

REGIONAL BIODIVERSITY DATABASE (REBIDA) - THE FIRST COMPREHENSIVE DATABASE OF BIOLOGICAL DIVERSITY OF BOSNIA AND HERZEGOVINA

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Abstract

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Received

August, 2017

Accepted

October, 2017

Published

December, 2017

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Genetics & Applications,
The Official Publication
of the Institute for
Genetic Engineering and
Biotechnology,
University of Sarajevo

Letter

The expert reports state that Bosnia and Herzegovina, despite the presence of diverse and valuable natural resources, lacks systematic, coordinated and harmonized pipeline for biomonitoring. Successful solutions to serious problems regarding environmental protection, management and research rely on the efficient use of exhaustive and unfailing information on the nature around us. However, more often than not, transitional and developing countries lack any centralized, nationally funded databases that could be used as dependable source of information in decision making process. University of Sarajevo-Institute for Genetic Engineering and Biotechnology (INGEB) developed the Regional Biodiversity Database – REBIDA with the aim to collate all known biological data on wild and domesticated natural resources of Bosnia and Herzegovina. This internet-based database represents a comprehensive, searchable and open access platform for science community, academia, governmental and non-governmental stakeholders and general public. Besides its scientific value, REBIDA will serve as an educational tool for discovering the diversity and importance of natural resources, with special emphasis on indigenous and endemic flora, fungia and fauna from the Balkans. It is the only such database in the country, consisting of three functionally connected segments: tissue database, DNA database and digital genetic database on plant, animal and human samples. To complement REBIDA, a mobile application called REBIDA SCANNER was also developed. It will be free to download for IOS and Android platforms and will enable professionals, nature enthusiasts and any other interested parties to contribute to REBIDA through data collection, field sampling and documentation of B&H wild life.

Key words: *biodiversity, database, REBIDA, REBIDA scanner, DNA barcoding*

Introduction

United Nations *Convention on biological diversity* defines biodiversity as “the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part” which includes diversity within species, between species and of ecosystems (UNEP, 1992). Therefore, modern conservation biology aims to protect natural biodiversity at the level of genes, species and ecosystems. Biodiversity databases are crucial

components of these activities because they store information about biodiversity and make them digitally available (Turnhout & Boonman-Berson, 2011). Bosnia and Herzegovina is geographically positioned in the part of Europe that served as a refugium for flora, fungia and fauna during the last ice age. This resulted in rather high level of species diversity that determines a very rich ecological diversity of the country. On a relatively small territory that Bosnia and Herzegovina occupies (about 52,000 km²), there are 252 ecosystems registered that construct 11 biomes (Redžić, 2007;

2011; Redžić et al., 2008; 2011). According to the *Report on the state of the environment in Bosnia and Herzegovina* from 2012 (Ministry of Foreign Trade and Economic Relations of B&H (MFTER), 2012), the only national document that addresses the number of different groups of taxa, natural resources of our country comprise of 1119 species of cyanobacteria and algae, 3882 species of vascular plants, 20 species of amphibians, 38 species of reptiles, 119 fish species, 326 species of birds and 85 species of mammals. Some taxa are largely underexplored (MFTER, 2012; Federal Ministry of Environment and Tourism, (FMOIT) 2008; 2014), invertebrates and fungi in particular. Over 10,000 species of invertebrates have been described although it is estimated that B&H fauna might contain five times as many. Similarly, only around 600 species of fungi are known out of 15,000 to 20,000 estimated species. At the level of global biodiversity, Bosnia and Herzegovina holds special significance due to the numerous endemic and relict species that inhabit the country, especially in the karstic region. It is estimated that 15% of Bosnia and Herzegovina's flora and fauna has endemic character (Redžić, 2012).

Despite the presence of diverse and valuable natural resources, Bosnia and Herzegovina lacks systematic, coordinated and harmonized pipeline for biomonitoring (MFTER, 2012). As stated in the mentioned report on the state of the environment in Bosnia and Herzegovina, some information about the environment are partially or completely missing such as data on biodiversity, climate change, soil resources etc. Successful solutions to serious problems regarding environmental protection, management and research rely on the efficient use of comprehensive and unfailing information on the nature that surrounds us (Laurila-Pant et al., 2015). Therefore, the availability of this information, as one of the most valuable assets, is becoming ever more important in our society.

