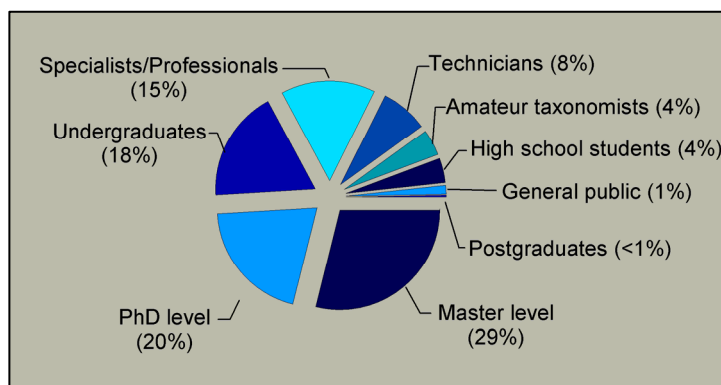


Figure 5. Target audience of the trainings.

3.1.5. Periodicity and length

Trainings are most of the time organised on a regular basis *i.e.* at least once a year (77% of the respondents, Fig. 6) or on demand (19%). A striking result is the small share of trainings held in the framework of a special occasion, such as a colloquium or a workshop. This is probably due to the fact that respondents felt that this type of training was not the subject of the questionnaire. Several replies of this nature were received.

Other categories of trainings (3%) are organised less frequently than each year, if a suitable number of candidates is met or depending also on grants availability.

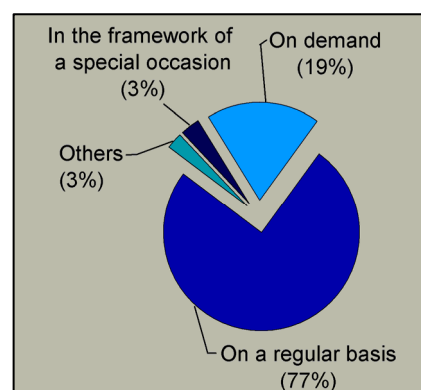


Figure 6. Periodicity at which the trainings are organised.

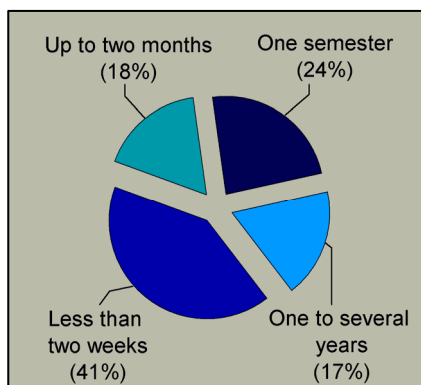


Figure 7. Length of the trainings.

41% of the trainings are short, intensive courses that last for less than two weeks (Fig. 7). Academic courses generally spread out over one semester (24%) to a minimum of one year for masters and other programmes (17%) (see text box n°2). Trainings completed within a period of two months share 18% of the answers. In some cases and if needed, the length of the trainings can be adapted to the level of the participants.

The past few years have seen a small increase in the number of new training courses (Fig. 8). This can be linked to international projects that were set up recently, such as the Global Biodiversity Information Facility (GBIF, 2001), the European Network for Biodiversity Information (ENBI, 2003) and the SYNTHESYS (Synthesis of systematic resources) project (2004).

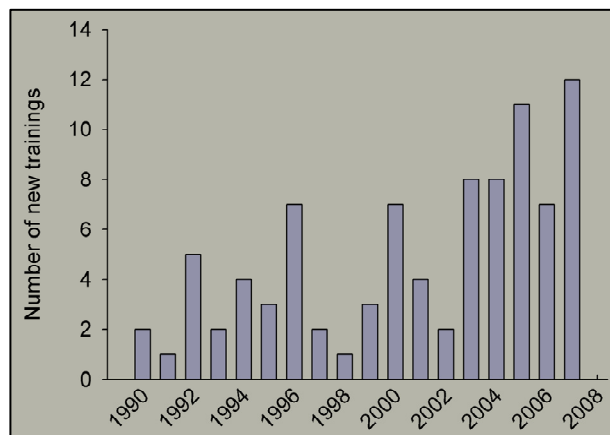


Figure 8. Evolution of the number of new trainings in taxonomy since 1990.

Text box n°1

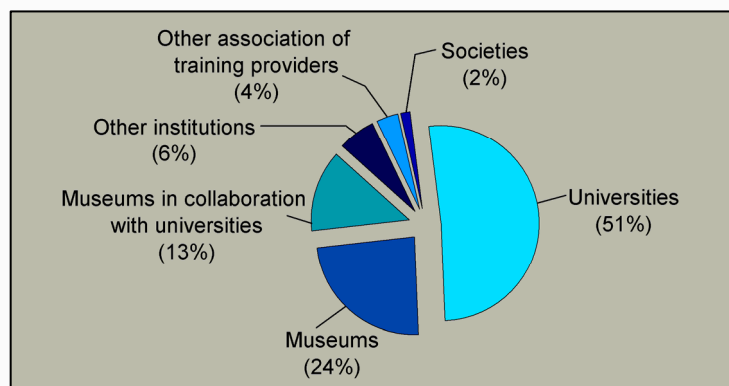
Where is the training capacity in taxonomy found?

The organisers of trainings in taxonomy can be divided into a few categories:

- (1) Universities
- (2) Museums, including herbaria and botanical gardens
- (3) Associations between museums and universities
- (4) Official institutions other than museums and universities
- (5) Associations of institutes different from the consortium universities + museums
- (6) Societies

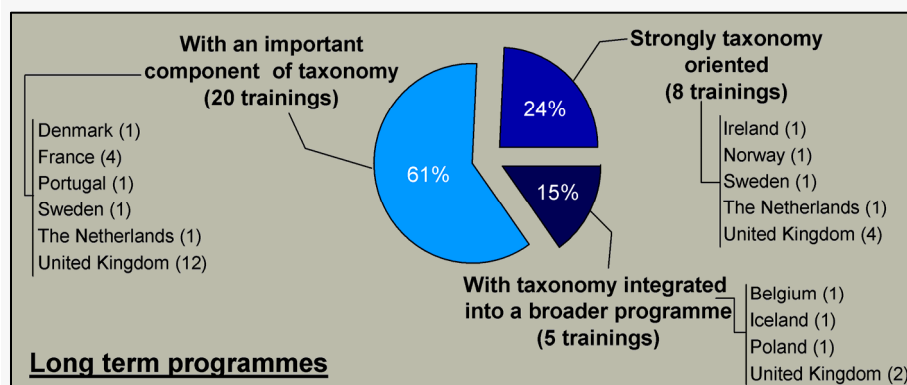
Half of the training courses are held in universities and another 13% take place in collaboration with museums. The museums themselves organise 24% of the trainings. These three types of training providers include 88% of all the trainings. Other associations of training providers almost always comprise a university. The low score obtained for societies (2%) probably does not reflect the actual situation since they are very often active in the training of the general public.

