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Original paper

Bioprospecting Wild Biodiversity in Romania: Case Study - Gentiana lutea

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Abstract

The scope of this article is to discuss critical points in developing a bioprospecting protocol for Romania under the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity that entered into force in October 2014. By taking as a case study Gentiana lutea L., (yellow gentian) an endangered plant species of pharmaceutical importance, listed in the Annex D of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), our study reveals that bioprospecting is not officially implemented in our country. However, for ensuring the conservation of biodiversity as a whole it is needed to further strengthen and harmonize all legal provisions among international treaties such as CITES, Nagoya Protocol and Multilateral System adopted under the International Treaty on Plant Genetic Resources for Food and Agriculture or Plant Treaty.

Keywords : access to genetic resources, biodiversity conservation, bioprospecting, Romania, Gentiana lutea L.

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Introduction

Plant species are today major sources for food and non-food industry. Two major technology areas from economic point of view are represented by pharmaceuticals and biotechnology followed by different other sectors such as: cosmetics, dyes and colorants, herbal health products, different intermediates, plant protection or essential oils (A. LUBBE & R. VERPOORTE [1]). Only for genetically engineered seeds was recorded a revenue of US$ 5.6 billion in 2013 (J. STRAUS [2]) and for biopharmaceuticals of US$ 150 billion in 2015 (J. NIOSI [3]). Today we assist to the increasing interest to synthetic biology, which arose with cephalexin synthesis (P.P. SAVIOTTI [4]). By funding research, development and innovation, pharmaceutical industry is continuously increasing worldwide even the costs for placing on the market of a single product is estimated to reach US$1 billion (B. DAVID & al. [5]; J.A. DIMASI & al. [6]). Over 25% of the nowadays pharmaceutical drugs are originating from plant natural products (A. LUBBE & R. VERPOORTE [1]) and 76% of the 1073 new chemical entities belonging to small molecules approved to be placed on the market up to 2010 are of natural origin (A.G. ATANASOV & al. [7]). These authors recognized among major challenges for pharmaceutical industry the accessibility of the starting material in their search for new bioactive compounds. Species important for their biological active compounds are widely spread all over the world. Some of them are common species and others are rare, endangered species that need conservation measures to be in place for their protection. It was recorded an increasing demand for plant species accession for research, development and innovation purposes (B. VANHEUSDEN & G. VAN DEN BERGHE [8]).

Romania is recognized as a very rich country in terms of biodiversity, mainly on native wild medicinal and aromatic plants. At least 300 wild plant species were recorded and described for their food potential (C. DRĂGULESCU [9]). A number of 24 plant species have been classified as important for essential oil production, 47 as aromatic, 48 for dyes and 32 for colorants, 186 are medicinal plant species, 79 poisonous species relevant for their alkaloids content and 223 are high pollen production species (A. BELDIE [10]). Today, it is agreed that the Romanian common wild flora is not seriously threatened by collecting from the wild (W. KATHE & al. [11]). The scope of this article is to identify and discuss some critical points regarding bioprospecting from the wild of Gentiana lutea in Romania for ensuring the full implementation of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their Utilization to the Convention on Biological Diversity (Nagoya Protocol), in harmony with already existing regulatory frameworks in order to further support the conservation of biodiversity as a whole. This wild species falls under the scope of Nagoya Protocol – prior accession (i.e. when discussing the access to genetic resources) and under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) for trade (i.e. when discussing the trade of species and specimens).

Materials and Methods

Description of the study site. The research was conducted in June, 2013 in Postăvaru Massive, Brașov county, Romania Lat. N: 45°34'60" Long E: 25°33'0" at an average altitude of 1,480 m, where the occurrence of Gentiana lutea L. was recorded before (E.C. MUICA & al., [12]).

Method. Critical identified points in developing a bioprospecting protocol as a step-by-step process is discussed following certain recommendations (T. GREIBER & al., [13]) and addressing as a case study on bioprospecting Gentiana lutea L. from the mountain range Postăvaru with the intention of collecting for scientific research and development purposes.

Biological material. Minimal standards guiding bioprospecting in the classical manner were applied for the characterization of selected genotypes (A.B. CUNNINGHAM [14]).

Results and Discussion

Bioprospecting under multilateral environmental agreements.

