

<i>Travaux du Muséum National d'Histoire Naturelle</i> «Grigore Antipa»	Vol. L	pp. 517–526	© Octobre 2007
--	--------	-------------	-------------------

ROMANIAN TAXONOMY IN CRISIS – PRESENT STATUS AND FUTURE DEVELOPMENT

DAN COGĂLNICEANU, DOREL RUȘTI, DAN MANOLELI

Abstract. In this paper we evaluate the current status of animal taxonomy in Romania. The present-day situation can be summarized by several questions: (1) Do we really require taxonomy? (2) How can we benefit from the existing network of natural history museums, research institutes and universities with focus on taxonomy? (3) How can taxonomy increase its attractiveness and utility in the present day socio-economic and scientific environment? (4) How can we solve the present chronic under funding of taxonomy studies? From analyzing the situation in Romania it appears as urgent the need to launch a National Taxonomy Program. Besides responding to a political commitment made after signing the Convention on Biological Diversity, it would have a positive medium and long-term impact on strengthening institutional capacity and the development of scientific research at national and regional level.

Résumé. Ce travail se propose d'évaluer la situation actuelle de la taxonomie animale, avec un accent spécial sur la situation en Roumanie. La situation actuelle de la taxonomie en Roumanie peut être résumée en posant quelques questions: (1) avons-nous réellement besoin de la taxonomie? (2) comment peut-on valoriser le réseau existant de musées de sciences naturelles, d'instituts de recherches et d'universités? (3) comment pourrait-on augmenter l'attractivité et la compétitivité de la taxonomie dans l'actuel contexte socio-économique et scientifique? (4) comment peut-on résoudre l'actuel sous-financement chronique de la taxonomie? En analysant la situation de Roumanie, il en résulte l'urgence de lancer un Programme National de Taxonomie qui, en plus de la réalisation d'une obligation politique assumée dans le cadre de la Convention pour la Diversité Biologique de Rio de Janeiro, devrait avoir également un impact positif à long terme sur le développement et l'augmentation de la capacité institutionnelle et des recherches scientifiques sur le plan national et régional.

Key words: taxonomy crisis, taxonomy in Romania, National Program in Taxonomy.

INTRODUCTION

Taxonomy defined as the science of the categorization of living things and includes the identification and naming of types of plants, animals and micro-organisms of the world (CBD SBSTTA 9, 2003), is of fundamental importance for all biological sciences and biotechnology. Taxonomy is the original version of what we call today bioinformatics and, despite the revolution in information technology which has achieved satellite imaging, genome mapping and so on, taxonomic information has practically remained unchanged for the last 250 years, since Linné introduced the binary system of classification of living organisms (Linnaeus, 1758).

Since its beginning, taxonomy was vital for biology since it adheres to a strict set of nomenclature rules, which are presently codified by the international commissions on biological nomenclature (International Commission on Zoological Nomenclature, 1999). Although taxonomic rules do not have an official status in any country worldwide, they are universally valid and are invaluable for allowing the international traffic of taxonomic information in all major fields and applications which operate with biological material, transgressing language and scientific barriers. In contemporary language, the Linnean inheritance which is still the

backbone of all biological sciences, can be described as a distributed database without central administrator.

Presently taxonomy is in decline and the almost total absence of new taxonomists has reached alarming levels (Disney, 1998; Jaspars, 1998).

Although taxonomy is fundamental for the entire biological sciences, presently it is mostly confined to natural history museums, so its integration with the rest of the scientific community is inadequate.

It soon became obvious that there was a taxonomic impediment to the sound management, sustainable use, and conservation of biodiversity. The importance of taxonomy was acknowledged by the Convention on Biological Diversity (CBD) which addressed at Conference of Parties 2 (COP 2) the issue of the lack of taxonomists needed for the national implementation of the Convention (Secretariat of the Convention on Biological Diversity, 2001). Later, after COP 4 the Global Taxonomy Initiative (GTI) was launched, which amongst others, invited Governments to submit reviews or studies on specific taxonomic needs within each country, as well as any information on national taxonomic needs assessments that may have been undertaken. In the end all countries should develop a National Program in Taxonomy.