These results suggest that an increasing collaboration between museums and the academic world should be encouraged. Furthermore, in view of the large reservoir of knowledge present in societies and associations and their low representation in this survey, their integration in EDIT should be stimulated.



Text box n°2

Long-term training programmes in taxonomy: what is their profile?



This survey made clear that the training offer comprises both short intensive courses and long-term programmes (*i.e.* courses lasting more than 6 months). All of these long-term trainings are provided by universities and include masters in sciences, research masters, PhDs and international diplomas. Depending on

the importance that taxonomy occupies in the programmes, they intend to train people whose abilities will range from being the future specialists of a taxonomic group to professionals with a sound expertise in taxonomy. From the collected information, the United Kingdom is the country with the largest offer of long-term programmes strongly oriented in the study of taxonomy.

3.2. Content

3.2.1. Teaching approach

The teaching approach is very classic in the sense that lectures (given in 94% of the trainings), exercise sessions (79%) and laboratory work (64%) are dominating the teaching schema (Fig. 9). Almost half of the trainings include field work. Curation practices are dealt with in 29% of the trainings. E-learning is not often used (8%). This latter result is not fully in agreement with the one in figure 15 (Form of training material and notes), which is probably the result of a broad interpretation of what 'E-learning' means. The 'Other' teaching options (2% of the answers) consist of group projects, paper discussions and research dissertations.

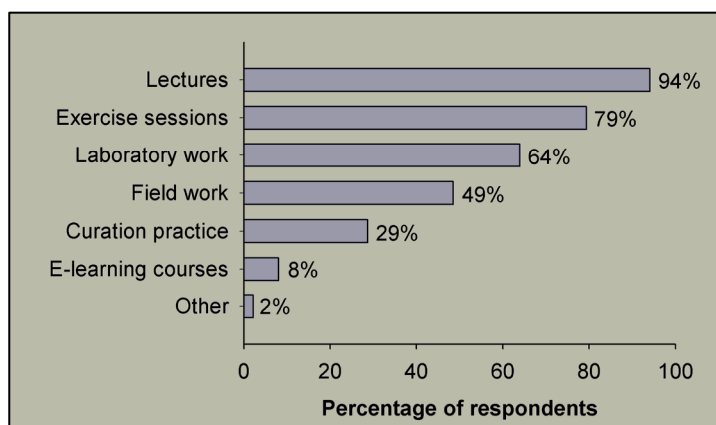


Figure 9. Teaching approach of the trainings.

3.2.2. Integration with other scientific disciplines

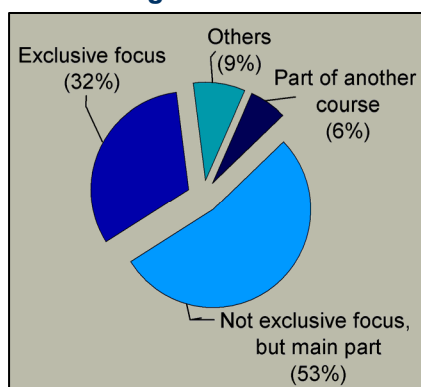


Figure 10. Importance of taxonomy during the trainings compared to other disciplines.

For more than half of the respondents, taxonomy is the most important part of the training but not the exclusive focus (Fig. 10). One third of the trainings only deal with taxonomy without reference to other fields of sciences. 6% of the trainings are indeed part of another course. The remaining trainings (9%) have either a reduced concern about taxonomy or use taxonomy in a broader context.

3.2.3. Global approach

Few courses (3%) focus exclusively on the teaching of molecular techniques to address taxonomy (Fig. 11). Most of the trainings cover either morphological aspects only (46%) or both approaches (48%). A few trainings (3%) are concerned by neither approach because they are focusing on preservation or conservation matters.

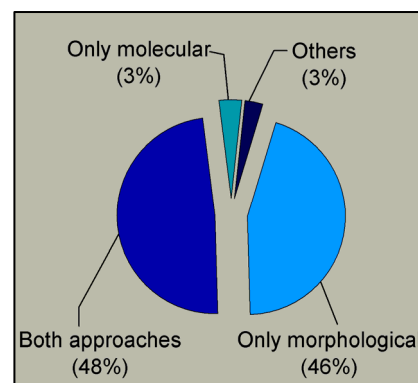


Figure 11. Fundamental approach of the trainings.

3.2.4. Nomenclatural rules

The issue of nomenclatural rules is taken into account in 51% of the trainings while 49% do not mention this topic.

3.2.5. Taxa

Almost half of the trainings do not deal with a particular taxon (Fig. 12,A) while the other trainings have their focus on one or several group(s) of organisms. For those trainings, the distribution among the five kingdom system* is (Fig. 12,B): Monera (5%), Protocista (5%), Fungi (14%), Plantae (28%) and Animalia (47%).

The taxa treated within the Monera kingdom are Archaeobacteria, Bacteria and Cyanobacteria. Concerning Protocista, trainings address Ciliata, Flagellata, Amoeba, Dinophyta, Foraminifera but most of the courses are related to Macrophyta. No specifications at a lower level than the kingdom is found for Fungi. There is a low level of specification for Plantae. They all treat Magnoliophyta (=Angiospermae) except one on Bryophyta. Looking into more details for the most studied kingdom, Animalia, 59% of the trainings are devoted to

Arthropoda (Fig. 12,C). Taxa mentioned for the Chordata (21%) are all fishes. The category 'others' refers to courses on Nematoda, Rotifera and Oligochaeta (21% of the trainings). Finally, the studied taxa within Arthropoda show the prevalence of Hexapoda (63%) on other groups (Fig. 12,D). The absence of significant groups such as Mammalia or Amphibia does probably not reflect reality.

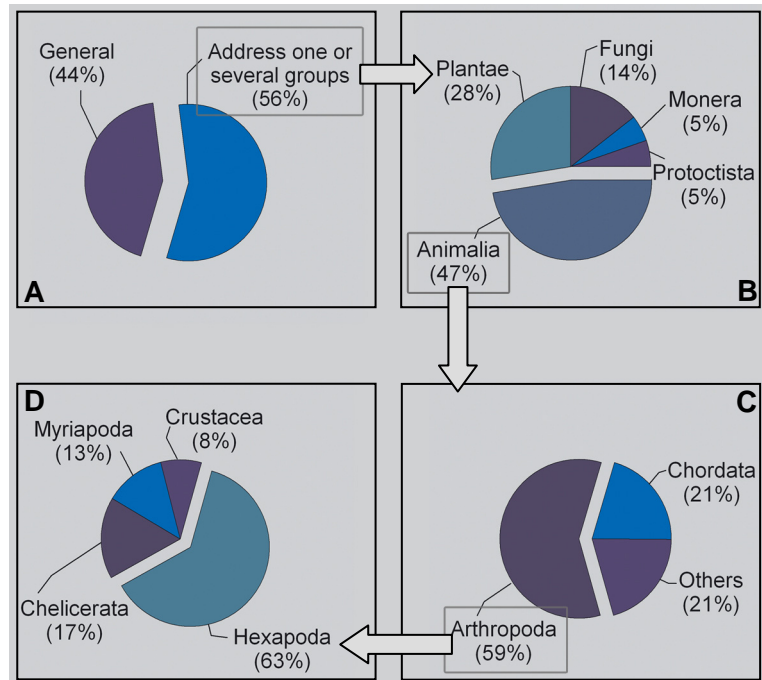


Figure 12. Targeted taxa of the trainings. (A) Specificity of the trainings, (B) Distribution of targeted taxa within the five kingdoms system, (C) Distribution of targeted taxa within kingdom Animalia, (D) Distribution of targeted taxa within phylum Arthropoda.

