Laboratoire International Associé **CEBACOL**

Between **Instituto Alexander von Humboldt** (IAvH, Bogotá, Colombia)

and **Evolution et Diversité Biologique** (UMR5174 EDB, Toulouse, France)

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1. Introduction

Mitigating the erosion of biodiversity is a global challenge, and there is an increased recognition that the health of nature largely conditions the future of our societies. The pivotal role of biodiversity for human health and wellbeing is now better considered[1]. In tropical America, a major reservoir of terrestrial biodiversity, this challenge is even more pressing, even though in this region our knowledge on biodiversity is the most limited. The International Panel for Biodiversity and Ecosystem Services has recently produced regional assessments, including one for the Americas[2], and it has been made clear through this assessment that gaps in knowledge are a major impediment to the implementation of effective policies for biodiversity conservation, especially for South American countries.

In spite of the lack of knowledge in both the distribution of species and the processes that underpin their coexistence, the legal framework for biodiversity has evolved rapidly, illustrating a shift in the perception of the biodiversity crisis. In France, a law called 'Law for the re-conquest of biodiversity', aimed at sheltering biodiversity from the threats of overexploitation and the destruction of habitats, has been passed in 2016. The main scope for this law is mainland France, which has been exposed to a range of threats related to urban development, transportation networks, agro-industrial activities, all resulting to environmental pollutions and reduction/fragmentation of natural habitats for wildlife.

Comparatively, the impact of human activity on biodiversity and the consequences of a change in the legal framework have received much less attention in French overseas territories. French Guiana, a territory of France, is an iconic example of a territory where conflicts of interest over environmental resources are active, debated, and may have major consequences on biodiversity in the years to come. For an area of only 12% that of France, French Guiana harbours

[1] Romanelli, C. et al. 2015. Connecting global priorities: biodiversity and human health: a state of knowledge review. World Health Organization and Secretariat of the Convention on Biological Diversity. 364 pp.

[2] Intergovernmental Panel for Biodiversity and Ecosystem Services (IPBES) – Regional and sub-regional Assessment of Biodiversity and Ecosystem Services for the Americas. Sixth session, Medellín, March 2018.

over 6,000 plant and nearly 700 bird species, more than in mainland France. France has created the largest protected area of the European Union in the South (Parc Amazonien de Guyane, 33,900 km^2 compared with a total area of 83,534 km2 for French Guiana). Yet, the French government is considering allowing an open-air gold mining concession which will have a dramatic impact on the environment, and will have only short-term benefits on employment and on the local economy[3].

The implementation of the French Law on biodiversity in French Guiana has unveiled fascinating debates about the vision of our society on biodiversity, but also obvious limitations related to the lack of solid data, especially in the tropics, with which policy could be constructed. **It is clear that the tools for monitoring the state and changes in biodiversity are currently inadequate.** The French Laboratory of Excellence CEBA has contributed evidence-based research on biodiversity since 2012, and is in the process of a prolongation for the period 2020-2024. The present request for the creation of a LIA builds in part upon the research and knowledge generated by Labex CEBA, and in part upon the scientific project of **UMR Evolution et Diversité Biologique in Toulouse** (EDB), which co-proposes this project.

The main motivation for CEBACOL is that any rigorous attempt to implement novel methods for biodiversity monitoring in the tropics should not be based on a single case study but on comparative studies, with contrasted situations. **Colombia** offers a fantastic opportunity for studying biodiversity and implementing innovative tools for biodiversity monitoring. Colombia is one of the most biodiverse countries on the planet. Including only five groups of animals (amphibians, birds, fish, mammals, and reptiles) and vascular plants, Colombia ranks as the second most species-rich country on the planet, just behind Brazil but before Indonesia. Colombia shelters no less than 25,163 plant species, and 6,222 vertebrate species (including over 1,800 bird species), according to a recent report of the Instituto Humboldt[4]. This outstanding biodiversity is found in a country that is unique geographically. Situated North of South America it is of major importance to understand the biogeographic history of the entire region. Colombia is being dissected among three Andean cordilleras and spans almost 6000 m in elevation, with unique gradients – the top of Sierra Nevada de Santa Marta, at 5770 m asl, is only 42 km from the Atlantic Ocean, and this isolated mountain covers an area twice smaller than Parc Amazonien de Guyane. In Colombia, the past seventy years have seen cycles of violence, with armed conflicts which have caused hundreds of thousand casualties, millions of refugees within the country and political and economic instability. The peace deal signed and approved in 2016 between the Colombian Government and the major guerrilla movement, the FARC, has opened a new era for Colombia. It has also opened

[3] https://fr.wikipedia.org/wiki/Montagne_d%27or_(mine)
[4] Biodiversity 2016. Status and Trends of Colombian Continental Biodiversity. Instituto Humboldt Editions 2017.

many areas, inaccessible for decades, for scientific enquiry but also for extractive activities and the development of agro-industrial projects, that could further harm biodiversity and the provisioning of ecosystem services[5].

Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH) is a non-profit civil corporation, created by the law 99 of 1993 and linked to the Ministry of Environment and Sustainable Development of Colombia. IAvH's mission is to promote, coordinate and carry out basic and applied research on continental biodiversity and ecosystem services that contributes to knowledge, conservation and sustainable use of them. As part of its functions, IAvH is responsible for carrying out scientific research on biodiversity in the continental territory of the nation, including hydrobiological and genetic resources. Since its creation, IAvH has fostered basic and applied research in biodiversity providing guidelines for assessing and monitoring biodiversity, informing decision makers and communicating science to the society. IAvH has also been one of the major actors of the development of IPBES in Latin America, sheltering the technical support unit in charge of coordinating the biodiversity assessment for the region and leading the organizing of its Sixth Session in Medellín (march 2018). IAvH has an ambitious research program in biodiversity sciences, that parallels to a large extent the one developed by EDB in Toulouse. It has especially a strong program in applied biodiversity science, at the nexus of social sciences, biology and environmental sciences.