Romania has to decide on a national strategy on these issues. To ignore the increasing requirements for taxonomists, continue with the present state of underfunding and enhance the future dependence on costly foreign expertise or even complete lack of expertise of certain taxa, or develop a National Program in Taxonomy which will require relatively modest investments on medium term but will provide important benefits on long-term.

Based on these facts, in the present paper we attempt to evaluate of the status of animal taxonomy worldwide and then focus on the particular situation in Romania, in an attempt to offer arguments and a vision to revigorate taxonomy. Several aspects related to the present taxonomy crisis must be analyzed before any recommendation can be made: (1) do we really need taxonomy, (2) what should be done with the existing network of natural history museums, research institutes with a focus on taxonomy, and universities which prepare taxonomists? How can taxonomy become competitive and attractive and how can these specialists be better integrated into nowadays society and, (3) how can the present chronic lack of funds for taxonomy be solved.

THE GLOBAL SITUATION OF ANIMAL TAXONOMY

We will briefly present and comment on the most frequently used arguments against and in favour of taxonomy, and, whenever possible, give arguments or present options to provide a win-win solution.

Arguments against animal taxonomy

1. Widespread misidentification, synonymy and the use of invalid names.

The proportion of misidentification in museum collections can sometimes reach unacceptable levels. For example, Meier and Dikow (2004), during a revision of the robber-fly genus *Euscelidia* (Diptera, Asilidae), found that between 62-73% of the material borrowed was misidentified. Rose (2000) reported for rove beetle (Staphylinidae) a percentage of misidentification of 17%. Synonymy is another

widespread problem. For example, Dubois and Ohler (1994) showed that for the frogs of the subgenus *Rana (Pelophylax)* the number of invalid names was equal to the number of valid ones.

2. The legacy of the more than 250 years of past studies is a heavy burden for taxonomists (complex synonymy, scattered type material, difficult to access primary literature etc).

Many taxonomists spend most of their career trying to interpret the work of nineteenth-century taxonomists, or searching the world's museums for type material that is often in very poor condition or missing altogether (Godfray, 2002). The amount of synonymy also poses a heavy burden on researchers.

3. Opposition towards killing animals.

Is specimen collecting a real threat to the survival of threatened species? Proponents assert that specimen collecting adds to the current biological crisis and suggest that collectors pose a serious threat to many species (Stuebing, 1998). While keeping this within limits, survival of populations will hardly be affected by periodic culling of a small proportion for collections. Also, alternative collections can be developed like: ingluvia, exuvia, tissues, fur, feathers, stomach content, eggs, nests, slides, photos, audio and video recordings, frozen tissues, alcohol-preserved tissues for DNA etc. Dead, sick, or road-killed animals can also be collected and stored as an alternative to direct collecting. For example, the Herpetological Division of the Field Museum of Natural History, Chicago maintains also specialized collections: histological slides, stomach contents, frozen tissues, tape recordings, colour slides, black and white photos, and X-ray negatives (Resetar and Voris, 1997). Botanical collections do not face this problem and their perception by the public is more favourable than zoological collections.

4. New collections are unnecessary since existing ones are sufficient for any present or future studies.

Taxonomy is a European 'invention', therefore Europe still concentrates most taxonomic resources and the best taxonomists. Most type-specimens are concentrated in European museums. Thus, for butterflies and moths (Insecta, Lepidoptera), over 80% of all type-specimens are in European museums, 60% being in the Natural History Museum in London (The Lepidoptera Taxome Project <http://www.ucl.ac.uk/taxome/>).

There is still a huge number of species waiting to be described and museum collections are needed as repositories. Unfortunately, faunal collections are not evenly distributed, at all spatial scales: global (we have species-rich but collection-poor tropics), regional (biased towards some areas while others are not covered), and even local (only certain taxa are studied or collected). The bias is also size oriented, with the many small taxa being chronically undersampled. Major collections are not located in the mega-diversity countries; they are concentrated in USA, United Kingdom, Australia, the Netherlands or France. These collections provide an enormous scientific advantage in the biological field held by western countries (Stuebing, 1998).