3.2.6. Geographical cover

The majority of the trainings (63%) does not target a specific geographical region (Fig. 13). When a region is mentioned, this is in majority the Palearctic region (83%). The Afrotropical region is relatively well represented (13%) while the Neotropical (2%) and Indomalayan (2%) regions are seldom mentioned.

3.2.7. Skills developed during the trainings

Trainings often address issues like using taxonomy-related databases (53%), search the web for taxonomic information (52%), conserve and manage collections (49%) or use taxonomy related informatics' software (42%) (Fig. 14). A subject less often covered is the funding possibilities for taxonomy (10%). Respondents state in 45% of the answers other skills that are targeted during the trainings. Very often, the trainings intend to improve skills like the recognition of species in the field or in the laboratory (22% of the trainings) but also how to apply taxonomy to research areas such as evolutionary biology, phylogeny, ecology, conservation, biogeography, biological functions, environmental assessment and palaeontology (13%).

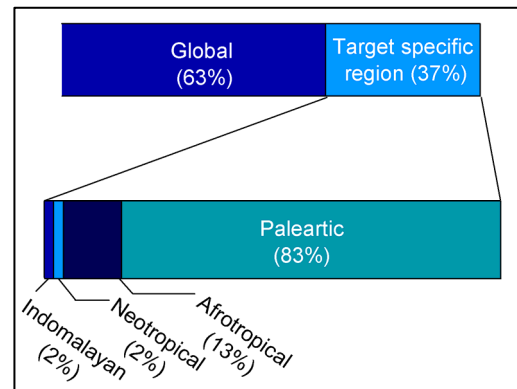


Figure 13. Targeted geographical cover of the trainings.

* Based on Margulis L. & Schwartz K.V. (1998). Five Kingdoms: an illustrated guide to the Phyla of life on earth. 3rd edition. Freeman: New York, NY (USA), 520 pp. ISBN 0-7167-3027-8.

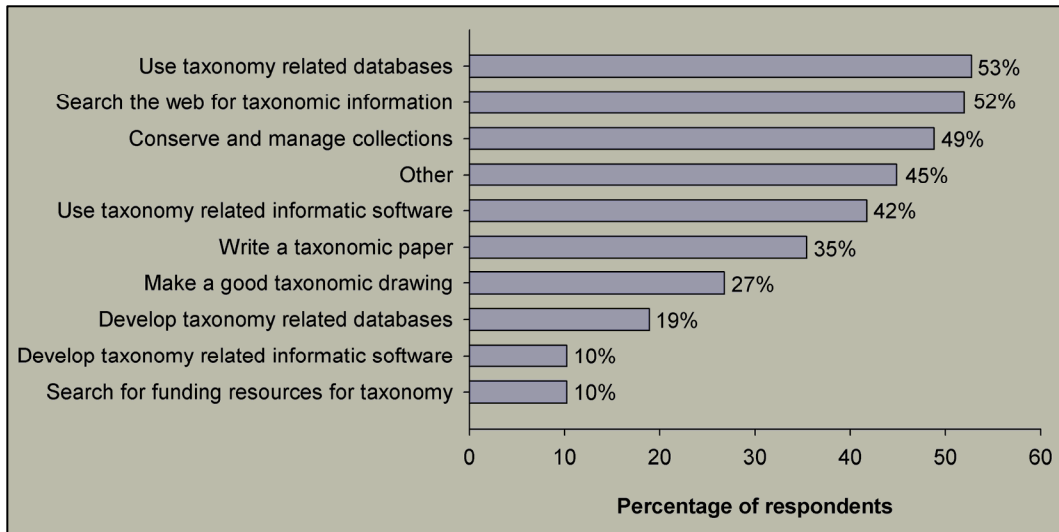


Figure 14. Skills developed during the trainings.

3.3. Training material

3.3.1. Form

A majority of the trainings (91%) use educational material as a support to the lectures. Among these, demonstration material (75%), PowerPoint presentations (73%) and books (56%) are the preferred teaching tools (Fig. 15). Other classic forms of training material (syllabi, web documents, notes, computer workstation, CD-Rom) are each regularly used during trainings (24% to 32% of the respondents). The category 'Other' includes microscopes, usual laboratory and sampling materials, datasets, identification keys and scientific literature. Comprehensive e-learning facilities are still little used (only 4% of the trainings).

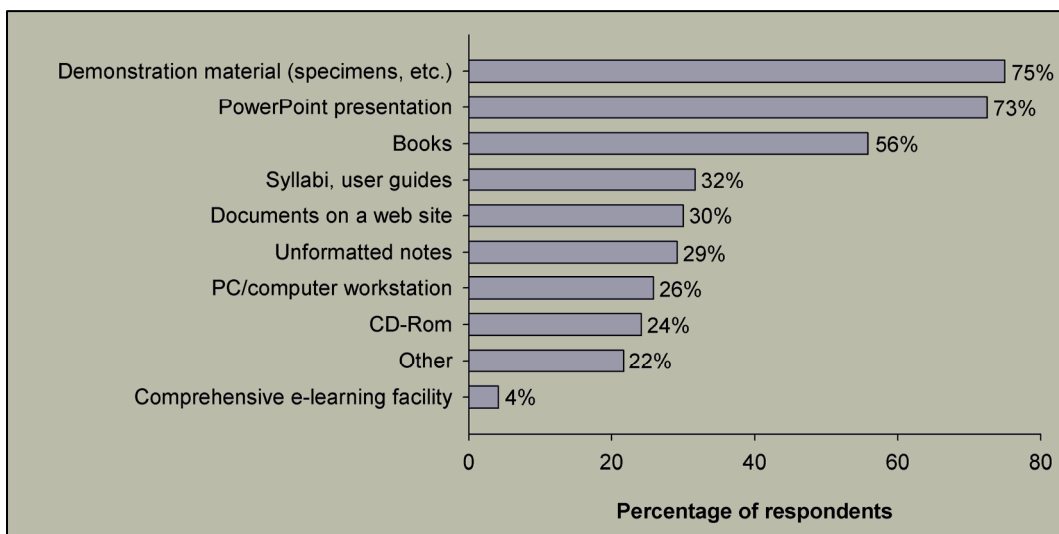


Figure 15. Form of material used during the trainings.