2. Motivation and context

Here we propose the establishment of a Laboratoire International Associé between UMR EDB in France (Toulouse) and Instituto Humboldt in Colombia (Bogotá). The central aim of this joint venture is to develop and apply transformative approaches for the exploration and the monitoring of biodiversity in the Neotropics, where biodiversity is high and prior base knowledge is limited (and often insufficient).

EDB and IAvH have been collaborating for some time now. Two of the staff scientists at the Program Ciencias de la Biodiversidad, Mailyn-Adriana Gonzalez and Natalia Norden, were trained at EDB (PhD defended in 2009 and 2007, respectively). A number of publications have been jointly published at this time, and several visits between EDB and IAvH have been conducted (to Colombia: Jerome Chave in 2014, Amaia Iribar in 2017, Antoine Fouquet in 2016-2017; to France Mailyn-Adriana Gonzalez in 2015 and 2018).

[5] Baptiste, B. Et al. 2017. Greening peace in Colombia, Nature Ecology Evolution, 1, 102.

Also, EDB has been heavily involved in research on Neotropical biodiversity, notably since 2011 through the **laboratory of excellence CEBA** (Centre of the study of Biodiversity in Amazonia), which operates in French Guiana, but seeks to reach out to other Neotropical countries. Supported by CEBA, two of the staff scientists at Humboldt attended CEBA thematic schools in 2013 and 2016 ("Advanced methods on Neotropical biogeography" and "Functional ecology of tropical forest in the context of climate change"). Labex CEBA is being considered for a prolongation for the period 2020-2024 (5 years), and **the LIA CEBACOL would then foster collaboration between CNRS and Instituto Alexander von Humboldt**, enabled by the funding of Labex CEBA. In the request for prolongation of Labex CEBA, this LIA proposal has been explicitly cited as an opportunity of expansion. Conversely, the present LIA proposal has been designed to be compliant with the science program of the second phase of Labex CEBA.

Science-wise, **three areas of research** motivate the present proposal.

- The first motivation for the present request is that both units have engaged in innovative research on **environmental genomics, and especially metabarcoding, in French Guiana (EDB) and Colombia (IAvH),** and that we hope to gain knowledge and share expertise by reinforcing our collaboration through the CEBACOL project. Dr Gonzalez has initiated a research program on metabarcoding in natural gradients of Colombia, including in a famous Colombian páramo, Iguaque. PCR and sequencing have been conducted by EDB (2016). More recently, EDB and IAvH have been included in the ANR-funded GlobNets projects to conduct comparative analyses of metabarcoding datasets, including those acquired in Colombia (the aforementioned Iguaque project, and more recent project on dry forests). EDB is bringing a large metabarcoding project including over 50 sites distributed across the coastal zone of French Guiana, obtained as part of the CEBA[6]. There are opportunities for synergies on this research theme, including improving methodology, expanding sampling strategies (beyond topsoil, e.g.[7]), and engaging in comparative syntheses.
- The second motivation is that **this LIA would be an ideal opportunity to expand biogeographical research across South America**. Colombia and French Guiana cover environmentally important, yet distinctive, forest habitats, which are home to many amphibian, bird, fish, and plant species. French Guiana is covered almost fully by tropical forests of the Guiana Shield, with poor soils, high-biomass forests, and slow dynamics. This

[6] Zinger L. et al. In review. Determinants of soil community assembly in a tropical forest. Molecular Ecology.
[7] Kocher, A et al. 2017. Vector soup: high-throughput identification of Neotropical phlebotomine sand flies using metabarcoding. Molecular Ecology Resources, 17 172-182

forest type has been poorly accounted for in dynamic vegetation models[8]. Colombia span a wide range of forest types, from critically endangered dry forests, to wet forests in Amazonia, and the lesser known forests of the Chocó Region along the Pacific. Also, remarkably, Colombia shelters forests in the Western extreme of the Guiana Shield, thus offering comparative opportunities with French Guiana. Consequently, plenty of opportunities exist for fostering **comparative biogeography** projects between EDB and IAvH. The two laboratories are ideally placed to conduct field research on a range of organisms, but also to analyse biodiversity databases. For instance, IAvH coordinates the Biodiversity Information System Colombia, SiB Colombia, which is a GBIF node point; while EDB has initiated a biodiversity platform for French Guiana – a node point to GBIF – called Guyanensis[9]. Moreover, both laboratories lead networks of permanent vegetation plots allowing the establishment of comparative studies.

- The third motivation is that IAvH has been spearheading research at the **science-policy interface in South America** for some time now. In contrast, France has a limited expertise in this region, and through a long-term collaboration, much could be learned from Colombian scientists. A major instrument developed to operationalize the science-policy dialogue is Nature's Contributions to People (NCP [10]). Different components of biodiversity, such as **functional and phylogenetic diversity** have been studied as a means to quantify these NCP, and much recent progress has been made by our teams in groups as diverse as plants[11], birds[12], fish[13], and amphibians[14]. We will build upon this knowledge to better share resources, improve databases and facilitate the science policy interface.

3. Project

The LIA CEBACOL will foster collaboration between two research centers: Evolution et Diversité Biologique research unit in Toulouse, France (EDB, UMR CNRS, Université Paul Sabatier, IRD), and the Program Ciencias de la Biodiversidad from Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH), based in Bogotá, Colombia. Both research units

[8] Johnson et al. 2016. Variation in stem mortality rates determines patterns of above-ground biomass in Amazonian forests: implications for dynamic global vegetation models. Global Change Biology, 22, 3996-4013

[9] https://sibcolombia.net/; http://guyanensis.ups-tlse.fr:8080/carto/fr/rechercher

[10] Díaz et al. 2018. Assessing Nature Contributions to People. Science, 359

[11] Díaz S. et al. 2016. The global spectrum of plant form and function. Nature, 529, 167.

[12] Montoya, P. Et al. 2018 A morphological database for 606 Colombian bird species. Ecology, in press.

[13] Toussain et al. 2016 : Toussaint A., Charpin N., Brosse S. & Villeger S. 2016. Global functional diversity of freshwater fish is concentrated in the Neotropics while functional vulnerability is widespread. ***Scientific Reports*** 6:22125.