In 2010 in Nagoya (Japan) during the 10th Meeting of the Parties to the CBD the Nagoya Protocol was adopted and entered into force in the 12th of

October 2014. Romania signed the Protocol in the 20th of September 2011, as a European Union (EU) Member State approved the Protocol on the date of entering into force and nowadays must comply with the Protocol's provisions into the EU context (M. BUCK & al., [15]; G.S. NIJAR, [16]). Before the adoption of Nagoya Protocol, the Bonn Guidelines recognized by the EU provided recommendations on access for benefit sharing (ABS) upon the access of genetic resources, after its adoption at the 6th Conference of the Parties to the CBD (S. TULLY, [17]; U. SCHÜKLENK & al., [18]; S. BHATTI & al., [19]). The scope, of Nagoya Protocol, was established in the text of article 1: "the fair and equitable sharing of the benefits arising from the utilization of genetic resources", which in fact is the third objective of the CBD (S. BHATTI & al., [19]; M.W. TVEDT & al., [20]). In other words, granting access to genetic resources for an applicant from another country, for research and development aiming the commercialization of new products, must give back revenues to the country of origin of genetic resources (M. BUCK & al., [15]; J. DREXL, [21]). Thus, it is vital from economic point of view to integrate the objectives of biodiversity conservation into the national development strategies, to create synergies among different sectors in order to meet the mandates of the CBD (S.B. BRUSH, [22]). According to the provisions of Art. 22.5. f) of the Nagoya Protocol, entitled "Capacity": "each party have to develop measures including bioprospecting associated research and taxonomic studies". In this regard an official bioprospecting protocol should be adopted at the national level and in case of Romania it should be in line with the EU policy. This protocol should be the subject of a bilateral contractual agreement based on mutual agreed terms (MAT) between applicant and the Party (M. BUCK & al., [15]).

Some relevant terms need to be clarified for Nagoya Protocol for the current national regulatory framework such as following: applicant, country of origin and bioprospecting.

The term "applicant" was first defined into the text of Art. 2 (Definitions) of the Council Regulation (EC) 338/97 on the protection of species of wild fauna and flora by regulating trade therein. The same term was included in 2010 into the text of the Nagoya Protocol, namely into the provisions of Art. 13, regarding the national focal points and competent national authorities. In case of bioprospecting genetic resources in Romania the applicant will be defined according to the Council Regulation (EC) 338/97.

If "country of origin of genetic resources" for the CBD means the country which possesses those genetic resources into in situ conditions for Nagoya Protocol, it is noted a slight change: "Party or the Parties providing genetic resources that is the country or are the countries of origin of such resources or a Party or Parties that have acquired the genetic resources in accordance with the Convention". For EU countries based on the provisions of the Council Regulation (EC) 338/97, the term "country of origin" is defined as "the country in which a specimen was taken from the wild, captive-bred or artificially propagated" and fits with the terms agreed for the Nagoya Protocol. Thus, an applicant from another country will comply with the Council Regulation (EC) 338/97. In this case, in situ and ex situ origins of genetic resources may become "countries of origin" of the accessed genetic resources with the ratification of the Nagoya Protocol. Thus, ex situ collections of public interest may become the subject for bioprospecting as well.

The term "bioprospecting" is not mentioned in the text of the CBD but it is into the provisions of Art 22.5. (f) of the Nagoya Protocol. This term is also missing in the text of the Council Regulation (EC) 338/97 and therefore is missing too in the national regulatory framework for transposing this regulation. Bioprospecting is defined as the official granted search for plant and animal species from which commercially valuable compounds can be obtained. On contrary bioprospecting without permit is biopiracy (M.J.W. COCK & al., [23]). The term bioprospecting cannot be considered as an activity embedded or hidden under the term "scientific research" citing the Governmental Emergency Ordinance 57/2007 (GEO 57/2007) and transposing the Habitat Directive, Birds Directive and the Council Regulation (EC) 338/97. Based on the provisions of Art. 15 para. 2 let. d) of the GEO 57/2007, the term „scientific research" is related strictly to conservation measures of species and habitats that include scientific observations and monitoring activities. There is no connectivity to any potential sustainable use of genetic resources for

research and innovation or biotechnology. In case of protected species and habitats, scientific research is allowed based on derogations only for supporting the conservation, inside or outside protected areas, according to provisions of Art. 38 for setting down derogations according to the provisions of Art. 33 of the GEO 57/2007. Therefore, it can be concluded that in the national regulatory framework is missing an official procedure for bioprospecting as well as for accessing genetic resources according to Nagoya Protocol.

A bioprospecting protocol should be harmonized with already existing rules and procedures under other treaties and already existing domestic regulatory framework such as those of Multilateral System (i.e. this system is functioning under the International Treaty on Plant Genetic Resources for Food and Agriculture or Plant Treaty) and of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). We mention here that the Gene Bank of Suceava is the national focal point for the Plant Treaty, working under the Ministry of Agriculture (i.e. Romania adhered to the Treaty through the Low 42/2005). Ministry of Environment is the national competent authority for CITES implementation, closely working with the Commission for Nature Monuments of the Romanian Academy and The Forest Research and Development National Institute as scientific authorities according to provisions of Art 2. of the Law 69/1994 for the ratification of CITES Convention. Moreover, public ex situ collections may belong to public institutions functioning under the Ministry of Education or Ministry of Research.