3.3.2. Access

The access to educational material is privileged for those people attending the training (85% of the respondents) (Fig. 16). Only 17% of these 85% declare that the training material could also be obtained by another way (*i.e.* if purchased or requested). The notes are freely available for 21% of the trainings but 76% of these notes are for the trainees only. Training material can be purchased for 14% of the trainings, is available on request for 10% and is in the public domain for 10%. The category 'Other' refers to training material offered partly through

web-sites (available not only to people attending the course but also to those working at the institution where the training is held or to students enrolled at the concerned institution), or available in libraries.

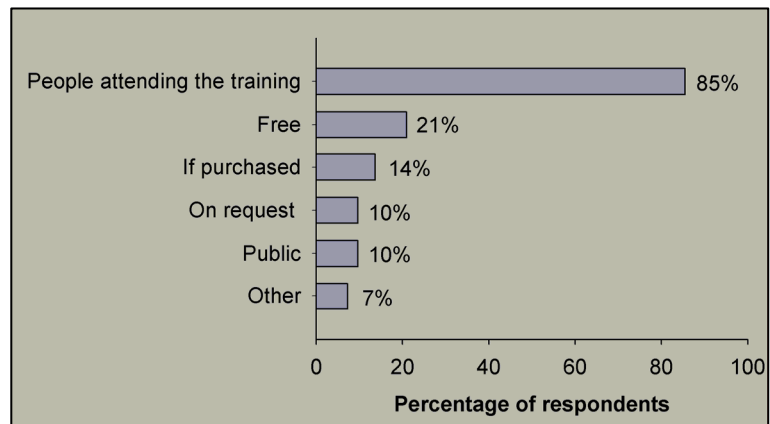


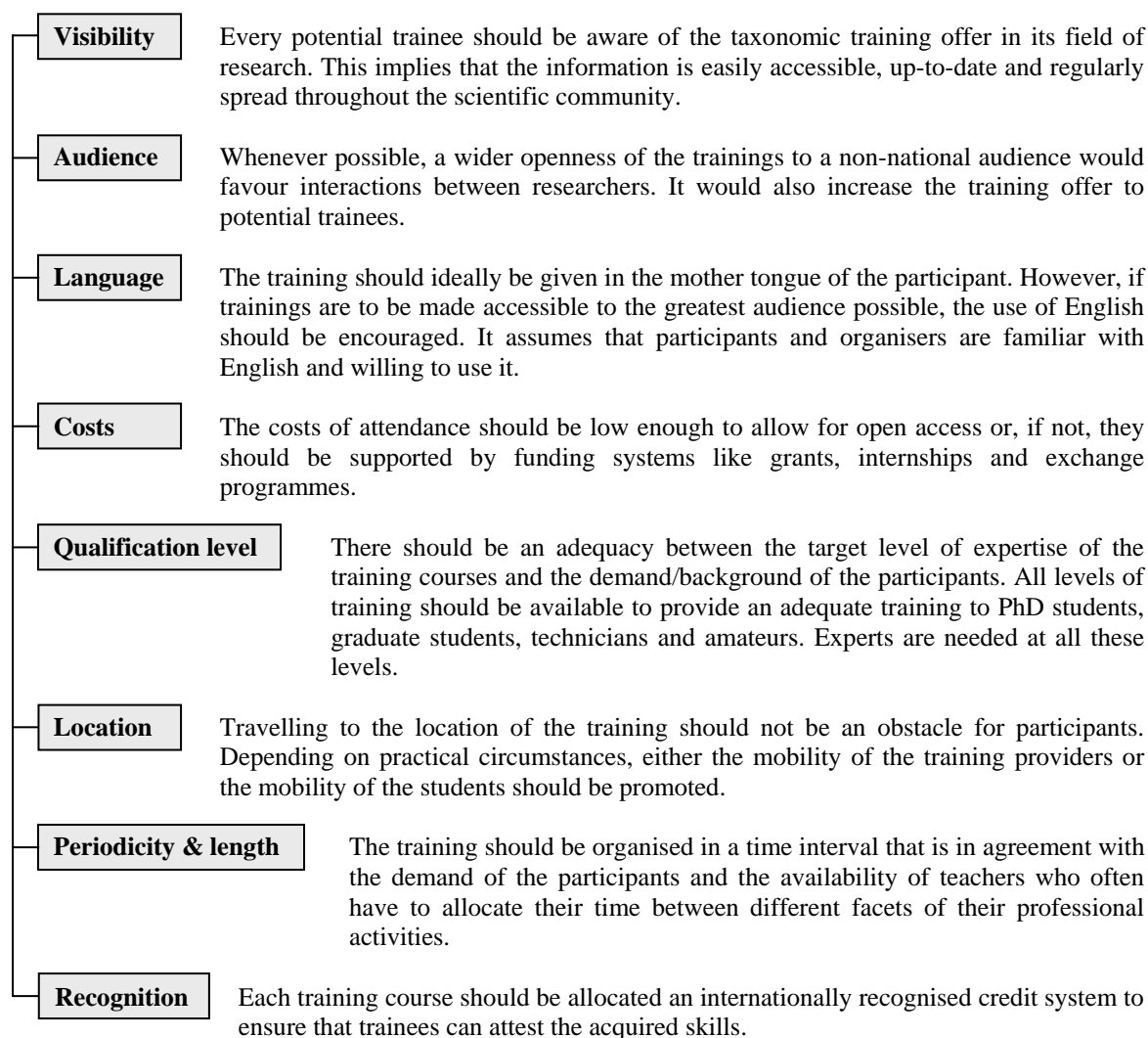
Figure 16. Conditions of access to the training material.

4. TRAINING RESOURCES IN TAXONOMY: WHAT IS NEEDED?

European science is facing a tremendous loss of taxonomic expertise. There is currently a shortage of young researchers being trained to a high level of competence in systematics and with a detailed understanding of the various uses and problems involved. To address this problem, education is an essential tool that still needs to be optimised. Throughout Europe and elsewhere, a diverse training offer in taxonomy does exist. However, it could substantially be improved and optimised, as outlined in the following section.