[14] Vacher JP et al. Submitted. Large scale DNA-based survey of Amazonian frogs suggests a vast underestimation of species richness and endemism. Global Ecology and Biogeography.

have an excellent expertise in biodiversity science, and the LIA CEBACOL will be a platform to increase knowledge exchange between the scientists of these two groups. In addition, CEBACOL will materialize the informal collaborations initiated by labex CEBA (Center for the study of Biodiversity in Amazonia), which is led by EDB.

3.1 Deciphering the diversity of tropical soils using metabarcoding

Environmental genomics uses DNA that may be extracted from any environmental sample. Using techniques similar to DNA forensics, it is now possible to avoid contaminations, amplify target DNA fragments, sequence them using next-generating sequencing technology (Illumina), and assign these DNA sequences to reference libraries, thus producing lists of taxon occurrence, and possibly even of taxon abundance and function. This has first been developed to explore the biodiversity of the microbial world[15], which constitutes a large part of the biodiversity of our planet (and of the related NCP). It has been extended to exploring macro-organisms (animals, plants), through the use of a different set of DNA primers, and this method has been generically referred to as DNA metabarcoding[16]. This has been massively used to unravel the diversity of oceans by the TARA project[17], the Human Gut Genome project[18] and in natural habitats such as topsoil[19]. Yet, little remains known about the rules of community assembly, and therefore the processes underpinning the patterns identified by these studies often remain elusive.

In **work-package 1** (WP1), we will join forces to use techniques such as metabarcoding in a concerted effort to improve the quality and the relevance of these data. One crucial aspect of this effort is to associate reliable environmental data to samples, which can be extremely challenging across political borders. Another crucial aspect is to assign molecular operational taxonomic units to suitable groups. This challenge has arisen especially since metabarcoding has been used to retrieve DNA from animals or plants (see ref. 15 for many examples). Reliable DNA reference libraries need to be developed and the quality of these libraries depends directly on the quality of the taxonomic collections. Finally, the development of this research line depends on our ability to tackle large amounts of sequence data, and methods have already been developed by collaborators[20] and are routinely used at EDB, Toulouse.

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[15] Pace, N. R. (1997). A molecular view of microbial diversity and the biosphere. *Science*, *276*(5313), 734-740.
[16] Bonin, A., Taberlet, P., Zinger, L., & Coissac, E. (2018). *Environmental DNA: For Biodiversity Research and Monitoring*. Oxford University Press
[17] Bork, P., et al. 2015. Tara Oceans studies plankton at planetary scale. Science.
[18] Yatsunenko, T. et al. 2012. Human gut microbiome viewed across age and geography. Nature, 486, 222.
[19] Bahram, M. et al. 2018. Structure and function of the global topsoil microbiome. *Nature*, 1.
[20] Boyer, F., et al. 2016. Obitools: a unix-inspired software package for DNA metabarcoding. *Molecular Ecology Resources*, *16*, 176-182.

The two partner laboratories have built a good expertise at implementing DNA metabarcoding surveys in the Neotropics, and informal collaborations are already underway, so WP1 will help reinforce already existing collaborations. Concretely, EDB has implemented tests of soil metabarcoding in French Guiana starting in 2010 (with P Taberlet from UMR LECA)[21], and has provided support and advice for the first metabarcoding project of IAvH in the Páramo of Iguaque, Colombia, and further collaborations are underway. Both IAvH and EDB are involved in the ANR-funded GLOBNETS project, with LECA in Grenoble (PI W Thuiller), which seeks to compare soil metabarcoding datasets worldwide. Finally, some actions of Labex CEBA are also devoted to metabarcoding. These efforts have been paired with a long-term effort to construct and consolidate reference DNA collections for plants, arthropods, fish, and amphibians in French Guiana. A similar effort will be considered as part of CEBACOL. By conducting this joint effort, we will build shared and standardized DNA-based biodiversity databases, which will facilitate species identification in environmental DNA surveys and set a standard for other countries in the Neotropics.

This work-package will start during year 1. It will involve, for EDB: **J Chave**, **J Murienne** (PI of CEBA-funded project DIAMOND), **S Brosse** (freshwater metabarcoding), **I Cantera** and **A Cerdan** (both PhD students working on the topic). For IAvH, WP1 will involve **M Gonzalez**, **P Pulido Santacruz**, and taxonomic specialists (**C Dosnascimiento**, **A Acosta**, **JC Neyta**). Concretely, participants will be involved in a 1st year meeting, and will then coordinate field surveys co-funded by CEBACOL.

3.2 Accelerating comparative biogeography using high throughput sequencing

The acquisition of large reliable DNA-based references in major taxonomic groups will allow us to address fundamental questions about the origins and the history of biodiversity in the Neotropics. High-throughput sequencing, as is commonly implemented in several laboratories in France, including EDB, allows to multiplex many individuals at once, so as to explore intraspecific variability and delineate the boundaries among species, including detecting still unnamed species. This approach has been taken in eastern Amazonia for several groups of amphibians (ref. 13) and it has unveiled a much higher diversity than previously envisioned. We conclude that rapid DNA-based methods of species verification are still extremely useful in the Neotropics, and is likely to reveal surprises in most plant and animal groups.

[21] Yoccoz, N. G. et al. 2012. DNA from soil mirrors plant taxonomic and growth form diversity. Molecular Ecology, 21, 3647-3655.

The second approach consists in sequencing large genomic regions to gain confidence in phylogenetic reconstructions. EDB has produced phylogenetic hypotheses for plants and amphibians based on organellar genomes (full plastome or full mitogenome) – sometime called 'ultrabarcodes'[22] – and these phylogenetic hypotheses have revealed surprises, one example being the broad redefinition at generic level in an important family of tree species, Chrysobalanaceae[23]. There is good reason to believe that a similar approach would be beneficial in lesser known taxonomic groups, and our team will advance this research within this work-package (WP2), by conducting more sequencing in plants and animals of important conservation significance. Even though the analysis can nowadays be highly streamlined, advances still critically depend on field collections, and building a collaboration between experts in Colombia and France (French Guiana) will be essential since these territories show little overlap in species.