European and Global Biodiversity Databases

A number of countries in Europe that successfully implement conservation and revitalization projects have different types of databases on natural resources, often established and maintained at the

national level. The scope and the content of these databases vary, from those focusing on a specific group of organisms to those covering the complete inventory of animals, plants and fungi in the country.

The Spanish Freshwater Fish Database (SIBIC, 2014) is the example of former, integrating all information about biology and ecology of the Spanish freshwater fish, with associated bibliographic references. It is available online and opened to general public. The Wyoming Natural Diversity Database – WYNDD (University of Wyoming, 1998) is an interesting example of the latter type of databases. It collects and tracks information about Wyoming's native plants, animals and ecosystems, especially the rare and endangered ones. It is also coupled with the WyoBio (WyoBio, 2014), the project that brings together scientists and citizens in order to discover, collect and investigate the wild life of Wyoming.

Some European countries have started implementing novel genetic technologies and methods, such as high throughput sequencing and DNA barcoding, in attempt to capture the genetic diversity of their resources and make referent inventories. Often maintained as national initiatives, constituted of various institutions in the respective countries, these projects resulted in reference sequence libraries available to the public in form of databases (e.g. gBOL – Germany, NorBOL – Norway, FINBOL – Finland, BDV – France, NBOL – Netherlands, SwissBOL – Switzerland) (Table 1). These databases do not only contribute to the knowledge about biological species at national level, but also have global impact through their connection to the worldwide projects such as the International Barcode of Life (iBOL) and Barcode of Life (BOLD).

The massive global infrastructure expansion that has been occurring in the last decades can damage the environment beyond repair if based on unreliable data. Many of these construction projects are implemented in developing countries that hold most of the planet's biodiversity, emphasizing the need for available, relevant data and decision-making tools (Laurance et al., 2015). However, more often than not, transitional and developing countries lack

Table 1. Some of the national and international databases on biodiversity with accompanying internet addresses

Database name	Country	Web page
The Spanish Freshwater Fish Database (SIBIC)	Spain/Portugal	http://www.sibic.org/
Freshwater Diversity Identification for Europe (FREDIE)	Germany	http://www.fredie.eu/
German Barcode of Life (gBOL)	Germany	https://www.bolgermany.de
Norwegian Barcode of Life (NorBOL)	Norway	http://www.norbol.org/en/
Finnish Barcode of Life (FINBOL)	Finland	http://www.finbol.org/
Bibliothèque du vivant	France	http://bdv.ups-tlse.fr/
Netherlands Barcode of Life (NBOL)	Netherlands	http://dnabarcoding.nl/
Swiss Barcode of Life (SwissBOL)	Switzerland	http://www.swissbol.ch/
Barcode of Life (BOLD)	Global	http://www.boldsystems.org/
The International Barcode of Life Project (iBOL)	Global	http://ibol.org/

any centralized, nationally funded databases that could be used as reliable source of information in decision making process. In such cases, databases established in academic and scientific institutions could serve as valuable starting points.

Regional Biodiversity Database - REBIDA

Over the past fifteen years, the Laboratory for Molecular Genetics of Natural Resources (LMG) of the Institute for Genetic Engineering and Biotechnology Sarajevo (INGEB) has paid great attention to the research of the BH indigenous and endemic plant and animal species, as well as human population of Bosnia and Herzegovina.

**Figure 1.** REBIDA web interface

During this period, independently or in cooperation with partner institutions, LMG conducted more than 30 scientific and research projects financed by national and international grants. Through the

implementation of these projects, over 1500 tissue samples were collected, as well as DNA samples. The amount of population-genetic and environmental data obtained from the laboratory and field analyses exceeds the number of sampled individuals several times, since each collected sample is analyzed for a number of molecular markers. However, the data obtained through these projects have been dispersed and stored only on the Institute's servers, consequently not available for public use, to policy makers or to the researchers outside of INGEB. Therefore, in 2015, with the support of the Federal Ministry of Education and Science, INGEB developed the Regional Biodiversity Database (REBIDA). It is a long-term project that aims to collect all known biological and geographical data on wild and domesticated natural resources of Bosnia and Herzegovina and make them available not only for scientific community but to the general public as well. Created with cross platform PHP:MySQL solutions, REBIDA is web-oriented, open-access and searchable database, hosted at <http://www.rebida.ba/> (Figure 1).