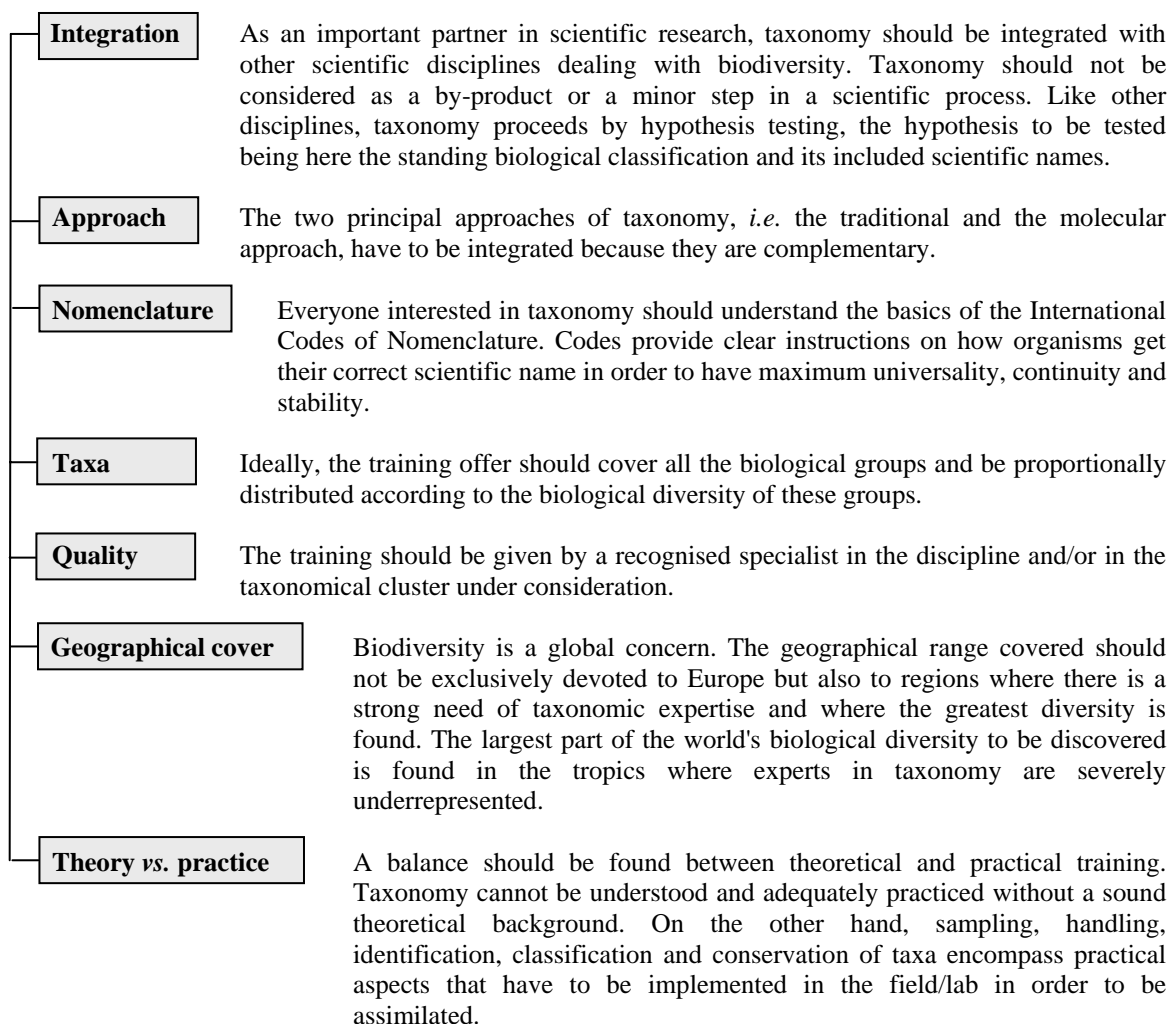
4.1. Accessibility

If the goal is to increase the expertise in taxonomy in a relatively short time-span, the future trainees simply need to have an easier access to the training offer. The following criteria have their importance:



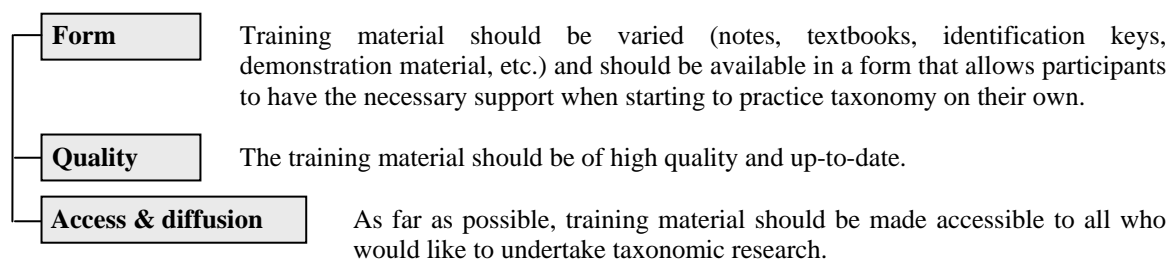
4.2. Content

The training offer should meet the standards relevant to the needs of ‘twenty-first century taxonomy’. This addresses the need to better document the world’s biodiversity, especially poorly known taxa, as well as the integration of appropriate and up-to-date techniques and methods.



4.3. Training material

Training material is an essential component of the courses, not only for teaching but also as reminders during follow-up practice.



5. TRAINING RESOURCES FOR TAXONOMY: WHAT COULD BE IMPROVED?

5.1. Accessibility

5.1.1. Dissemination of the information

This analysis did not specifically address the problem of the dissemination of information on taxonomic trainings. However, our search for trainings clearly pointed out that a tool, process or organism to centralise the information is crucially missing. EDIT proposes to fill in this gap by setting up a web portal that will publicise the existing training offer in taxonomy. This portal will host an online catalogue of training resources, which will be updateable by concerned parties. In the future, training providers could also link their teaching material to this online catalogue.

EDIT will also disseminate on a CD-ROM the listing of training resources in taxonomy available in Europe and elsewhere compiled during the present survey.

5.1.2. Targeted geographical audience and language

Almost half of the respondents state that the targeted geographical audience is national. However, the training topics of these respondents do not appear to be significantly different from the topics of the trainings open to an international audience. This lack of openness to an international audience probably finds its origin in tradition. The necessity of a common language is also most likely interfering. However, openness and its consequence, the use of a common language, have not to be imposed in each situation. Indeed, it is also an important concern that students learn in their mother tongue to acquire the necessary level of expression needed for their future career.

Nonetheless, an important barrier to the promotion of trainings outside the organising country is the language in which it is held. In this respect, it is encouraging that some training adapts the teaching language to the audience. This usage should be promoted. Some respondents also state that the course would or could be held in English in the future, which should increase the number of potential participants.

Consequently, spreading the use of a common language (English in most cases) where trainings can really attract an international public is recommended.

5.1.3. Financial aspects of attendance

Since a large fraction of the trainings are organised by universities, inscription fees for enrolment must be paid to attend the courses. Where it still does not exist, a system of payment by course should be promoted instead of the full payment for an entire academic programme.

For those trainings requiring funds, EDIT has a key role to play in order to direct the future trainees to potential sources of funding. The search for funding possibilities in taxonomy is rarely dealt with during taxonomic training although the demand is high and this aspect could also be more developed during the training.