Contracting with applicants under Nagoya Protocol

Mutual agreed terms (MAT) under a binding instrument such as a bilateral contractual agreement should be developed for bioprospecting implementation. In this case a guideline should be adopted to explain on case-by-case basis different situations that may emerge, by considering the specific of the country and targeted group of species. Some of deficiencies of the market and contractual approaches for governance all over the globe for these bilateral contractual agreements have been described (M. BUCK & al., [15]; T. DEDEURWAERDERE, [24]; L. ONOFRI, [25]; I.M. SOLIS, [26]). A bilateral contractual agreement for bioprospecting should include clear financial obligations for the applicant from another country in case of benefit arising from accessing genetic resources from the country of origin (S.P. SINGH & al., [27]). This regulatory act should be in line with the current regulatory framework for nature protection in the European countries (S.R. HARROP, [28]; L. MAGGIONI, & al., [29]). However, the current GEO 57/2007 works only for the conservation of biodiversity without considering the third objective of the CBD. Notifications under the scope of scientific research were received by our national environmental authorities from other countries such as: Serbia, Bulgaria, Hungary, Austria and Germany (personal communications) and therefore in case of accessing genetic resources it is necessary to comply to the objective of the Nagoya Protocol (E.C. KAMAU & al., [30]; E. GUNDU & al., [31]). In case of collecting from the wild yellow gentian for scientific research have been described different methods and some of them are highly destructive (D. PEĆANAC, [32]; M.R. POP & al., [33]). Thus, in case of endangered species only aerial parts of plants should be allowed to be collected, on a case by case basis, for ensuring first the maintenance of optimum population size of the species. The bilateral contractual agreement should also stipulate the beneficiary direct contribution to the national monitoring system that needs to meet the requirements of the provisions of Art. 17 of the Habitats Directive in the EU context.

Case study - Gentiana lutea

Gentiana lutea was described for its composition in different biological compounds and uses as a medicinal plant since 1821 (J.E. ATKINSON & al., [34]). Different compounds classes have been recorded (i.e. secoiridoid glicosides, flavonoid, xanthone, pyrone) and medicinal effects have been described. It contains unique compounds that are subject for cancer therapy or anti-inflammatory drugs development (S. POPOV & al., [35]; H. HARAGUCHI & al., [36]; O. PRAKASH & al., [37]). As an example, an amount of 10 mg of pure gentiopicroside, purified from yellow gentian, costs today 132 Euro (BOTANICERT & al., [38]). Yellow gentian is the subject of ABS for cloning

carotenogenic genes during the flowering for lutein production (C. ZHU & al., [39]), the isolation of new triterpenoids (Y. TORIUMI & al., [40]) or for biotechnology purposes (N.M. DROBYK & al., [41]).

In Romania, Gentiana lutea L. is a protected species since 1977 (i.e. the first group of protected species includes six species: Taxus baccata, Pinus cembra, Angelica archangelica, Gentiana lutea, Leontopodium alpinum and Cypripedium calceolus) all over the country territory (A. BELDIE [10]). The species, continues to be in a favourable status of conservation on the current territory of the country (G. DIHORU & al., [42]). Today, based on the current regulatory framework, the species is listed in the Annex no. 4A for protected species of community interest of the Governmental Emergency Ordinance 57/2007 (GEO 57/2007). Yellow gentian populates meadows and grasslands, and in Romania may be found in floristic associations with species belonging to the following genus: Nardus, Agrostis, Setaria (H. HELTMAN, [43]). Official data regarding the presence of the species in protected areas are supplied by the Order of Ministry of Environment 1964/2007, being recorded in several protected areas of community importance and listed under Chapter 3.3. of the Natura 2000 Standard Data Form (i.e. other species), in four sites of community importance according to already published management plans: ROSCI0013 (PARCUL NATURAL BUCEGI [44]), ROSCI0027 (PARCUL NAŢIONAL CHEILE BICAZULUI – HĂŞMAŞ [45]), ROSCI0122 (FĂGĂRAŞ NATURA 2000 [46]) and ROSCI0229 (REZERVAŢIE SIRIU [47]).

According to the European Commission data base EIONET Gentiana lutea is in a favorable status of conservation in the alpine regions for Austria, Germany, Bulgaria, Spain, France, Italy, Romania and Slovenia (EUROPEAN TOPIC CENTRE ON BIOLOGICAL DIVERSITY [48]).