Substantial numbers of species are represented by only one or few individuals in collections, sometimes in poor condition and unsuitable for any further studies (Stuebing, 1998).

5. Presently taxonomy offers poor value for money and is not appreciated in the scientific community.

For example, the average impact factor (AIF) of 253 top zoology journals is 0.56 (Popescu, 2000). When compared with biochemistry journals which have an AIF of 2.59 (n=299), environmental sciences journals with an AIF of 0.91 (n=178), or even botany journals which have an AIF of 0.79 (n=219), the low-impact in science of zoology becomes obvious.

There are several interesting directions of research trying to develop either rapid biodiversity assessment estimators of species richness, including the use of parataxonomists (Oliver & Beattie, 1993). Despite their utility and importance, these methodologies are not a surrogate for taxonomy but a mere complementary tool. While these methods can prove extremely useful, especially in providing rapidly much needed information for decision-makers, the loss of ecological information can sometimes become unacceptable (Maurer, 2000). Overall, we are facing a situation when taxonomists themselves have become 'endangered species' (Boero, 1996), with less than 10,000 taxonomists left worldwide (Gewin, 2002), and they have to cope with between three and more than 100 million species (Groombridge, 1992; Savage, 1995). The lack of specialists in taxonomy is even used as an argument for usefulness of the so-called taxonomic sufficiency approach, i.e. identifying taxa to the highest category possible (genus, family, order etc.) without losing statistically significant vigour in assessing pollution impacts in monitoring programs (Maurer, 2000).

Arguments in favor of animal taxonomy

1. Studying species leads to new insights or discoveries, while collections provide reference information and make innumerable contributions to science and society.

This represents a major biological and intellectual resource, recognized as such by the Convention on Biological Diversity. Biological collections play a critical role in public health and safety as cornerstones in studies of environmental health and epidemiology. They are even central to national security in providing tools for the prevention and detection of invasive species and dangerous pathogens. Museum collections contribute unique and invaluable insights to the study of pathogens, vectors of disease, and environmental contaminants. Collections are often used to track the history of infectious diseases and identify their sources or reservoirs. Museums also provide an essential baseline that can be used to detect and monitor the accumulation of contaminants in the environment (Suarez & Tsutsui, 2004). Museum collections have even been used to measure evolution in invasive species (Berenbaum & Zangler, 1998). Museum collections have even been used for estimating species richness and developing conservation strategies (e.g. Heyer et al., 1999), adding new values to old ones.

Taxonomy represents the basis for bio-prospecting and biotechnology, providing invaluable expertise for the pharmaceutical and cosmetics industries and for biotechnology (Jaspars, 1998). Also agriculture depends for pest control and monitoring on taxonomical expertise.

Monitoring human impact on biodiversity and even the effects of global changes on biota also requires taxonomic expertise (Parmesan et al., 1999; Thomas et al., 2001).

Finally, maintaining and developing the infrastructure of museums will most likely produce unforeseen benefits, adding optional values (Suarez & Tsutsui, 2004).

Since museum-based taxonomy is under-funded, most European museums and universities with tradition in taxonomy have re-oriented towards other fields, recognized as priorities and with higher funding opportunities. USA has recognized the scientific and commercial importance of taxonomy and finances it through major programs focused for taxonomy and systematics (National Science Foundation 2002 <http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf02074>).

2. Collecting samples of individuals even from highly endangered populations is possible.

Individuals cannot be conserved forever since they will eventually die. Only populations can be conserved. Culling/collecting samples of individuals of endangered species can be done if focusing on old, diseased, or already dead animals.

3. Reducing the 'taxonomic impediment' for the global evaluation of biodiversity.

The large majority of the countries have signed and ratified the CBD (there are 190 parties of which 168 have signed the convention), which stipulates, among others, the need for national inventories and monitoring (article 7), provide access to and transfer of technology and know-how (articles 16), facilitate the exchange of information, including repatriation of information (article 17), and technical and scientific cooperation between countries (article 18).