We are aware that phylogenetic hypotheses based on organellar genome information may not accurately reflect the evolutionary history of some groups, especially those that have evidence recent diversification events. An excellent recent example is provided in the plant genus *Espeletia*, an iconic group of plants of the páramo[24]. Alternative approaches such as sequence capture methods could be used instead[25] and this will be the topic for discussions within the consortium.

Personnel involved in WP2 will include for EDB: **A Fouquet** (amphibians), **J Murienne** (opilions), **J Chave** (plants), **T Oberdorff** (fish) and **A Iribar** (lab coordinator). For IAvH, it will include **C Dosnascimiento** (fish), **A Acosta** (amphibians), and **JC Neyta** (insects). Because it is difficult to develop such projects in small groups, we will also collaborate with other experts from CNRS: Frédéric Delsuc (ISEM Montpellier, PI for CEBA-funded project NEOTROPHYL), and Jesus Mavarez (LECA Grenoble, specialist of *Espeletia*, a plant clade restricted to the páramo), and from Colombia: James Richardson (professor at University Rosario, plant phylogenetics), Andrew Crawford (prof Universidad Los Andes, amphibians), and Carlos A Lasso (fish).

3.3 Functional and phylogenetic diversity for the management of biodiversity

The LIA CEBACOL will explore how functional and phylogenetic diversity may contribute to improved knowledge in conservation science. This is not a novel topic, for instance it has been

[22] Kane, N. et al. 2012. Ultra-barcoding in cacao (*Theobroma* spp.; Malvaceae) using whole chloroplast genomes and nuclear ribosomal DNA. American Journal of Botany, 99, 320-329.
[23] Bardon L. et al. 2016. Unraveling the biogeographical history of Chrysobalanaceae from plastid genomes. American Journal of Botany, 103, 1089-1102.
[24] Pouchon, C. et al. 2018. Phylogenomic analysis of the explosive adaptive radiation of the *Espeletia* complex (Asteraceae) in the tropical Andes. *Systematic Biology*, syy022.
[25] Chau, J. H., Rahfeldt, W. A., & Olmstead, R. G. (2018). Comparison of taxon-specific versus general locus sets for targeted sequence capture in plant phylogenomics. *Applications in Plant Sciences*, *6*, e1032.

shown that rare species tend to support unique ecological functions[26], and has motivated important studies in groups as varied as plants (ref. 10) or fish[27]. This science is increasingly connected with management questions, such as the identification of priority conservation areas[28], ecosystem restoration[29], management of biological invasions, and adaptation to climate change[30]. The consortium has many opportunities to discuss these questions with applied cases in French Guiana and Colombia, but also to explore how this science informs decision making on a practical level. In this area, IAvH has been exemplary among countries to push forward a scientific agenda that can be readily taken upon by policy makers and stakeholders. This has involved developing economic frameworks for the management of biodiversity, developing effective mapping and graphical representation tools (ref. 4) and implementing regional and national scenarios. The French party will learn from this experience.

In this work-package 3 (WP3), we will explore ways of mobilizing functional traits to inform dynamic community models that will in turn be useful in implementing scenarios. One example of application that we will carry out is the parameterization of an individual-based forest dynamic vegetation model, TROLL[31], which uses many of the functional traits that are being collated for woody plants. The model has already been calibrated and validated in a French Guiana forest, and extending this to forests of Colombia would allow to learn more about the dynamics of tropical forests, but also help guide programs in ecological restoration of forests, and protection of secondary forests.

This WP3 will include experts again from the two institutes. From EDB, trait database experts include: **C Jézéquel**, **T Oberdorff** and **S Brosse** (fish), **J Chave** and **F Fischer** (plants). From IAvH, experts include **C Gomez** (mammals), **N Norden**, **R Gonzalez** and **A Avella** (plants). WP3 will be initiated during year 2 of the project.

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[26] Mouillot, D. Et al. 2013. Rare species support vulnerable functions in high-diversity ecosystems. PLoS Biology, 11, e1001569.

[27] Villéger, S. et al. 2017. Functional ecology of fish: current approaches and future challenges. *Aquatic Sciences*, *79*, 783-801.

[28] Chapman, P. M. et al. 2018. Contrasting impacts of land-use change on phylogenetic and functional diversity of tropical forest birds. *Journal of Applied Ecology*, *55*, 1604-1614.

[29] Díaz-García, J. M. et al. 2017. Amphibian species and functional diversity as indicators of restoration success in tropical montane forest. *Biodiversity and Conservation*, *26*, 2569-2589.

[30] Thomas, E. et al. 2017. The importance of species selection and seed sourcing in forest restoration for enhancing adaptive potential to climate change: Colombian tropical dry forest as a model. Secretariat of the Convention on Biological Diversity.

[31] Maréchaux, I., & Chave, J. 2017. An individual-based forest model to jointly simulate carbon and tree diversity in Amazonia: description and applications. *Ecological Monographs*, *87*, 632-664

3.4 Organization and timeline

The French PI for CEBACOL is Jerome Chave (DR CNRS, EDB Toulouse). He is deputy director of EDB, coordinator of the closely-related labex CEBA, and is CNRS staff since 2001. The Colombian PI is Mailyn Gonzalez (PI in conservation genetics at IAvH). She was trained in Switzerland and France (PhD in 2009 at EDB), and is now PI of the conservation genetics lab at IAvH. The proposed team includes 17 scientists, 8 from EDB and 9 from IAvH.

The organization of the LIA CEBACOL will follow practice of French research laboratories. We will set up a direction board. This board will include 2 personnel from each of the institutions, and it will be in charge of coordinating actions of the LIA. We will hold at least three meetings per year (by teleconference), to coordinate actions, prepare face-to-face meetings, explore co-funding options and decide on budget allocation.

The timeline of the project is summarized in the GANNT chart below. Further justification for the actions is provided in the budgetary details (see further below, in French).

