

## Current status of *microbial ecology* in Colombia

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Laura C. Bohórquez, Martha Cepeda, María Mercedes Zambrano,

Corporacion Corpogen, Bogotá D.C., Colombia

Research in microbial ecology and related fields in Colombia includes both basic and applied work in topics such as clinical, environmental and industrial microbiology, among others. There is an ongoing transition from traditional work on isolated microorganisms to novel methodologies and culture-independent techniques, especially in an attempt to study communities and understand the role of microorganisms in environmental settings. It is anticipated that in the next years there will be an increase in research funding for science driven by a growing interest to promote science and technology that may ultimately impact society with new developments. Hopefully, this will further strengthen the growing scientific community in Colombia and its capacity to productively interact and collaborate in research projects at both the national and international levels.

### 1. Scientific Societies.

The following is a list of some of the societies most relevant to the area of microbial ecology. **The Colombian Society of Microbiology** (ACM; <http://www.scmicro.org/>) has just started and aims to bring together researchers in this and similar fields and facilitate interactions with other national and international societies. The **Colombian Association of Plant Pathology and Related Sciences** (Ascolfi; <http://ascolficolombia.org/>) was founded in 1974 and focuses on agriculture, bringing together researchers and academics working on plant pathology and related sciences. **The Colombian Society of Parasitology and Tropical Medicine** (SCPMT; <http://www.saludtropicalcolombia.org/qs.asp>) was founded in 1965 and promotes scientific activities, education and research among physicians, biologists, microbiologists, parasitologists, bacteriologists and other professionals interested in the field. **The Colombian Association of Infectious Diseases** (ACIN; <http://www.acin.org/new/>), created in 1987, brings together professionals involved in the prevention, management, control, education and research of infectious diseases. **The Colombian Association of Biotechnology** (ASOBIOTEC; <http://www.asobiotec.com/>) was created in 2008 to strengthen cooperation and links between university and industry through activities that encourage biotechnology research and innovation in order to improve competitiveness and productivity. **The Colombian Association of Biological Sciences** (ACCB) groups professionals, students and teachers in the general area of the biological sciences.

### 2. Research Activities.

Many of the research groups, within universities and in independent research centers, are registered at the site of the national funding agency, *Colciencias*, which provides a broad panorama of the work carried out in microbial ecology and fields such as infectious and tropical diseases, biotechnology, bioremediation, and bioprospecting, microbial diversity, biocontrol, phytopathology, agricultural and industrial microbiology and metagenomics. One of the main areas of research in the country is agriculture, reflecting the current economic importance of this sector. More recent emphasis has been placed on conservation and sustainable use of natural resources and valuation of biodiversity as a means to strengthen development through biotechnology. There is also a broad interest in infectious diseases and diseases that are endemic to tropical areas or to our region. Thus, research is varied and covers a broad range of interests.

Some of the most consolidated research centers are partially financed with resources derived from key economic activities (such as coffee, sugarcane, palm industry, flowers, aquaculture, etc.). There are also autonomous centers that, though in many cases much smaller than the above mentioned centers, are also key players in the national system of science and technology (such as CIAT, CIC, CIB, Corpogen, CIDEIM, CIF). A recent initiative to establish interdisciplinary and collaborative efforts brought together groups to work as a consortium, forming "*Centers of Excellence*" that were funded for five years and focused on areas of national interest. Four of eight such centers are currently working in microbial ecology or related areas (Gebix, Ciebreg, CCITB, CENM). The Gebix center works specifically on microbial ecology, diversity and bioprospecting through metagenomics and bioinformatics, and the CCITB works on tuberculosis from epidemiology to molecular aspects of host-pathogen interactions. Other collaborative initiatives in recent years include the CIMA consortium, which works on soil microbial ecology and agriculture. There are also collaborative programs with European Union partners, such as *MAGIC-PAH* that seeks to find and analyze polyaromatic hydrocarbon degradation pathways, STOP LATENT TB and SLAM TB, that focus on both diagnosis of resistant strains and the biology of the tuberculosis bacillus during latent infections. Recently, more groups have started to work with metagenomics as means to access and study microbial communities both in the environment, such as soils, waters and oceans, as well as those communities that make up the microbiota associated with animals and the human host.