5.1.4. Level of training

Most of the trainings in taxonomy from this survey apply to people that have or are studying to have an academic degree. Programmes for technicians, parataxonomists and amateurs are underrepresented and/or do not specifically address their demands. Technical staff in museums and institutions should have, as academics and scientists, the opportunity to attend taxonomic and collection management courses. Often the courses require an academic diploma as selection criteria. Without these training possibilities, there could be a non-optimal functioning of these institutions and a risk that curators and scientists are overwhelmed by too many tasks. EDIT should promote the training for the technical staff. Trainings provided by societies and associations, which sometimes have a large number of amateur taxonomists among their members, are not well represented in this survey. EDIT should seek more collaboration with these societies since in some groups a lot of new species and new records are discovered by amateurs. It should be noted that a significant number of amateurs work at a very high level of expertise.

5.1.5. Location

Currently, the mobility of students rather than the mobility of teachers seems to be the rule. Depending on the practical circumstances, the mobility of the training providers could be promoted since it may be more time and cost effective. In some cases, it should also be envisaged that both students and teachers should meet in a more appropriate place (*e.g.* close to adequate laboratory facilities, close to the taxa or habitat under concern, etc...).

5.1.6. Periodicity and length

Most of the trainings are organised at least yearly or on demand, a situation that does not need to be improved. However, half of the trainings on taxonomy do not concentrate over a short period of time (less than 2 weeks). Most of these are provided by universities and are spread over one or two semesters. It can hamper the participation of students who search for an intensive training in taxonomy. Although this is not a problem exclusively related to trainings in taxonomy, this situation could be improved by concentrating the programmes whenever possible. What certainly should be promoted is the development of intensive and condensed trainings that could attract more participants by demanding less time and funding resources.

5.1.7. Recognition

Many trainings do not have a systematic and standardised way to describe their educational programme and consequently suffer from a lack of recognition. The spreading of the European Credit Transfer and Accumulation System (ECTS) should be promoted among all trainings. It is a student-centred system based on the student workload required to achieve the objectives of a programme, objectives preferably specified in terms of the learning outcomes and competences to be acquired. The Credit system facilitates student mobility and international curriculum development.

5.2. Content

5.2.1. Teaching approach

Trainings in taxonomy are mostly into the hands of the academic world where both theoretical and practical aspects of taxonomy seem to be tackled during the courses. Laboratory work and field work are provided in 64% and 49% of the trainings, respectively. Classic teaching methods like lectures and exercise sessions are still the most frequently used methods. They are cheaper and easier to set up than true comprehensive e-learning facilities. However, e-learning courses might have a great future to teach students in taxonomy while avoiding the costs of travel and subsistence. Their use, as a complementary form of teaching (they will never replace true practical exercises) could be enhanced.

5.2.2. New developments

In contradiction to the concern that molecular techniques would supplant traditional methods in the field of taxonomy, there prove to be very few courses (3% of the answers) that focus specifically on molecular techniques. Efforts could be made to integrate the molecular approach into the traditional taxonomy based on morphology since half of the courses do not at all take into account the molecular approach. EDIT can certainly assist to put in touch morphological and molecular training programmes that share a pertinent content. Good phylogenomic analysis cannot be done without the help of taxonomists and evolutionary scientists: biologists cannot neglect the revolution that DNA sequencing has introduced.

5.2.3. Nomenclatural rules

Half of the trainings do not cover the subject matter of nomenclatural rules, among them trainings with an exclusive focus on taxonomy. Since the knowledge of nomenclature is crucial to the practice of taxonomy, the teaching of the nomenclatural rules should be strongly promoted. Neglect of the conventional rules and ignorance of the underlying basic principles are the major reasons for the unsettled nomenclature in many groups. For this reason, it is important that EDIT promotes the teaching of nomenclatural rules during training programmes. Specific courses such as the one held by the Spanish High Council for Scientific Research (CSIC) at the Museo Nacional de Ciencias Naturales on zoological nomenclature could be developed. This course is already expected to be held in London (in English), hosted by the International Commission on Zoological Nomenclature (ICZN). It is recommended to contact nomenclature governing commissions for all kingdoms on this matter.

5.2.4. Taxa

Our analysis showed that the current training offer is not proportional to the actual diversity of life. The targeted taxa are mainly arthropods, fishes and flowering plants. Consequently, it is expected that a significant part of the biodiversity will no longer be inventoried and monitored because in the future no experts will be available. An effort should be done to give more attention to the less studied groups having a recognised ecological importance and to support the existing trainings on these marginalised groups. These taxa can be selected in agreement with the assessments realised within the EDIT-Workpackage 7 (Applying Taxonomy to Conservation).

5.2.5. Geographical cover

The geographical cover of the targeted taxa is largely devoted to the Palearctic region but gaps in taxonomic knowledge still exist in this region and expertise on some groups could be improved. Furthermore, the major part of the biodiversity that still needs to be discovered is located in the tropical regions. North-South, South-North, and South-South exchange programmes to train taxonomists have to be developed. Some institutions from countries with former colonies are active in overseas countries and can be major players to promote these exchanges. Part of EDIT's training and financial opportunities should be reserved specifically for students from countries in the South.

5.2.6. Skills developed during the trainings

Skills linked to the use of informatics in taxonomy are largely developed during the trainings, but the input of modern bioinformatics can certainly be improved in a number of courses. It is also clear that the future developments in taxonomy, including revisions of groups, will probably occur with the internet playing a key role by allowing an efficient way to work and link people. EDIT will have to be at the cutting edge of these advances and promote the future working environment of taxonomy. This can be achieved in collaboration with Workpackage 5 - Internet Platform for Cybertaxonomy and Workpackage 6 - Unifying Revisionary Taxonomy.

Curation practices must continue to be an important component of the trainings to provide reference material.

Other skills like finding funding resources for taxonomy should be encouraged. Concerning this last point, EDIT can certainly play an important role by giving more visibility to the funding opportunities dedicated to taxonomic studies.

5.3. Training material

5.3.1. Form

A majority of respondents is using demonstration material together with PowerPoint presentations, syllabi and books. These are still the most cost effective teaching aids. There is a great promise in using e-learning facilities, in conjunction with practical sessions. E-learning in its more advanced form offers the possibility to learn at distance while keeping interactions with the teacher. The development of comprehensive e-learning facilities is difficult to set up because they require high qualifications and are expensive. However, EDIT could make the promotion of the use of web-based facilities for taxonomic training.

Furthermore, there is a lack of books dealing in a comprehensive way with both practical (collecting, handling, preservation, referencing and description) and more theoretical (taxonomy, systematics, ecology and distribution of the taxa) aspects of specific taxonomic groups. Those kinds of books would be a precious help to new taxonomists as well as for biodiversity assessments. They will never be replaced by unformatted notes. EDIT could ensure the promotion of those examples that currently exist (*e.g. Synopses of the British Fauna*, published by the Linnean Society of London; *Abc Taxa*, a new series of manuals for taxonomic capacity building).