Table 1. GANNT chart of the CEBACOL project

Action	Year 0 (2019)	Year 1 (2020)	Year 2 (2021)	Year 3 (2022)	Year 4 (2023)
WP1	preparation		lab work and analyses		
WP2					
WP3					
Seminars workshops	KO	Metabarcoding Villa de Leyva		Phylogenomics Toulouse	
Student visits					
Field trips			Field trip French Guiana		Field trip Colombia

4. Conclusion

CEBACOL will contribute the above research program by (i) facilitating exchange of information regarding technical challenges but also emerging societal challenges; (ii) facilitating access to field sites both in French Guiana and Colombia, to benchmark novel methods; (iii) training of students and technical staff by short stay exchanges or longer-term internships; (iv) help the respective research communities acquire and nurture long-term collaborations between IAvH and CNRS, and more generally between Colombia and France.

CEBACOL – Partenaires et Budget

1 – Partenaires, personnels, tutelles

- FRANCE

Nom du porteur Français : Jérôme Chave, DR1 CNRS
Unité : UMR 5174 Evolution et Diversité Biologique, Toulouse
Tutelles : CNRS, Université Paul Sabatier, IRD

Personnes impliquées dans le LIA dans l'unité du porteur

- Antoine Fouquet (EDB, CR CNRS) – amphibian biogeography and population genomics
- Jerome Murienne (EDB, CR CNRS) – arthropod biogeography, metabarcoding, macroecology
- Amaia Iribar (EDB, IR CNRS) – metabarcoding and molecular biology
- Uxue Suescun (EDB, AI CDD CNRS/CEBA) – metabarcoding and molecular biology
- Sebastien Brosse (EDB, PR Université Paul Sabatier) – fish ecology and biogeography, fish metabarcoding
- Thierry Oberdorff (EDB, DR IRD) – fish ecology and biogeography, coordinator of the Amazon-Fish project
- Pablo Tedesco (EDB, CR IRD) – macroecological patterns and processes in freshwater fish
- Céline Jézéquel (EDB, IE IRD/doctorante) – macroecological patterns and processes in Neotropical freshwater fish
- Isabel Cantera (EDB, doctorante CEBA) – fish metabarcoding
- Axel Cerdan (EDB, doctorant CEBA) – freshwater biodiversity

- COLOMBIE

Nom de l'unité partenaire : Ciencias de la Biodiversidad
Tutelle : Instituto of Investigación de Recursos Biológicos Alexander von Humboldt
Contact principal et personnes impliquées dans le LIA : Dr Mailyn-Adriana Gonzalez,
PI– conservation genetics, metabarcoding

Nom, statut/fonction, discipline et coordonnées du ou des partenaire(s)

- Carolina Gomez: Head of the Biodiversity Sciences Program – mammals ecology and conservation biology
- Paola Pulido Santacruz: Assistant researcher population genomics of birds and mammals and metabarcoding
- Natalia Norden: PI - dynamics and forest functioning group
- Andres Avella: PI - forest Forest Agenda
- Susana Rodriguez: spatial ecologist

- Roy Gonzalez : PhD student/IAvH Tropical dry forest
- Carlos Dosnacimiento: Curator - Fish taxonomy specialist
- Andres Acosta: Curator – Amphibians taxonomy specialist
- Jhon Cesar Neyta: Curator – Insects taxonomy specialist

2 - Budget prévisionnel

Le budget prévisionnel repose sur le principe de la réciprocité : le projet doit profiter autant aux chercheurs de la partie Française qu'à ceux de la partie Colombienne. Nous espérons qu'un co-financement de la partie Colombienne sera trouvé et qu'il permettra d'augmenter l'ambition de ce projet, et l'année de préfiguration servira en partie à préparer une telle demande. Mais nous ne pouvons pas compter à l'heure actuelle sur un tel cofinancement.

En revanche, il est certain que le projet, tel que présenté aujourd'hui, s'appuie sur de la science soutenue par le Labex CEBA pour la France et divers projets pour la Colombie (Suivi de la végétation des forêts sèches de Colombie, Zonation des Paramós de Colombie, Ecoregions des zones ripariennes de Colombie). Le LIA CEBACOL devrait donc agir comme un catalyseur de collaborations sur des sujets de recherche déjà engagés.

2.1 Année de préfiguration

Durant l'année de préfiguration, un séminaire sera organisé à Bogotá, incluant deux participants de EDB et les participants de IAvH (printemps 2019). Il sera consacré en partie (1 journée) à présenter le LIA CEBACOL afin de faciliter la signature de la Convention bipartite. Le soutien de l'Ambassade de France en Colombie sera recherché. Par ailleurs, une session d'analyse des données de metabarcoding et la préparation d'un manuscrit seront organisés (2 journées). Cette réunion préfigurera une réunion annuelle entre les partenaires (alternant les pays). Le coût de cette réunion est estimé à 3600€ (1200€/personne pour 4 chercheurs de EDB). Un budget supplémentaire pourra être mis à disposition par le Labex CEBA afin de faciliter la participation de plus de chercheurs EDB.

Il sera suivi d'un séminaire organisé à Toulouse incluant l'invitation de la porteuse de projet IAvH à la fin du printemps 2019 (coût estimé : 2000 €).

La demande totale pour 2019 s'élève à 5600 €.

2.2 Pour la 1ère année (à titre indicatif)

La première demande pour la première année (2020) est l'organisation d'un symposium « analyse de données génomiques » entre EDB et IAvH en Colombie. Il sera organisé à Villa de Leyva (Etat de Boyacá) durant une semaine et inclura des membres des deux laboratoires. Il aura pour objet de (1) valoriser les données de métabarcoding obtenues lors de projets conjoints (forêts de Guyane, paramó d'Iguaque, forêts sèches de Colombie), de (2) discuter du futur des approches de barcoding ADN et de l'opportunité de nouvelles méthodes (ultrabarcoding : séquençage de génomes d'organelles ; capture de génomes). Ce symposium sera l'opportunité d'inviter des participants internationaux, spécialistes de ces domaines, mais aussi de découvrir les collections de IAvH stockées dans les collections naturalistes du Humboldt à Villa de Leyva. Les capacités d'accueil dans cette ville sont excellentes, et la ville est facilement accessible depuis Bogotá. Le coût d'organisation inclut les voyages de 5 personnes de EDB (5600€), le transport sur place (500€) et le séjour et subsistance pour les participants de IAvH sur place (1000€). Coût total : 8100 €.