4. Improving the usefulness of genomic databases.

Genomic databases have experienced an exponential growth. Thus GenBank (<http://www.ncbi.nlm.nih.gov/Genbank/>) has increased from 19 million entries in October 2002 to more than 70 million in February 2007. Genomic databases sometimes suffer from inaccurate identification of the organisms which provided the genetic information. In the absence of a correct identification of the individual and/or species studied, the genetic information stored can become potentially useless in the future.

5. The urgent need for taxonomic databases

The existing taxonomic knowledge is scattered among countless books and journals, most of them old and difficult to access because of restricted circulation. Users of taxonomy have great difficulties accessing the information referring to the about 1.5-1.7 million species described until now (Gaston & May, 1992).

We need taxonomic expertise more than ever, but solving the practical issues requires a new approach in the management of the huge taxonomic information accumulated, just like Linné did 250 years ago. The scarcity of taxonomic information and its scarcity has repeatedly raised the need for additional financial resources (Gaston & May, 1992; Godfray, 2002). There is increased support for the creation of a global database with all the existing taxonomic information available on the web (Godfray, 2002).

There are several initiatives for building taxonomic databases at global scale, but unfortunately none is yet fully functional (see annex). While some taxa are well covered in databases (e.g. amphibians, bumble bees, fossil and contemporary echinoid) others are not.

The users of these databases will not only be taxonomists, but also biodiversity experts, conservationists and the general public (see for example

http://www.insects_online.de/, <http://www.nrm.se/ve/pisces/acara/welcome.shtml>,
<http://viceroy.eeb.uconn.edu/Orthoptera>).

What should be done to solve the present-day crisis? We suggest that first of all taxonomy and systematics should become more conservation-oriented. The major barrier in attracting financial resources is the apparent lack of direct, practical results. The involvement of taxonomists in more 'practical' issues like monitoring will help change the present perception of taxonomy as an optional discipline, a mere hobby of species collecting, similar to stamp or coin collection. This in turn should find a broader audience and impact which in return will provide more financial resources. Political and public support for institutions that are striving towards solutions for conservation problems can help shift more resources toward saving nature (Miller et al., 2002).

TAXONOMY IN ROMANIA

The present-day situation of taxonomy in Romania is complex. There is a mixture of strengths and weaknesses that will be briefly presented below.

Strengths

1. Traditionally, taxonomy was well developed and there is still a strong nucleus of taxonomists, despite the fact that their number is dwindling.
2. Many universities throughout the country offer master programs in taxonomy, despite the inadequate job market.
3. There is a strong network of natural history museums and research institutes throughout the country.
4. There is a huge amount of published data and information in taxonomy concerning Romania (Fig. 1).

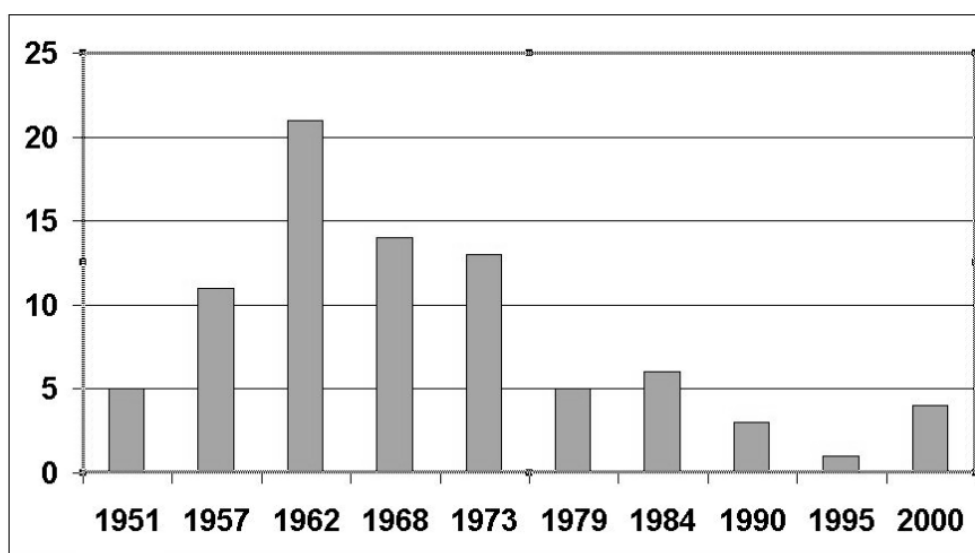


Fig. 1 – Chronology of publication in the series *Fauna of Romania*.