At the global level as a non-CITES species Gentiana lutea is monitored for the trade purposes as it is listed in the Annex D of the CITES Convention (i.e. import, export and re-export as such or part of it). Romania do not officially trade yellow gentian as dried plants or roots for research and development based on CITES data base. However, according to official data provided by CITES, in 2012 14,301.00 kg roots of yellow gentian were officially imported in European countries from third Parties and collected from the wild for pharmaceutical purposes (CITES TRADE DATABASE [49]). The global market demands of the species, between 2010 and 2013, came only from the European Union's countries such as Germany (76,563.00 kg) and Italy (9,749.00 kg). Small quantities have been imported also by Spain (4.00 kg) and Slovenia (0.50 kg). A total amount of 86,316.50 kg (i.e. 28,129.50 kg of dried plants 58,187.00 kg roots) have been imported by the European Community's applicants from third parties also belonging to the European continent (e.g. Albania, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro and Switzerland). The major contributor to yellow gentian export was Bosnia and Herzegovina with 72,310.00 kg followed by Albania (6,077.00 kg), Croatia (2,505.00 kg) Montenegro (1,958.50 kg), Makedonia (640.00 kg). Germany placed on the common market 2,714.00 kg of gentian originating from Albania and Switzerland exported a total amount of 112.00 kg gentian roots collected from the wild.

We underline that the unsustainable collecting from the wild may have negative impact on yellow gentian conservation. Thus, negative impact on the conservation of this species were already described for Bosnia and Herzegovina (S.U. PAULS & al., [50]), Albania and Macedonia, Croatia (Z. ŠATOVIĆ [51]; G. SAMY [52]) and Bulgaria (PETROVA & al., [53]). Moreover, in these countries of origin are not properly working financial mechanism for supporting the implementation of measurable conservation and/or ecological restoration indicators associated with gentian habitats (S. SULLIVAN [54]). Following the negative examples described above, the bilateral contractual agreement should include detailed risks assessment regarding the collection from the wild for each species.

Experiencing a potential bioprospecting Gentiana lutea in Postăvarul Massive

In Braşov area, in Bârsei Mountains, yellow gentian is best occurring in the grasslands of three mountains: Piatra Mare (ROSCI0195), Postăvarul (ROSCI0207) and Piatra Craiului (ROSCI0194) (E.C. MUICA & al., [12]). Protection measures are taken only in the Management Plan of Piatra Craiului, and by accident the species is not mentioned in the Ministerial

Order 1964/2007 (PIATRA CRAIULUI [55]; FUNDAȚIA CARPAȚI [56]; [57]). Granting the official access for bioprospecting the species in the wild and for collecting the minimum specimen numbers for analysis should include in situ description of the habitat and taxes for supporting biodiversity conservation (G.C. RAUSSER & al., [58]; N. PANASENKO [59]; G. KEPPEL & al., [60]).

In Romania, Gentiana lutea was the subject for scientific research and collecting from the wild, for biochemical analysis of pharmaceutical importance and for developing ex situ conservation protocols for in vitro micropropagation (I. HOLOBIUC & al., [61]; I. HOLOBIUC & al., [62]; L.S. MUNTEAN [63]). In case of an applicant from another country, there is a regulation gap regarding the access to yellow gentian that needs to be acknowledged and solved for the future. Moreover, the species was also considered for cultivation as a crop in Brașov area (C. SAVA [64]). It becomes obviously that there is a need for strengthening cooperation between the management units of protected areas or the custodians and the Ministry of Environment in developing clear provisions to be introduced into the bilateral contractual agreement regarding: specific period and areas for bioprospecting and collecting, imposed conditions, minimum training requirements for the involved personnel.

Species characterization based on filed observations

A large population of over 350 yellow gentian specimens for a single area of about 250 m2 on the South slope of the Postăvaru Massive according to the described GIS coordinates. The population is highly heterogeneous in terms of height but homogeneous for blooming stage. It is relevant to note that some morpho-anatomic descriptors related to species should be analyzed and provided to officials upon granting bioprospection (i.e. in case of yellow gentian it would be relevant to note the following descriptors: 3-4 rosette leaves, highly developed root, flowering stems of a height between 0.7 to over 1.3 m). It is relevant to note floristic associations with species belonging to the following genera Alchemilla, Carlina, Digitalis, Festuca. The bilateral contractual agreement should include on a case by case basis specific requirements regarding in situ measurements during bioprospection and collecting from the wild.