La seconde demande est l'accueil de chercheurs de IAvH à EDB pour l'analyse de données et l'utilisation de la plateforme de séquençage. Nous prévoyons d'accueillir 2 personnes en 2020, pour un coût de mission de 2000 € (800 € pour le billet d'avion, 12 jours à 90€/jour, et transport sur place). Cette action permettra de faire avancer des projets et de transférer les compétences. Finalement, des frais de fonctionnement seront prévus sur ce budget : un projet d'analyse de l'effet de la pollution sur une rivière de Colombie (2000€ pour un run Miseq, 500 € de réagents pour le séquençage – cet estimatif est au-dessous des prix actuels qui seront si nécessaires complétés par un cofinancement du CEBA ou de projets de IAvH). Coût total : 6500 €.

La demande totale pour 2020 s'élève à 14600 €.

2.3 – Budgets indicatifs pour les années suivantes

En 2021, nous organiserons une mission de terrain, soit en Guyane française, soit en Colombie, avec des chercheurs des deux laboratoires. Par ailleurs, nous poursuivrons notre programme d'échange entre chercheurs afin de faciliter l'accès des collections et laboratoires pour les deux parties. Finalement, nous favoriserons dès 2020 le dépôt de bourses doctorales sur des sujets conjoints (via le programme Colciencias en Colombie, et via l'école doctorale Sevab à laquelle EBD est associée pour la France). Le budget exact de ces actions n'est pas déterminé mais elles reposeront sur une demande comprise entre 10000 et 15000€ pour le LIA, complétée par du financement propre des deux parties.

En 2022, nous effectuerons un séminaire de travail comparable à celui organisé à Villa de Leyva, mais en France, dans la région de Toulouse. L'objectif de ce séminaire sera d'aborder les questions de biogéographie comparative et d'utilisation des bases de données de biodiversité pour l'aide à la décision en matière de politique publique. Des membres de EDB seront invités sur une période plus longue à travailler au Humboldt à Bogotá. Le budget exact de ces actions n'est pas déterminé mais elles reposeront sur une demande comprise entre 10000 et 15000€ pour le LIA, complétée par du financement propre des deux parties.

3 – Visas des directions des unités du porteur et de ses partenaires

Faire remplir les cadres suivants par la direction de chaque laboratoire concerné. Ajouter des cadres au besoin.

Je soussigné(e) : Jean-Louis Hemptinne

Directeur/directrice de : UMR 5174, Evolution et Diversité Biologique, CNRS, Université Paul Sabatier, IRD, 118 route de Narbonne, 31062 Toulouse

Atteste avoir été informé(e) de la préparation d'un dossier de demande de soutien en vue de la création du : *CEBACOL*

Date : 29 août 2018

HEMPTINNE Jean-Louis

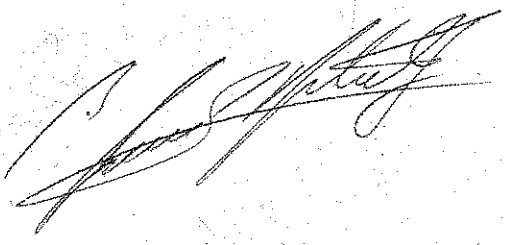
Signature numérique de HEMPTINNE Jean-Louis
DN : c=FR, l=Paris, o=Centre national de la recherche scientifique, cn=HEMPTINNE Jean-Louis
Date : 2018.08.30 20:33:40 +02'00'

Brigitte L.G. Baptiste

Head/Director of Instituto de Investigación de Recursos Biológicos Alexander von Humboldt

I hereby attest that I am aware of this application for the creation of: *CEBACOL*

Date: 29 august 2018



Associated International Laboratory CEBACOL

Extended project summary (English version)

Mitigating the erosion of biodiversity is a global challenge, and there is an increased recognition that the health of nature largely conditions the future of our societies. In tropical America, a major reservoir of terrestrial biodiversity, this challenge is even more pressing, even though in this region our knowledge on biodiversity is the most limited. Gaps in scientific knowledge are a major impediment to the implementation of effective policies for biodiversity conservation, especially for South American countries. On the one hand, the impact of human activity on biodiversity and the consequences of a change in the legal framework have received little attention in French Guiana, and the implementation of the Law on biodiversity has unveiled debates about the vision of our society on biodiversity. The French Laboratory of Excellence CEBA (Centre of the study of Biodiversity in Amazonia) has contributed evidence-based research on biodiversity. On the other hand, Colombia offers a fantastic opportunity for studying biodiversity and implementing innovative tools for biodiversity monitoring, being one of the most biodiverse countries on the planet. The Colombia peace deal opens many areas, inaccessible for decades, for scientific enquiry but also for extractive activities.

The main motivation for Laboratoire International Associé CEBACOL is that any rigorous attempt to implement novel methods for biodiversity monitoring in the tropics should not be based on a single case study but on comparative studies, with contrasted situations. The central aim of is to develop and apply transformative approaches for the exploration and the monitoring of biodiversity in the Neotropics, where biodiversity is high and prior base knowledge is limited (and often insufficient). CEBACOL will help join forces between UMR Evolution et Diversité Biologique (**EDB**), in Toulouse, and Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (**IAvH**). EDB has been heavily involved in research on Neotropical biodiversity, notably since 2011 through the laboratory of excellence CEBA, which operates in French Guiana, but seeks to reach out to other Neotropical countries. IAvH is a non-profit civil corporation, created by the law 99 of 1993 and linked to the Ministry of Environment and Sustainable Development of Colombia. IAvH's mission is to promote, coordinate and carry out basic and applied research on continental biodiversity and ecosystem services that contributes to knowledge, conservation and sustainable use of them.