5. Several important research programs are underway with international cooperation (e.g. Fauna Europaea, Biodiversity Inventory Monitoring System, IBIS etc.)

It might be worth mentioning that if the present state of underfunding will be maintained almost all these advantages would be lost.

Weaknesses

1. Most specialists are either old, or have competences only at national level. Few can provide expertise at regional or global level.
2. Most museum collections are small, insufficient for revisions or impact studies.
3. The libraries do not provide the needed taxonomic information.
4. The existing collections are poorly maintained and difficult to access. There is almost no exchange of specimens due to lack of funds.
5. There are no taxonomic databases available yet.

Who needs actually taxonomy in Romania? Who are the potential end-users? Basically everybody is involved in a way or another with species and requires information at certain moments. The list is long and definitely incomplete and includes:

- a. Members of the parliament and other law-makers that decide priorities in conservation and resource management
- b. Diplomats and civil-servants
- c. Customs employees that must monitor for invasive species and prevent international trade with endangered species.
- d. Decision makers and planners that require impact studies for the projects that can affect biodiversity
- e. Epidemiologists studying disease and vector distribution
- f. Researchers in agriculture and forestry for the integrated pest management
- g. Biologists and ecologists working in the field or conducting monitoring or inventories
- h. Ecotourists and environmental educators which require proper information and field guides

In view of the above-mentioned situation we urge decision-makers to implement a National Program in Taxonomy which should cover the following steps:

1. Education: increase the proportion of taxonomy in the curricula and also develop distance learning modules.
2. Develop and strengthen the existing natural history museums, research institutes and universities through adequate financing
3. Promote networking at national and international level.
4. Establish taxonomy as one of the priorities for research at national level.
5. Develop databases, eventually privately owned, that will store the existing data and information and can provide it to end-users. For private institutions or persons information could be provided for a fee (e.g. for environmental impact assessment studies) and thus contribute to financing further taxonomic studies.

Overall, developing a National Program in Taxonomy will have multiple benefits. Another requirement of the CBD is the development of a National Program of Integrated Monitoring. Without a good taxonomic support this program cannot be developed. The EU is also keen on identifying biodiversity indicators (European Environment Agency, 2003), but accurate taxonomic analysis is required for the use of indicator species to be effective (Grant et al., 1995). Not only will Romania fulfill its duties under the CBD but will also comply with the EU Water Framework Directive (article 8) which also requires good taxonomic knowledge for the monitoring of aquatic systems.

We believe that the initial costs for developing the National Program in Taxonomy will soon be recovered from the direct and indirect benefits. Despite its present drawback at institutional and individual level, Romania has still a high potential in taxonomy and could not only cover its legal requirements and needs, but also provide regional expertise. The long-term costs of under-funding in taxonomy will certainly be huge. The only option left for achieving the tasks related to monitoring, species inventory and conservation if taxonomy is not developed will require in the future hiring institutions and experts from abroad, thus losing the ability to manage our own natural resources properly.

Romania has still the institutional and human resources needed to maintain a strong profile in taxonomy. Elaborating and implementing a National Strategy for Biodiversity Inventory and Taxonomy will confirm the importance of taxonomy, and avoid losing the scientific capacity, thus becoming a mere 'satellite' of the developed countries which have the human and institutional capacity to address these issues.