5.3.2. Access

A large majority of the training material used during trainings is only available to the participants of the training and is not easily distributed by other means. Their accessibility and exchange can be improved by EDIT. An enhanced accessibility will allow more people, interested in the covered topic to get the information. In addition, more exchange of training material through collaboration between training

providers will decrease the loss of time involved to produce material already existing and will eventually increase content quality by sharing experiences.

6. ADDITIONAL RESULTS OBTAINED FROM OUTSIDE EUROPE

The networks used to find information on trainings in taxonomy reached not only people from Europe but also training providers from all around the world. As a result, we received 45 complete sets of information on training courses from outside Europe. Facts are presented in table 1. The complete listing of trainings with their details can be found on the EDIT's website and upon request on the CD-ROM of the component 8.1.1.

Table 1. Number of training courses in taxonomy from outside Europe.

Africa (1)*	Colombia (1)	Malaysia (1)	South Africa (2)
Argentina (3)	Costa Rica (2)	Mauritius (1)	Taiwan (1)
Australia (1)	Equatorial Guinea (1)	Mexico (1)	USA (15)
Bangladesh (1)	India (4)	Morocco (1)	Venezuela (1)
Brazil (1)	Indonesia (1)	Philippines (2)	
Canada (1)	Kenya (2)	Russia (1)	

* This training took place in different countries in Africa.

The number of collected answers is largely insufficient to perform a thorough analysis. However, for all the previous points discussed on European trainings, the trends reflected in the answers by non-European countries go exactly in the same direction.

No distinct differences between the answers of European training providers and those of non-European respondents were noticed. The accessibility to the trainings shares the same characteristics of targeted geographical audience, language, financial aspects of attendance, target levels of expertise, length and periodicity. The contents of the trainings browse the same subjects and use the same approaches and teaching methods as for Europe with evidently an adaptation to locally occurring organisms if the trainings are tax-oriented. The access and form of teaching material are identical. One particularity resides in the source of training providers (Fig. 17) which is slightly different from what is observed in Europe. Museums (including herbaria and botanic gardens) and associations between museums and universities are less frequent while private laboratories (included in 'Other institutions') are more represented. This pattern is mostly due to the important weight of the answers collected from the USA.

It is encouraging to note that even if not directly concerned by the EDIT School of Taxonomy, 90% of the respondents outside Europe state that collaboration with other training providers giving similar courses would be very relevant. It is a promising clue that the global concern of biodiversity and taxonomy will undoubtedly find constructive cooperation if communication, raising awareness and information sharing are developed.

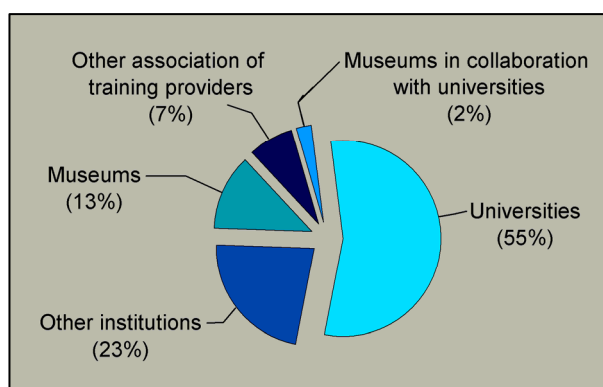


Figure 17. Training providers from outside Europe.

7. CONCLUSIONS AND RECOMMENDATIONS

Strengths

In Europe, training offer in taxonomy definitely exist and it is relatively well established. The current trend even shows a growing number of new courses organised in the past few years, thanks to recent initiatives like the Global Biodiversity Information Facility (GBIF, 2001), the European Network for Biodiversity Information (ENBI, 2003) and the Synthesis of Systematic Resources Project (SYNTHESYS, 2004).

Courses are mainly organised on a regular basis or on request so that the offer is likely to meet the demand, at least for the covered topics. Short, intensive and hence easily accessible trainings (because of time and money resources) are not the rule but still represent 40% of all the courses surveyed.

Taxonomy has no political or national borders and this statement is clearly understood by training providers who are open-minded about opening their courses to an international audience. The language barrier is especially taken into consideration in Scandinavian countries, where the use of English increases the number of potential participants.

The training offer covers a wide diversity of subjects: most of the trainings do not focus exclusively on taxonomy, but also include related disciplines such as biodiversity assessment and conservation. This tendency is positive since taxonomy needs to evolve into an integrated science to fulfil the needs of biodiversity research, including the ecosystem approach.

Weaknesses

It is extremely difficult to find information on available training courses and possibilities. Courses are generally advertised on a local scale by institutions or by universities, yet there is no centralised information system providing a general overview or compilation of available training courses in Europe. Networks such as BioNet International do exist and disseminate information but mainly on short, intensive courses for an international audience. Consequently, the training offer in taxonomy clearly suffers from a lack of visibility and publicity.

Since many courses are organised by universities and can be spread over several terms, potential students can be deterred by the time and cost investments needed for these trainings. Categories of potential trainees such as foreign students, young scientists wishing to re-orient their career or ecologists desiring to acquire knowledge in taxonomy, are susceptible to be attracted by short trainings. However, enrolment fees in universities are often prohibitive for these categories of training seekers.

Natural history museums hold a great expertise in taxonomy. They already offer a considerable number of courses, often in cooperation with universities. In some countries, for example in Germany, almost no more courses on taxonomy are taught in universities. Most of the remaining teaching capacity lies into the hands of the museums. However, this is only the case in the more active institutions and many contacted museums mentioned that they were not organising any trainings. Consequently, the training capacity of the museums is certainly not exploited at its maximum potential and may be increased, ideally in cooperation with universities.

Unfortunately, a large proportion of the trainings does not cover the study of nomenclatural rules. Nevertheless, scientific names provide us with a language to communicate on organisms. Like all languages, it is subject to specific rules – in this case nomenclatural rules. The uniqueness and stability of scientific names are an essential prerequisite to make taxonomy and its products reliable for users all over the world. A good background in nomenclatural practice is essential for the taxonomist.

The targeted taxonomic groups in the trainings mainly involve arthropods, vertebrates and flowering plants, which is a biased view of worldwide biodiversity. The appealing taxa are most comprehensively recorded and studied. Organisms that are less popular or more difficult to identify are often neglected. Yet, the need to produce accurate assessment of biodiversity has never been more pressing and encompasses these less

studied groups. Least-known groups can have a great potential for mankind, a.o. for understanding new diseases and agricultural pests.

Most of the course materials are only available to people attending particular trainings. Only few attempts have been produced to make course materials accessible to a wider public. Moreover, comprehensive e-learning taxonomic facilities that involve more than placing course notes on the internet, are virtually absent, though they would provide a very efficient and cheap alternative to teach taxonomy to a broad audience.