Science-wise, three areas of research motivate CEBACOL. **First**, both units have engaged in innovative research on environmental genomics, and especially metabarcoding, in French Guiana (EDB) and Colombia (IAvH). We hope to gain knowledge and share expertise by

reinforcing our collaboration through the CEBACOL project. EDB and IAvH currently collaborate though the ANR-funded GlobNets projects. There are ample opportunities for synergies on this research theme, including improving methodology, expanding sampling strategies, and engaging in comparative syntheses. **Second**, this LIA would be an ideal opportunity to expand biogeographical research across South America. Colombia and French Guiana cover environmentally important, yet distinctive, forest habitats, which are home to many amphibian, bird, fish, and plant species. Consequently, plenty of opportunities exist for fostering comparative biogeography projects between EDB and IAvH. **Third**, IAvH has been spearheading research at the science-policy interface in South America for some time now. In contrast, France has a limited expertise in this region, and much could be learned from Colombian scientists. Nature's Contributions to People will be quantified through functional and phylogenetic diversity, based on expertise already acquired by the team. We will build upon this knowledge to better share resources, improve databases and facilitate the science policy interface.

Overall, CEBACOL will contribute the above research program by (i) facilitating exchange of information regarding technical challenges but also emerging societal challenges; (ii) facilitating access to field sites both in French Guiana and Colombia, to benchmark novel methods; (iii) training of students and technical staff by short stay exchanges or longer-term internships; (iv) help the respective research communities acquire and nurture long-term collaborations between Colombia and France.

The French PI is Jerome Chave (DR CNRS, EDB Toulouse), and the Colombian PI is Mailyn Gonzalez (PI in conservation genetics at IAvH). The proposed team includes 17 scientists, 8 from EDB and 9 from IAvH.

The requested budget will include a workshop during Year 1 (prefiguration) to facilitate a common understanding on the goals of the program and help with the signature of the bipartite convention. The estimated costing of this action for Year 1 is 5600€ (and we will seek co-funding). Year 2 (first year of operation), we will devote part of the funds to an analytical workshop on metabarcoding in Villa de Leyva, Colombia (8100€), and part of the funds to facilitate the visit of Colombian scientists in France, especially to use the genomics platform at EDB (cost 6500€). Total estimated cost for 2020 is 14600€. For the following years, funding requests will depend on success in funding PhD projects between the partners and will facilitate their operational costs. The estimated costing is around 10000€ to 15000€ for years 2021 to 2023.

Laboratoire International Associé CEBACOL

Résumé étendu du projet (version française)

L'atténuation de l'érosion de la biodiversité est un défi mondial et il est de plus en plus reconnu que la santé de la nature conditionne largement l'avenir de nos sociétés. En Amérique tropicale, un réservoir majeur de biodiversité terrestre, ce défi est encore plus pressant, et cependant c'est dans cette région que nos connaissances sur la biodiversité sont les plus limitées. Nos lacunes dans les connaissances scientifiques constituent un obstacle majeur à la mise en œuvre de politiques efficaces de conservation de la biodiversité, en particulier pour les pays d'Amérique du Sud. D'une part, l'impact de l'activité humaine sur la biodiversité et les conséquences d'une modification du cadre juridique ont reçu peu d'attention en Guyane. Le laboratoire d'excellence CEBA (Centre d'étude de la biodiversité en Amazonie), a encouragé la recherche fondamentale sur la biodiversité. D'autre part, la Colombie offre une opportunité fantastique d'étudier la biodiversité et de mettre en œuvre des outils innovants pour la surveillance de la biodiversité, étant l'un des pays les plus riches en biodiversité de la planète. L'accord de paix avec la Colombie a ouvert de nombreuses zones, inaccessibles depuis des décennies, à la recherche scientifique mais aussi aux activités extractives.

La principale motivation du Laboratoire International Associé CEBACOL est que toute tentative rigoureuse de mettre en œuvre de nouvelles méthodes de suivi de la biodiversité dans les tropiques ne devrait pas reposer sur une seule étude de cas mais sur des études comparatives dans des situations contrastées. L'objectif central est de développer et d'appliquer des approches transformatives pour l'exploration et la surveillance de la biodiversité dans les Néotropiques, où la biodiversité est élevée et les connaissances fondamentales souvent insuffisantes. CEBACOL contribuera à renforcer les collaborations entre l'UMR Evolution et Diversité Biologique (EDB), à Toulouse, et l'Institut Alexander von Humboldt (IAVH). EDB s'est fortement impliqué dans la recherche sur la biodiversité Néotropicale, notamment depuis 2011 à travers le laboratoire d'excellence CEBA qui opère en Guyane, mais cherche à atteindre d'autres pays Néotropicaux. IAVH est une organisation à but non lucratif, en 1993 et liée au ministère de l'environnement et du développement durable de la Colombie. La mission de l'IAvH est de promouvoir, coordonner et mener des recherches de base et appliquées sur la biodiversité continentale et les services écosystémiques qui contribuent à la connaissance, à la conservation et à leur utilisation durable.

Sur le plan scientifique, trois domaines de recherche motivent CEBACOL. **Premièrement**, les deux unités ont mené des recherches innovantes sur la génomique environnementale, et en particulier le métabarcoding, en Guyane française (EDB) et en Colombie (IAVH). Nous espérons

acquérir des connaissances et partager notre expertise en renforçant notre collaboration à travers le projet CEBACOL. EDB et IAvH collaborent actuellement à travers le projet GlobNets financé par l'ANR. Il existe de nombreuses possibilités de synergies sur ce thème de recherche, notamment l'amélioration de la méthodologie, l'élargissement des stratégies d'échantillonnage et la réalisation de synthèses comparatives. **Deuxièmement**, ce LIA est une opportunité pour développer la recherche biogéographique en Amérique du Sud. La Colombie et la Guyane française couvrent des habitats forestiers importants mais distincts, qui abritent de nombreuses espèces d'amphibiens, d'oiseaux, de poissons et de plantes. Par conséquent, il existe de nombreuses possibilités de promouvoir des projets de biogéographie comparative entre EDB et IAvH. **Troisièmement**, l'IAvH mène des recherches à l'interface science-politique en Amérique du Sud. En revanche, la France possède une expertise limitée dans cette région et il y a beaucoup à apprendre des scientifiques Colombiens. Les contributions de Nature aux personnes seront quantifiées par le biais de la diversité fonctionnelle et phylogénétique, à l'aide de l'expertise déjà acquise par l'équipe. Nous nous appuierons sur ces connaissances pour mieux partager les ressources, améliorer les bases de données et faciliter l'interface entre les politiques scientifiques.