TAXONOMIA DIN ROMÂNIA ÎN CRIZĂ - SITUAȚIA ACTUALĂ ȘI PERSPECTIVE VIITOARE

REZUMAT

Lucrarea își propune o evaluare a situației actuale a taxonomiei animale, cu accent special pe situația din România. Situația actuală a taxonomiei în România poate fi rezumată în câteva întrebări: (1) avem cu adevărat nevoie de taxonomie? (2) cum poate fi valorificată rețeaua existentă de muzee de științele naturii, institute de cercetare și universități? (3) cum ar putea fi sporită atractivitatea și competitivitatea taxonomiei în actualul context socio-economic și științific? (4) cum se poate rezolva actuala subfinanțare cronică a taxonomiei? Analizând situația din România, rezultă urgența lansării unui Program Național de Taxonomie care, pe lângă îndeplinirea unei obligații politice asumate în cadrul Convenției pentru Diversitate Biologică de la Rio de Janeiro, ar avea și un impact pozitiv pe termen lung asupra dezvoltării și întăririi capacității instituționale și a cercetării științifice pe plan național și regional.

LITERATURE CITED

- BEREMBAUM, M. R., A. R. ZANGERL, 1998 – Chemical phenotype matching between a plant and its insect herbivore. *Proceedings of the National Academy of Sciences of the United States of America*, 95: 13743-13748.
- BOERO, F., 1996 - Episodic events: their relevance to ecology and evolution. *Marine Ecology*, 17: 237-250.
- DISNEY, R. H. L., 1998 - Rescue plan needed for taxonomy. *Nature*, 394: 120.
- DUBOIS, A., A. OHLER, 1994 - Frogs of the genus *Pelophylax* (Amphibia, Anura, genus *Rana*): A catalogue of available and valid scientific names, with comments on name-bearing types, complete synonymies, proposed common names, and maps showing all type localities. *Zoologica Poloniae*, 39: 139-204.

- GASTON, K. J., R. M. MAY, 1992 - Taxonomy of taxonomists. *Nature*, 356: 281-282.
- GEWIN, V., 2002 - All living things, online. *Nature*, 418: 362-363.
- GODFRAY, H. C. J., 2002 - Challenges for taxonomy. *Nature*, 417: 17-19.
- GRANT, J., A. HATCHER, D. B. SCOTT, P. POCKLINGTON, C. T. SCHAFER, G. V. WINTERS, 1995 - A multidisciplinary approach to evaluating impacts of shellfish aquaculture on benthic communities. *Estuaries*, 18: 124-144.
- GROOMBRIDGE, B. (Ed.), 1992 - Global Biodiversity. Status of the Earth's Living Resources. Chapman & Hall, London.
- HEYER, R. W., J. CODDINGTON, J. W. KRESS, P. ACEVEDE, D. COLE, T. L. ERWIN, B. J. MEGGERS, M. G. POGUE, R. W. THORINGTON, R. P. VARI, M. J. WEITZMAN, S. H. WEITZMAN, 1999 - Amazonian biotic data and conservation decisions. *Ciencia e Cultura Journal of the Brazilian Association for the Advancement of Science*, 51: 372-385.
- JASPARS, M., 1998 - Tough time for taxonomy. *Nature*, 394: 413.
- LINNAEUS, C., 1758 - *Systema naturæ per regna tria naturæ, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*, L. Salvii, Holmiae. Pp: [1-4], 1-824.
- MAURER, D., 2000 - The dark side of taxonomic sufficiency (TS). *Marine Pollution Bulletin*, 40: 98-101.
- MEIER, R., T. DIKOW, 2004 - Significance of specimen databases from taxonomic revisions for estimating and mapping the global species diversity of invertebrates and repatriating reliable specimen data. *Conservation Biology*, 18: 478-488.
- MILLER, B., W. CONWAY, R. P. READING, C. WEMMER, D. WILDT, D. KLEIMAN, S. MONFORT, A. RABINOWITZ, B. ARMSTRONG, M. HUTCHINGS, 2002 - Evaluating the conservation mission of zoos, aquariums, botanical gardens, and natural history museums. *Conservation Biology*, 18: 86-93.
- OLIVER, I., B. J. ANDREW, 1993 - A possible method for the rapid assessment of biodiversity. *Conservation Biology*, 7: 562-568.
- PARMESAN, C., N. RYRHOLM, C. STEFANESCU, J. K. HILL, CH. D. THOMAS, H. DESCIMON, B. HUNTLEY, L. KAILA, J. KULLBERG, T. TAMMARU, W. J. TENNENT, J. A. THOMAS, M. WARREN, 1999 - Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature*, 399: 579-583.
- POPESCU, I. I., 2000 - Journal ranking and average impact factors of basic and allied sciences. *Seria Factori de Impact*. Edit. Horia Hulubei. Bucureşti – Măgurele. [9] pp.
- RESETAR, A., H. K. VORIS, 1997 - Herpetology at the Field Museum of Natural History, Chicago: the first one hundred years. *Collection Building in Ichthyology and Herpetology*, Ch. 29: 495-506.
- ROSE, A., 2000 - The rove beetles of the collection F. and R. Struve from Borkum Island in the North Sea. *Entomologische Blätter für Biologie und Systematik der Käfer*, 96: 127-156.
- SAVAGE, J. M., 1995 - Systematics and the biodiversity crisis. *BioScience*, 45: 673-679.
- STUEBING, R. B., 1998 - Faunal collecting in Southeast Asia: fundamental need or blood sport? *The Raffles Bulletin of Zoology*, 46: 1-10.
- SUAREZ, A. V., N. D. TSUTSUI, 2004 - The value of museum collections for research and society. *BioScience*, 54: 66-80.
- THOMAS, C. D., E. J. BODSWORTH, R. J. WILSON, A. D. SIMMONS, Z. G. DAVIES, M. MUSCHE, L. CONRADT, 2001 - Ecological and evolutionary processes at expanding range margins. *Nature*, 411: 577-581.