Conclusions

Following this study, it was highlight that Romania needs to develop and adopt an official bioprospecting protocol. This could help to contribute for fully addressing all commitments taken under the Convention on biological diversity with specific focus on the Nagoya Protocol. Such a protocol will protect the over-collecting from the wild, will ground financial revenues for the country of origin and at the same time will catalyze the optimization ratio between in situ and ex situ conservation strategies for ensuring the preservation of all genetic resources (M.R. BELLON & al., [65]).

Furthermore, the case study of collecting from the wild yellow gentian revealed already the need to include for a future bioprospecting protocol, specific requirements as taxes, minimal descriptors related to the place of origin, habitat and species. Such a protocol, based on a bilateral contractual agreement, may support officials for creating synergies with the monitoring system of endangered species and habitats (C.F. BLIDAR & al., [66]). Moreover, it will become compulsory that bioprospecting measures to be included into all current management plans for protected areas all over the country.

In terms of capacity building the future notification system for bioprospecting should empower the Ministry of Environment as a competent authority closely working in harmony with the Ministry of Agriculture in charge with Multilateral System as well as with the Ministry of Education, Ministry of Research and any other potential authority dealing with ex situ collections of genetic resources.

We also consider that the fully implementation of Nagoya Protocol will catalyze the development of research in genomics, metabolomics and proteomics in our country by creating awareness regarding the importance of patenting biodiversity by accessing genetic resources for creating new products and services of commercial use (M. NEGRUȚĂ & al., [67]; R.M. STOICA & al., [68]; C. P. CORNEA & al., [69]).

The appropriate implementation of Nagoya Protocol at the country level will further contribute for harmonizing policies, strategies including legal provisions that work among treaties such as Nagoya Protocol, Cartagena Protocol on Biosafety, CBD, CITES as well as the Plant Treaty highly important for Romania as well as for all countries in the region on this subject (N.M. ABUMHADI & al., [70]).

Conflict of interest disclosure

There are no known conflicts of interest in the publication of this article. The manuscript was read and approved by all authors.

Compliance with ethical standards

Any aspect of the work covered in this manuscript has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

References

1. A. LUBBE, R. VERPOORTE, Cultivation of medicinal and aromatic plants for specialty industrial materials. Industrial Crops and Products, 34(1), 785-801 (2011).
2. J. STRAUS, Intellectual property rights and bioeconomy. Journal of Intellectual Property Law & Practice. Doi:10.1093/jiplp/jpx059. (2017).
3. J. NIOSI, Imitation and innovation new biologics, biosimilars and biobetters. Technology Analysis & Strategic Management, 29(3), 251-262 (2017).
4. P.P. SAVIOTTI, Structural Change, Knowledge and the Bioeconomy. In Knowledge-Driven Developments in the Bioeconomy (pp. 17-32). Springer, Cham. (2017).
5. B. DAVID, J.L. WOLFENDER, D.A. DIAS, The pharmaceutical industry and natural products: historical status and new trends. Phytochem Rev. 14(2): 299-315 (2014).
6. J.A. DIMASI, H.G. GRABOWSKI, R.W. HANSEN, Innovation in the pharmaceutical industry: new estimates of R&D costs. Journal of Health Economics, 47, 20-33 (2016).
7. A.G. ATANASOV, B. WALTENBERGER, E.M. PFERSCHY-WENZIG, T. LINDER, C. WAWROSCH, P. UHRIN, V. TEMML, L. WANG, S. SCHWAIGER, E. HEISS, J.M. ROLLINGER, D. SCHUSTER, J.M. BREUSS, V. BOCHKOV, M.D. MIHOVILOVIC, B. KOPP, R. BAUER, V.M. DIRSCHA, H. STUPPNER, Discovery and resupply of pharmacologically active plant-derived natural products: a review. Biotechnology Advances, 33(8), 1582-1614 (2015).
8. B. VANHEUSDEN, G. VAN DEN BERGHE, The Implementation of 'Access and Benefit-sharing'in Five EU Member States: The Achievements and Deficiencies of the Nagoya Protocol and the EU Regulation 511/2014. Journal for European Environmental & Planning Law, 14(1), 7-40 (2017).
9. C. DRĂGULESCU, Cormoflora judetului Sibiu. Editura Universităţii" Lucian Blaga din Sibiu, Sibiu. 831 p (2010).
10. A. BELDIE, Flora României: determinator ilustrat al plantelor vasculare (Vol. XIII). Editura Academiei Republicii Socialiste România 306 p. (1977).
11. W. KATHE, A. HEYM, S. HONNEF, Medicinal and aromatic plants in Albania, Bosnia-Herzegovina, Bulgaria, Croatia and Romania. Bundesamt für Naturschutz. 246 p (2003).
12. E.C. MUICA, A. POPOVA-CUCU, The composition and conservation of Romania's plant cover. GeoJ 29(1): 9-18 (1993).
13. T. GREIBER, S.P. MORENO, M. ÅHRÉN, J.N. CARRASCO, E.C. KAMAU, J.C. MEDAGLIA, M.J. OLIVA, F. PERRON-WELCH in cooperation with N. ALI and C. WILLIAMS, An Explanatory Guide to the Nagoya Protocol on Access and Benefit-sharing, IUCN, Gland, Switzerland. XVIII, 372 pp. (2012)
14. A.B. CUNNINGHAM, Applied ethnobotany: people, wild plant use and conservation. Earthscan Publications Ltd, London and Sterling, VA. 321 pp. (2001).
15. M. BUCK, C. HAMILTON, The Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the Convention on Biological Diversity. Review of European Community & International Environmental Law 20(1): 47-61 (2011).