CEBACOL contribuera au programme de recherche ci-dessus en (i) facilitant l'échange d'informations concernant les défis techniques mais aussi les nouveaux défis sociétaux; (ii) facilitant l'accès aux sites sur le terrain, tant en Guyane française qu'en Colombie, afin de comparer les nouvelles méthodes; (iii) la formation des étudiants et du personnel technique par des échanges de courte durée ou des stages de longue durée; (iv) aidant les communautés de recherche respectives à acquérir et entretenir des collaborations à long terme entre la Colombie et la France.

Le responsable français est Jérôme Chave (DR CNRS, EDB Toulouse) et la responsable colombienne est Mailyn Gonzalez (chercheur principal en génétique de la conservation à l'IAvH). L'équipe proposée comprend 17 scientifiques, 8 d'EDB et 9 d'IAvH.

Le budget demandé comprendra un atelier au cours de la première année (préfiguration) pour faciliter une compréhension commune des objectifs du programme et aider à la signature de la convention bipartite. Le coût estimé de cette action pour la première année est de 5600 € (et nous chercherons un cofinancement). Année 2 (première année de fonctionnement), nous consacrerons une partie des fonds à un atelier analytique sur le métabarcoding à Villa de Leyva (Colombie) (8100 €) et une partie des fonds pour faciliter la visite des scientifiques colombiens en France utiliser la plateforme de génomique à EDB (coût 6500 €). Le coût total estimé pour 2020 est de 14600 €. Pour les années suivantes, les demandes de financement dépendront du succès du financement de doctorants entre les partenaires et chercheront à faciliter les coûts opérationnels. Le coût estimé est d'environ 10000 à 15000 € pour les années 2021 à 2023.

Laboratoire International Associé CEBACOL

Short summary (English) Résumé court (Français)

CEBACOL aims to develop and apply transformative approaches for the exploration and the monitoring of biodiversity in the Neotropics, where biodiversity is high and prior base knowledge is limited. CEBACOL will help join forces between UMR Evolution et Diversité Biologique (**EDB**), in Toulouse, which has much prior expertise in French Guiana, and Instituto Alexander von Humboldt (**IAvH**), in Colombia. CEBACOL will cover three research topics: (i) in environmental genomics, and especially metabarcoding, we will gain knowledge and share expertise by reinforcing our collaboration; there are ample opportunities for synergies, including improving methodology, expanding sampling strategies, and engaging in comparative syntheses; (ii) we will expand biogeographical research across South America: Colombia and French Guiana cover important, yet distinctive, forest habitats, which are home to many amphibian, bird, fish, and plant species; (iii) IAvH has been spearheading research at the science-policy interface in South America: Nature's Contributions to People will be quantified, and this will help share resources, improve databases and reinforce the science policy interface. CEBACOL will facilitate exchange of information regarding technical and emerging societal challenges; access to field sites both in French Guiana and Colombia, to benchmark novel methods; training of students and technical staff by short stay exchanges or longer-term internships; research communities in acquiring and nurturing long-term collaborations between Colombia and France. The French PI is Jerome Chave (DR CNRS, EDB Toulouse), and the Colombian PI is Mailyn Gonzalez (PI in conservation genetics at IAvH). The proposed team includes 17 scientists, 8 from EDB and 9 from IAvH.

CEBACOL a pour objectif de développer et d'appliquer des approches nouvelles pour l'exploration et la surveillance de la biodiversité dans les Néotropiques, où la biodiversité est élevée et les connaissances de base préalables limitées. CEBACOL matérialise une collaboration entre l'UMR Evolution et Diversité Biologique (**EDB**), à Toulouse, qui possède une expertise en Guyane et l'Institut Alexander von Humboldt (**IAvH**), en Colombie. CEBACOL couvrira trois sujets de recherche: (i) en génomique environnementale, et en particulier le métabarcoding, nous obtiendrons des données et partagerons notre expertise en renforçant notre collaboration; Il existe de nombreuses possibilités de synergies, notamment l'amélioration de la méthodologie, l'élargissement des stratégies d'échantillonnage et la réalisation de synthèses comparatives; (ii) nous étendrons des recherches biogéographiques en Amérique du Sud: la Colombie et la Guyane française couvrent des habitats forestiers importants, mais distincts, qui abritent de nombreuses espèces d'amphibiens, d'oiseaux, de poissons et de plantes; (iii) IAvH est leader de la recherche à l'interface science-politique en Amérique du Sud: les 'Nature's Contribution to People' seront quantifiées, ces connaissances permettront d'améliorer les bases de données et renforceront l'interface science-politique. CEBACOL facilitera l'échange d'informations sur les défis techniques et sociétaux nouveaux; l'accès à des sites de terrain en Guyane et en Colombie, afin de comparer les nouvelles méthodes; la formation des étudiants et du personnel technique par des échanges de courte durée ou des stages de plus longue durée; communautés de recherche pour acquérir et entretenir des collaborations à long terme entre la Colombie et la France. Le responsable français est Jérôme Chave (DR CNRS, EDB Toulouse) et la responsable colombienne est Mailyn Gonzalez (chercheur principal en génétique de la conservation à l'IAvH). L'équipe proposée comprend 17 scientifiques, 8 de l'EDB et 9 de l'IAVH.