The Structure and Content of REBIDA

REBIDA consists of three segments that are functionally connected: tissue database, DNA database and digital database with genetic data of

plant, animal and human samples. Each specimen in the database is represented with the tissue sample, stored in the tissue database following the Good Laboratory Practice for preserving the respective type of tissue (leaf, seed, fin, muscle, etc.). In cases where the entire organism (plant, animal or fungi specimen) is available, vouchers are deposited in the National Museum of Bosnia and Herzegovina, and sequences retrieved from them stored in the BOLD database. All isolated DNA are stored in the DNA databank freezers at -80°C , prolonging the shelf-life of the samples and keeping them suitable for genetic analyses. This allows for a sample to be additionally analyzed with new markers or utilizing new methodology thus updating the available data on the given species. Digital segment of REBIDA database is the most elaborate of the three. It is available through internet platform with three levels of access: 1) administrator, with the permission to change data and database parameters; 2) advanced user, with the possibility to submit new data (for scientists and researchers; and 3) publicly available – which allows a review of existing data.

Each entry is aimed to contain the following information:

- 1) Species taxonomy;
- 2) GPS coordinates of the sampling points;
- 3) Species distribution;
- 4) Digital images of the sample;
- 5) DNA barcoding data;
- 6) All other available genetic information associated with a sample;
- 7) Conservation status of the species;
- 8) Bibliography (Figure 2).

Only through correlation of genetic information with habitat information, ecology and taxonomical relationships of the species, the value of molecular biological information can be fully realized (Shanmughavel, 2007).

All genetic data contained in REBIDA are formatted in a way to be fully compatible with BOLD database. Furthermore, REBIDA contains the links from international databases for data submitted by INGEB, in order to facilitate information access to its users. Initially, the database is available only in Bosnian language, but the English version will be developed as well in order to extend the impact. The

database is now at the testing phase, with the plans to have it fully operational in the spring of 2018.

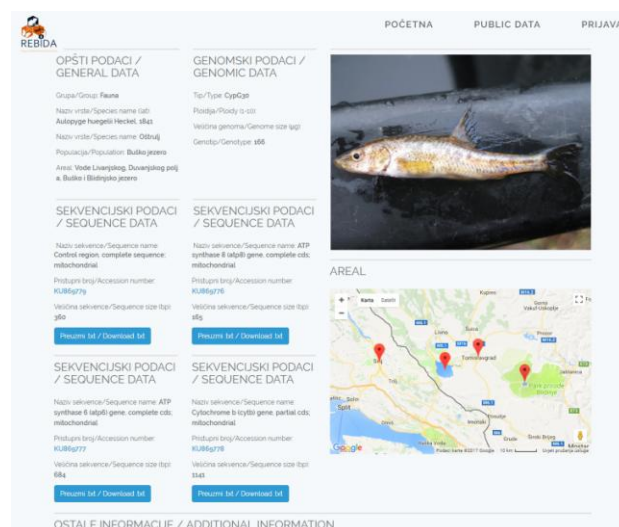


Figure 2. Entry for *Aulopyge huegelii*, Dalmatian Barbelgudgeon, in REBIDA

REBIDA Scanner

To complement REBIDA, a mobile application called REBIDA SCANNER was also developed by BioInfo research group (INGEB and the Faculty of Electric Engineering, University of Sarajevo; <http://bioinfo.ba/>) that will be free to download for IOS and Android platforms. The idea behind this app is to introduce a new concept – citizen scientist. Professionals, students, nature enthusiasts or hikers will be able to contribute to REBIDA through field sampling, data collection and documentation of B&H wild life. The application will be connected to the REBIDA database, allowing uploads of images taken with the app. On demand, the app users will also be provided with the REBIDA scanner kits containing tubes, labels, fixatives and sampling bags. The collected samples will be sent back to INGEB for analysis and all gathered data would be publicly available through REBIDA. This concept provides mutual benefits for scientists and non-professionals: on one hand, it helps to reveal the diversity of living organisms to the local communities and enables them to contribute to its exploration and protection. On the other hand, collecting samples through REBIDA scanner in cooperation with citizens helps scientists investigate larger part of Bosnia and Herzegovina then they

would be able on their own, with limited financial and human resources.