Most training courses are intended for people holding a university degree or for those on the way to obtain it. There is an evident lack of trainings for technicians and other non-academics working in taxonomy. Technical staff in museums and institutions does not have always the opportunity to attend taxonomic and collection management courses. Often the courses require an academic diploma as a selection criterion. The lack of training opportunities for technical staff hampers adequate curation of collections, which in turn might cause non cost effective burden for researchers.

A subject that is hardly covered by trainings is the search for funding opportunities in taxonomy. People do not seem to be aware of the possibilities that are offered to finance their taxonomic studies. Moreover, a lack of time and staff to do the management and administration may form an impediment to the submission of proposals. There probably exists a link between this result and the fact that every curator in museums can cite the loss of students interested in taxonomy, but could not get sufficient fellowship support or failed to find a paid job.

Many trainings do not have a systematic and standardised way to describe their educational programme (European Credit Transfer and Accumulation System) and consequently suffer from a lack of recognition. Moreover, comparison between programmes becomes difficult for students seeking the most appropriate training.

Opportunities

The School of Taxonomy, which is just starting to emerge, is an essential component of EDIT's centre of excellence. The purpose of the school is to federate the training offer in taxonomy around a common vision, for the benefit of all those who are interested in high level and up-to-date taxonomic education. Quality education and knowledge sharing are fundamental prerequisites in the development of future generations of taxonomists in Europe and beyond.

This School will train modern taxonomists who will not only have the knowledge and skills acquired by the traditional taxonomy but also taxonomists who can integrate these skills with those derived from the new and emerging approaches. Besides the identification and description of taxa, this new generation of taxonomists will also have to carry out, *e.g.* population genetic analyses, community pattern analyses or data integration and management.

The general objectives of the School of Taxonomy are the transfer of knowledge between current and future generations of taxonomists. The training curriculum will target both modern disciplines such as molecular systematics and biodiversity informatics, and the more traditional approaches such as morphology, descriptive taxonomy and collection management. The School needs to re-integrate taxonomy into the future challenge that science is facing regarding ecology, biodiversity research, ecosystem conservation, forestry, fisheries, agriculture, biosecurity, bioprospecting or even epidemiology. This framework is a prerequisite to the revalorisation of taxonomy and to the creation of durable and attractive job opportunities for young taxonomists.

The philosophy of the School is loosely inspired from the UK-based 'Open University'. It will be open to trainees with varied levels of qualifications, provide flexible and modular training and investigate ways to provide distance learning opportunities (*e.g.* e-learning). Education via ad-hoc modules and courses will be complemented by a system of hands-on training within research projects. The training programme will be open to European and non-European scholars.

In conjunction with these overall objectives, the EDIT School of Taxonomy will address the following issues:

- Defining teaching priorities related to future research, new tools and technologies in taxonomy. This assessment will be carried out in collaboration with Workpackage 4 (Coordinating Research) and Workpackage 7 (Applying Taxonomy to Conservation).
- Promoting collaboration with societies and associations, representing a pool of human resources with sometimes a high level of expertise.
- Stimulating the organisation of more short and intensive courses.
- Reinforcing the study of nomenclatural rules in the training programmes.
- Improving the accessibility and exchange of training material, in particular the development of online collaboration between training providers (in collaboration with Workpackage 5 - Internet Platform for Cybertaxonomy).
- Sharing the unique expertise and access to resources derived from the study of fauna and flora in the former colonial territories by supporting capacity building in countries in the South.

Threats

This study indicated a gap between what is taught during the trainings and what is done in research. Half of the trainings do not take into account the molecular approach while most of the newly financed research programmes promote the molecular approach, either in conjunction to more traditional work or not. There is an increasing threat that the traditional taxonomy becomes obsolete with the rise of new technologies if taxonomists do not integrate molecular techniques in their research and teaching*.

Consequently, there is a risk that those trainings only dealing with the traditional approach fall in disuse and will disappear in favour of trainings which are more or entirely molecular oriented. Future taxonomy needs to evolve and encompasses both traditional and molecular techniques. Achievements in this direction exist in North America with the Partnership for Enhanced Expertise in Taxonomy (PEET) that links traditional and molecular works on particular groups of organisms, leading to joint publications.

K. Elaine Hoagland, Executive Director of the Association of Systematics Collections, highlighted an important threat to the future of taxonomic expertise and training while responding to the 'taxonomic impediment', the term coined to point to the lack of taxonomic expertise preventing other biodiversity research from going forward[‡]:

"Growing out of a tradition of reciprocity and collegiality, taxonomists frequently do not charge clients directly for their specialized services and products, such as identifications and biodiversity databases, even though the users of these services and products now extend far beyond their fellow taxonomists. These service activities are often ancillary to a taxonomist's basic monographic work, for which he or she receive grant funds, or subsidizes on his own or through his employers. The cost of doing taxonomy is not factored into most biodiversity or ecology projects. [...] The result is a classic market failure in which the cost of taxonomy is externalized. Employers are unwilling to hire persons who do not bring in financial resources. Students shy away from the field of systematics in favor of fields that offer more fellowships, grants, and jobs. Courses in taxonomy are therefore under-subscribed, giving universities further incentive to cut faculty positions."

To solve this problem, the costs of taxonomy will need to be internalised when planning research projects.

Another evident threat is the lack of replacement of retiring taxonomic experts. Many of these experts are also involved in trainings in taxonomy. Without their active participation, the quality of the trainings could rapidly decrease. The succession of retiring qualified taxonomists is, however, hampered by reorientation of work and by cuts in staff. Consequently, training opportunities may decrease together with long-term professional prospects for young taxonomists.

* see the review on celebrating the 300th anniversary of the birth of Linnaeus, *Nature* (2007), vol. 446: 247-263.

‡ Hoagland, K.E. (1996). The taxonomic impediment and the Convention of Biodiversity. *Association of Systematics Collections Newsletter*, 24(5), 61-62, 66-67.

Although the numbers and impacts of international actions to promote taxonomy are increasing, similar initiatives tend to develop less well at national levels. The tendency is to believe that since biodiversity (and consequently its utmost important scientific component, taxonomy) is a global concern, national initiatives are less important and less necessary. However, international initiatives base themselves on the already existing expertise at a national level. This situation will not evolve until national politics realise the importance of taxonomists and take concrete measures to assure them long-term positions.

The advent of the electronic age together with the growing importance of databases and networking has changed the way information is passed on and accessed. Electronic material and the internet have proven to be very useful tools for scientists. Taxonomists are already extensively using databases and will probably use in the near future more and more the internet for electronic publications.

However, databases can only incorporate, classify and diffuse the information which already exists. Electronic material is only a tool and an aid for taxonomists. It cannot replace the fundamental work of collecting, handling, naming, describing and classifying taxa. There is a threat that the increased funding of database-related projects will absorb the funds needed for feeding them with valuable and new information, *i.e.* taxonomy-oriented programmes. The same reasoning holds true for taxonomic trainings that should not exclusively become courses on database accessing and handling.