*
* *

- CONVENTION ON BIOLOGICAL DIVERSITY, SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL AND TECHNOLOGICAL ADVICE, 2003 - Draft Guide to the Global Taxonomy Initiative. Ninth meeting, Montreal. 93 pp.
- EUROPEAN ENVIRONMENT AGENCY, 2003 - An inventory of biodiversity indicators in Europe, 2002. Technical Report no. 92. Luxembourg. 42 pp.
- INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE, 1999 - International Code of Zoological Nomenclature. The International Trust for Zoological Nomenclature, c/o The Natural History Museum, London.

SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, 2001- Handbook of the Convention on Biological Diversity. Earthscan Publications Ltd., London and Sterling, VA.

Received: May 2, 2007
Accepted: May 17, 2007

Dan Cogălniceanu
Universitatea Ovidius Constanța,
Facultatea de Științele Naturii
Bvd. Mamaia nr. 124, 900527 - Constanța, România
e-mail: dan_cogalniceanu@yahoo.com

Dorel Ruști
Muzeul Național de Istorie Naturală „Grigore Antipa”,
Șos. Kiseleff nr. 1, 011341 București 2, România
e-mail: dmr@antipa.ro

Dan Manoleli
Universitatea București, Facultatea de Biologie
Str. Schitu Măgureanu nr. 1, etaj 4,
Sector 5, 050025 – București, România
e-mail: dan.manoleli@gmail.com

ANNEX

<http://www.cetaf.org/>

<http://www.biocase.org/>

http://www.insects_online.de/

<http://www.faunaeur.org/enbi/info.html>

Species 2000 - <http://www.sp2000.org/>

<http://viadocs.essex.ac.uk/html/>

All Species Initiative - http://www.all_species.org/

Global Biodiversity Information Facility - <http://www.gbif.org/>, <http://www.ento.csiro.au/globis/>

<http://www.sis.agr.gc.ca/pls/itisca/taxaget>

<http://tolweb.org/tree/phylogeny.html>

<http://research.amnh.org/herpetology/amphibia/index.php>

<http://www.nhm.ac.uk/entomology/bombus/index.htm>,

<http://www.nhm.ac.uk/palaeontology/echinoids/index.htm>

http://www.insects_online.de/

<http://www.nrm.se/ve/pisces/acara/welcome.shtml>

<http://viceroy.eeb.uconn.edu/Orthoptera>