Benefits of REBIDA Database

Scientific information about biodiversity is mainly concentrated in major research centers in developed countries (Shanmughavel, 2007), while transitional and developing countries are largely lagging behind. REBIDA is the only structured, comprehensive and open-access database on biodiversity in Bosnia and Herzegovina.

Depending on the type of users, REBIDA database provides a threefold benefit. For the academic and scientific community, it serves as a source of information for basic and applied research. It was shown that the establishment of effective online biodiversity databases accelerates the description of new species, such as in case of SpeciesLink, Brazilian e-infrastructure that provides free and open access to biodiversity primary data and associated tools (Canhos et al., 2015). Informed environmental management, spatial planning and land-use can conserve biodiversity (Theobald et al., 2000; Geneletti, 2008). Therefore, for competent government institutions, REBIDA database can serve as a source of information for creation and adoption of legal acts, decision making, protection and management projects, planning of future protected areas, climate change actions, etc, much like VertNet in USA (Constable et al., 2010; Guralnick & Constable, 2010).

Agriculture and industry sector could also use REBIDA as a valuable driving force. For general B&H public, the database has an educational character, and can also be used as an innovative teaching tool in schools, similar to WyoBio (WyoBio, 2014).

Future Actions and Challenges

Current activities are focused on the development of the DNA barcoding segment of the database. DNA barcoding has gained a lot of attention in the scientific community during the last decade since it offers the alternative to traditional taxonomical methods for species identification through employment of short section of DNA from a

standardized region of the genome (Hebert et al., 2003). This method is fast, cost efficient, and allows the identification of species from different biological samples, thus being a useful tool for conservation purposes (Dudu et al., 2016). DNA barcoding has potential to improve bioassessment by providing increased taxonomic resolution, improving data quality (improved accuracy and objectivity), and enhancing the diagnostic ability of existing assessment tools (Stein et al., 2013).

Extensive efforts should be invested in building a national network of researchers working on different taxa that will regularly submit new data to REBIDA, ensuring its sustainability and relevance. Harmonization and standardization of the procedures for sample collection, documentation and data dissemination is to be achieved by means of protocols, handbooks, and trainings organized for REBIDA contributors of different expertise levels (scientists, students, government employees, educators and public). Collaboration with NGO sector is of paramount importance for promotion of REBIDA in a wider public. Depending on their goals and activities (agriculture, environmental protection, education, policy and law making, etc.), NGOs can serve as a link to the beneficiaries of this project and as a driving force in advertising the REBIDA scanner in particular.

This way, REBIDA will be able to respond directly to local challenges, besides simply feeding data into global system. One of the future challenges is to secure continuous and long-term funding for the database. Besides national grants and individual scientific projects of partner institutions, REBIDA can hugely benefit from international actions such as DNAqua-Net, COST project (CA15219) funded by European Union that aims to build a network of researchers who employ novel technologies and database resources in biodiversity assessments and biomonitoring.

From being only the internal storage of samples and data for INGEB, REBIDA evolved into a data collection used by the researchers from other scientific and academic institutions, with the potential for further growth. REBIDA offers necessary development and strengthening of environmental information and technical services for

the stakeholders in charge of nature protection and sustainable management. This provides the opportunity for REBIDA to, at some point in future, exceed its institutional character and potentially become an official national biodiversity database maintained by respective ministry or environmental agency.

Acknowledgement

Development of REBIDA database was funded by the Federal Ministry of Education and Science (grant no. 05-39-3930-1/15) and the Ministry for Education, Science and Youth of Canton Sarajevo (grant no. 11-05-14-22444/17). We would also like to thank all contributors of REBIDA for submitting the data to the database.

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