### **3. Education.**

Universities in Colombia offer a broad range of programs in the life sciences, many of which are related to microbial ecology and microbiology. Most of the emphasis has been on undergraduate education, with many universities offering undergraduate degrees in microbiology and bacteriology, and only recently are we starting to see more programs being offered at the graduate level, both Masters and some PhD programs. Public universities have historically offered the most opportunities, although some private universities are now starting to compete by offering solid academic programs. Opportunities for studying microbiology are therefore broad, although in many cases expensive for many low-income students since admission to public institutions is limited and tends to be concentrated in larger urban centers, a situation that is now starting to change as regional universities become more consolidated. According to the Colombian Department of Education, 12 out of 22 internationally accredited institutions of higher education have one or more programs related to microbiological sciences in areas such as environmental, biological, animal and plant sciences, food science and technology and medical sciences. Four of nine undergraduate level programs in microbiology are fully accredited and several universities and colleges are in the accreditation process. In terms of graduate studies, there are still relatively few PhD programs available in the life sciences in general, and in microbiology in particular. Due to lack of funding, many qualified students seek graduate training abroad, a situation that has started to change, as more funding for students and local graduate programs is made available by the Government. There are also a few scholarships available for foreign students through international agreements such as the Cooperative Forum for Latin America, Asia and East (FOCALAE), the countries of Caribbean-Basin, and the Inter American Agency for Cooperation and Development (ACID-OEA). In addition to formal training, some universities are also open to exchange programs and, although difficult to obtain, can in some cases offer limited financial aid. The growing availability of grants for students has greatly enhanced interest in the sciences and in scientific training, and the development of

joint activities to promote meetings, seminars, courses and conferences among national and international institutions. Despite these growing efforts, there is still a need for postdoctoral training grants upon completion of graduate studies, currently non-existent, and of additional job opportunities for trained scientists.

#### **4-Practical applications.**

Despite ample research in aspects of microbial ecology and microbiology, the applicability of much of the work is still not evident. This is reflected in the small number of known patents or patent applications and novel inventions. The problem is partly due to a lack of interaction between academia and industry, difficulties and costs associated with product development and, more recently, with legal compliance with local and regional laws regarding access to genetic resources. There are, however, some sectors where applied research is more distinct. In the agricultural sector, for example, there are many small companies that currently produce and commercialize biological based solutions for pest control and crop management, such as biofertilizers. Some large research centers focused on agricultural sectors, such as sugarcane and coffee, seek more sustainable agricultural practices by strategies that go from substitution of fertilizers and pesticides to novel plant varieties. Another area of great interest involves the use of natural resources and biodiversity. Many groups are doing bioprospecting for a variety of potential products, such as biocontrol agents, antimicrobials, biopolymer production and industrial enzymes, and are beginning to incorporate metagenomics and genomics in their research activities. Another example involves research for the petroleum industry with the successful development of corrosion detection systems based on studies of microbial communities. More recently, the Government has launched a new initiative for multi-institutional and collaborative networks that must involve both basic and applied research in an effort to bring together academia and industry and link together fundamental research with applied results. Even though the money invested in such efforts is well below that invested in other countries in South America, it is expected that this effort will start to bridge the gap between basic and applied science and promote interest in research that directly impacts society.

#### **5- Future opportunities and international relations.**

Colombia is at a prime moment for future developments and collaborations. The number of groups and researchers working in microbial ecology and related areas, especially young scientists with renewed enthusiasm and advanced training, has grown substantially in the last years. This is coupled to the ongoing efforts by the Government to increase science funding in Colombia and to promote interaction among research groups and between scientists and other interested parties, such as governmental agencies, the industrial sector and the public at large. There are also ongoing efforts to stimulate cooperation with international partners via specific calls for collaborations with other countries (such as Spain, Brazil, Germany, France, among others), most of which will cover travel only. The hope is that these bilateral exchanges will promote joint research projects that can be mutually beneficial. Exchanges that can strengthen the scientific community in particular areas, such as bioinformatics and genomics, as well as those aimed at consolidating basic research and linking it with practical applications will probably have the greatest impact. Thus the country is now at a point where it has a more solid scientific community and the capacity to offer more extensive opportunities in the shape of collaborations and joint efforts at the international level.