16. G.S. NIJAR, The Nagoya Protocol on access and benefit sharing of genetic resources: analysis and implementation options for developing countries. South Centre. https://www.southcentre.int/wp-content/uploads/2013/05/RP36_The-Nogoya-Protocol_EN.pdf. 60 pp. (2011).
17. S. TULLY, The Bonn guidelines on access to genetic resources and benefit sharing. Review of European Community & International Environmental Law. 12(1): 84-98. (2003).
18. U. SCHÜKLENK, A. KLEINSMIDT, North–south benefit sharing arrangements in bioprospecting and genetic research: a critical ethical and legal analysis. Dev World Bioeth 6 (3): 122-134. (2006).
19. S. BHATTI , S. CARRIZOSA, T. YOUNG, P. MCGUIRE, Contracting for ABS: The Legal and Scientific Implications of Bioprospecting Contracts IUCN, Gland, Switzerland. XXIVI, 308 pp. (2009).
20. M.W. TVEDT, O.K. FAUCHALD, Implementing the Nagoya Protocol on ABS: A hypothetical case study on enforcing benefit sharing in Norway. The Journal of World Intellectual Property 14(5): 383-402 (2011).
21. J. DREXL, Intellectual property and implementation of recent bilateral trade agreements in the EU. In: EU Bilateral Trade Agreements and Intellectual Property: For Better or Worse? Springer Berlin Heidelberg, pp. 265-291 (2014).
22. S.B. BRUSH, Bio-cooperation and the benefits of crop genetic resources: the case of Mexican maize. World Dev 26 (5): 755-766 (1998).
23. M.J.W. COCK, J.C. VAN LENTEREN, J. BRODEUR, B.I.P. BARRATT, F. BIGLER, K. BOLCKMANS, F.L. CONSOLI, F. HAAS, P.G. MASON, J.R.P. PARRA, Do new access and benefit sharing procedures under the convention on biological diversity threaten the future of biological control?. BioControl, 55(2): 199-218 (2010).
24. T. DEDEURWAERDERE, From bioprospecting to reflexive governance. Ecol Econ 53(4): 473-491 (2005).
25. L. ONOFRI, Material transfer agreements: An economic and econometric analysis Ecol Econ 107:422-430 (2014).
26. I.M. SOLIS, A Good Example of Positive Results from Bioprospecting without Damaging Environment. J Biodivers Biopros Dev 2(144): 2376-0214 (2015).
27. S.P. SINGH, A.M. SINGH, Bioprospecting: Enhancing the Value of Biodiversity and Intellectual Property. In Plant Genetic Resources and Traditional Knowledge for Food Security Springer Singapore pp. 231-236 (2015).
28. S.R. HARROP, 'Living In Harmony With Nature'? Outcomes of the 2010 Nagoya Conference of the Convention on Biological Diversity. J Environ Law 15(1): 449-454 (2011).
29. L. MAGGIONI, I. LÓPEZ NORIEGA, I. LAPEÑA, V. HOLUBEC, J. ENGELS, Collecting Plant Genetic Resources in Europe: A Survey of Legal Requirements and Practical Experiences in Coolsaet B, Batur F, Broggiato A, Pitseys J, & Dedeurwaerdere T, (Eds.). (2015). Implementing the Nagoya Protocol: Comparing Access and Benefit-sharing Regimes in Europe. Hotei Publishing. 327-362 (2015).
30. E.C. KAMAU, B. FEDDER, G. WINTER, The Nagoya Protocol on access to genetic resources and benefit sharing: what is new and what are the implications for provider and user countries and the scientific community? Law & Development Journal (LEAD) 6(3): 248-263 (2010).
31. E. GUNDU, J.E. ADIA, Conservation Methods of Endangered Species. Journal of Research in Forestry, Wildlife and Environment 6(2): 76-83 (2014).
32. D. PEĆANAC, Conceptions of Sustainability in the Medicinal and Aromatic Plants Sector in Bosnia and Herzegovina, International Master Programme at the Swedish Biodiversity Centre Master theses No. 45 Uppsala ISSN: 1653-834X (2007).
33. M.R. POP, C. SAND, M. TANASE, C.H. BARBU, Studies concerning the phenotipical variability of some Gentiana lutea L. genotipes Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal

Science and Biotechnologies 63/64: 453-456 (2009).

34. J.E. ATKINSON, P. GUPTA, J.R. LEWIS, Some phenolic constituents of Gentiana lutea. Tetrahedron, 25(7): 1507-1511 (1969).
35. S. POPOV, N. MAREKOV, A new iridoid precursor of gentiopicroside. Phytochemistry, 10(12), 3077-3079 (1971).
36. H. HARAGUCHI, Y. TANAKA, A. KABBASH, T. FUJIOKA, T. ISHIZU, A. YAGI, Monoamine oxidase inhibitors from Gentiana lutea. Phytochemistry 65(15): 2255-2260 (2004).
37. O. PRAKASH, R. SINGH, S. KUMAR, S. SRIVASTAVA, A. VED, Gentiana lutea Linn.(Yellow Gentian): A comprehensive. Journal of Ayurvedic and Herbal Medicine, 3(3): 175-181 (2017).
38. Botanicert and Extrasynthese: http://www.extrasynthese.com/products-catalog/monoterpene/gentiopicrin-p4838295-c0000-gk.html accessed on February 2018.
39. C. ZHU, S. YAMAMURA, H. KOIWA, M. NISHIHARA, G. SANDMANN, cDNA cloning and expression of carotenogenic genes during flower development in Gentiana lutea. Plant Molecular Biology, 48(3), 277-285 (2002).
40. Y. TORIUMI, R. KAKUDA, M. KIKUCHI, Y. YAOITA, M. KIKUCHI, New triterpenoids from Gentiana lutea. Chemical and pharmaceutical bulletin, 51(1), 89-91 (2003).
41. N.M. DROBYK, V.M. MEL'NYK, M.O. TWARDOVSKA, I.I. KONVALYUK, V.A. KUNAKH, Tissue and Organ Cultures of Gentians as Potential Sources of Xanthones and Flavonoids. Springer-Verlag Berlin Heidelberg, J.J. Rybczyński et al. (eds.), The Gentianaceae-Volume 2: Biotechnology and Applications, 307-317, DOI 10.1007/978-3-642-54102-5_13 (2015).
42. G. DIHORU, G. NEGREAN, Cartea roşie a plantelor vasculare din România. Editura Academiei Române. pp. 520 (2009).
43. H. HELTMAN, Contribuţii la studiul biologiei speciei Gentiana lutea (ghinţura galbenă), încercări preliminare de introducere în cultură în ţara noastră. Analele Academiei Române de Ştiinţe Agricole: 1965 – 1967 (1967).
44. PARCUL NATURAL BUCEGI, Planul de management al Parcului Național Bucegi (Management Plan of National Park Bucegi): http://www.bucegipark.ro/docs/Plan_de_management.pdf, (accessed on February 2018).
45. PARCUL NAȚIONAL CHEILE BICAZULUI – HĂȘMAȘ, Planul de management al Parcului Național Cheile Bicazului-Hășmașu Mare (Management Plan of Cheile Bicazului Hășmașu Mare): http://www.cheilebicazului-hasmas.ro/plan_de_management_PNCB-H.pdf, (accessed on February 2018).
46. FĂGĂRAȘ NATURA 2000, Planul de management al Masivului Făgăraș (Management Plan of Făgăraș Massive): http://www.fagaras-natura2000.ro/plan-de-management, (accessed on February 2018).
47. REZERVAȚIE SIRIU, Planul de management al Siriului (Management Plan of Siriu) http://www.cjbuzau.ro/DDR/Siriu/PM%20SIRIU_28_11_2011_FINAL.pdf, (accessed on February 2018).
48. EUROPEAN TOPIC CENTRE ON BIOLOGICAL DIVERSITY http://art17.eionet.europa.eu/article17/reports2012/species/progress/?period=3&group=Vascular+plants&conclusion=population, accessed on 26 January 2018
49. CITES TRADE DATABASE, http://trade.cites.org/home.htm, accessed 26 January 2018.
50. S.U. PAULS, C. NOWAK, M. BÁLINT, M. PFENNINGER, The impact of global climate change on genetic diversity within populations and species Mol Ecol 22(4): 925-946 (2013).
51. Z. ŠATOVIĆ, Legal protection, conservation and cultivation of medicinal and aromatic plants in Croatia. In: D. BARECEVIC, J. BERNATH, L. MAGGIONI, E. LIPMAN, Eds. Report of a Working Group on Medicinal and Aromatic Plants, First Meeting, 12-14 September 2002, Gozd Martuljek, Slovenia. International Plant

Genetic Resources Institute, Rome, Italy. 34-38 (2004).
52. G. SAMY, V. CHAVAN, A.H. ARIÑO, J. OTEGUI, D. HOBERN, R. SOOD, E. ROBLES, Content assessment of the primary biodiversity data published through GBIF network: Status, challenges and potentials. Biodiversity Informatics 8(2): 94-172 (2013).
53. M. PETROVA, E. ZAYOVA, A. VITKOVA, Effect of silver nitrate on in vitro root formation of Gentiana lutea. Romanian Biotechnological Letters, 16(6), 53-58 (2011).
54. S. SULLIVAN, After the green rush? Biodiversity offsets, uranium power and the 'calculus of casualties' in greening growth. Human Geography 6(1): 82-101 (2013).
55. PIATRA CRAIULUI, Planul de management al Parcului Național Piatra Craiului (Management Plan of the National Parck Piatra Craiului) http://www.pcrai.ro//files/Plan_site.pdf, (accessed on February 2018).
56. FUNDAȚIA CARPAȚI, Planul de management al Muntelui Piara Mare (Management Plan of Piatra Mare) http://www.fundatiacarpati.ro/arii_protejate/PM%20Piatra%20Mare.pdf (accessed on February 2018).
57. FUNDAȚIA CARPAȚI, Planul de management al Masivului Postăvaru (Management Plan of Postavaru Massive) http://www.fundatiacarpati.ro/arii_protejate/Postavaru2014regulament.pdf (accessed on February 2018).
58. G.C. RAUSSER, A.A. SMALL, Valuing research leads: bioprospecting and the conservation of genetic resources. J Polit Econ 108(1): 173-206 (2000).
59. N. PANASENKO, Direct and Indirect Designation in Medicinal Plants' Names. International Journal of Humanities and Social Science 2(8): 217-233 (2012).
60. G. KEPPEL, K.P. VAN NIEL, G.W. WARDELL-JOHNSON, C.J. YATES, M. BYRNE, L. MUCINA, A.G.T. SCHUT, S.D. HOPPER, S.E. FRANKLIN, Refugia: identifying and understanding safe havens for biodiversity under climate change. Global Ecol Biogeogr 21(4): 393-404 (2012).
61. I. HOLOBIUC, R. BLINDU, In vitro culture introduction for ex situ conservation of some rare plant species. Rom. J. Biol - Plant Biology 51-52:13-23 (2006).
62. I. HOLOBIUC, R. CATANA, Recurrent somatic embryogenesis in long-term cultures of Gentiana lutea L. as a source for synthetic seed production for medium-term preservation. Archives of Biological Sciences, 64(2), 809-817 (2012).
63. L.S. MUNTEAN, Research in the field of medicinal and aromatical culture at University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Hop and Medicinal Plants 16(1-2): 73-81 (2008).
64. C. SAVA, Peculiarities for agricultural technology of Gentiana lutea. Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development 15(1), 449-454 (2015).
65. M.R. BELLON, E. DULLOO, J. SARDOS, I. THORMANN, J.J. BURDON, In-situ conservation–harnessing natural and human derived evolutionary forces to ensure future crop adaptation. Evolutionary applications 10: 965-977 (2017).
66. C.F. BLIDAR, I.M. TRIPON, C. ILEA, In Vitro Conservation of Genetic Resources of Nymphaea lotus var. thermalis (DC.) Tuzs., an Endangered Plant Species. Romanian Biotechnological Letters, 22 (2017).
67. M. NEGRUȚĂ, N. CUCU, I. NĂFTĂNĂILĂ, Biotechnology Project Management vs. Non-Registered Intellectual Property. Romanian Biotechnological Letters, 16(6), 6821-6832 (2011).
68. R.M. STOICA, O POPA, S. NIȚĂ, N. BĂBEANU, Influence of process parameters on the extraction of capsaicinoids from various Capsicum species cultivated in

Romania. Romanian Biotechnological Letters, 20(5), 10767-10772 (2015).

69. C. P. CORNEA, I. GREBENISAN, R. MATEESCU, E. VAMANU, G. CAMPEANU, Isolation and characterization of new Bacillus spp. strains-useful as biocontrol agents of plant pathogens. Romanian Biotechnological Letters, 8, 1115-1122 (2002).
70. N.M. ABUMHADI, A.I. ATANASSOV, Future challenges of plant biotechnology and genomics. Romanian Biotechnological Letters, 15(2), 127-142 (2010).