

Current status of microbial ecology in Uruguay: the future of integrative studies

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Scientific Societies for Microbial Ecology, Microbiology and related disciplines.

Uruguay has a population of ca. 3.4 millions inhabitants and from them 0.03% are scientists. There are three main scientific societies related to Microbiology and biological sciences:

- The Uruguayan Society for Microbiology (Sociedad Uruguaya de Microbiología, SUM) (www.sumuy.org.uy). SUM was founded at 1940, being the only scientific society devoted to the development and advancement of the microbiological research in the country. The SUM has organized the last ALAM (Latin American Association for Microbiology) Congress in Montevideo (2010), which received more than 800 microbiologists from several countries. This opportunity allowed many young microbiologists to know what is going on in the discipline not only in the country but also in the rest of the world and contribute to strength the links between different research groups.
- The Uruguayan Society for Biosciences (Sociedad Uruguaya de Biociencias, SUB) (www.pasteur.edu.uy/sub/). SUB was created in 1983 by a heterogeneous group of scientist belonging to different biological disciplines, including Biology, Medicine, Veterinary and Agronomy. This society has a division that is exclusively devoted to Biochemistry and Molecular Biology (SBBM) (www.iibce.edu.uy/SBBM/).
- The Uruguayan Society for the Advancement of Science and Technology (Sociedad Uruguaya para el Progreso y avance de la Ciencia y la Tecnología, SUPCTY) (www.supcyt.org.uy). This is a society created not only by scientists but also by citizens from several origins interested in the promotion and development of scientific knowledge, in order to integrate it to societal, cultural, productive and

economical progress of the country. It was founded in 2005 and since then has organized and coordinated the creation of scientist's networks, mainly through the co-organization of congresses together with the related societies from Brazil and Argentina.

Research Activities; characteristics, topics, current situation, research groups and websites.

In Uruguay, the earliest microbiological research activities are those related with clinical aspects of microbiology. However, during the last decade microbiology has increasingly grown and diversified, being now widespread in the different academic institutions. In the case of microbial ecology, its development has been encompassed by the promotion of the agricultural sciences made by the scientific funding agencies in Uruguay. Being a country economically based on livestock and agriculture, the strategy of the national science-funding agency (Agencia Nacional de Investigación e Innovación, ANII) has been focused on the development and application of innovative ideas able to be applied in the different agricultural and farming sectors. Therefore, microbial ecology of soil, biological control agents, plant-promoting microbes and related research themes have increasingly grow. A summary of the research topics and groups is presented below.

As the knowledge about the damage that agro-technology packages after the "green revolution" and transgenic crops impose to the environment and health grows all around the world, the demand for new alternatives to chemical fertilizers and agrotoxics has become apparent. Being an agricultural country, the national government started a few years ago (<10) to support scientific research related to biological control of pests, biofertilizers and bioremediation. Among the earlier investigation lines related to these topics to mention, the study of plant growth-promoting microorganisms received special attention due to their potential to improve the growth of plant species that are important food and bio fuel resources. There are research groups headed by young researchers dedicated to elucidate the role of diazotrophes nitrogen-fixers in artificial prairies, sorghum and sugar cane

(www.iibce.edu.uy/BIOGEM/index.html). Among the native soil microorganisms that are being studied in terms of diversity and environmental preferences we can find the nitrogen-fixing bacteria associated to roots of leguminous growing in floodplains next to Río Uruguay (Esteros de Farrapos). This place is a national protected area and contains vegetal associations that cannot be found in other parts of the country and that are well adapted to the soil and environmental characteristics of riparian floodplains. Therefore, a multidisciplinary team is disentangling the role of the associated microbial diversity and contributing to the conservation of this ecosystem.

In addition, some years ago and related to the above-mentioned development of productive chains, an interdisciplinary research group integrated by biologists, biochemists and veterinaries started to analyze the complex relationships between cattle feeding, diseases and ruminal microbiota, looking for probiotic microorganisms able to modulate it (www.iibce.edu.uy/MICRO/index.html).

During the last five years and along with the increasing global attention to the effects of climate and human-driven environmental change, new microbial ecology research groups emerged focused on aquatic microbial ecology. These research groups address several aspects of aquatic ecology, from the role of bacterial communities in the trophic web and carbon cycle of coastal ecosystems (such as Rio de la Plata and Atlantic coastal lagoons) to bacterial and cyanobacterial diversity and evolution. This research is made in tight collaboration with limnologists and oceanographers from several institutions from Uruguay and from other countries. This collaborative research allows performing studies on plankton communities integrating state of the art techniques in molecular community ecology, microbial diversity, classic aquatic ecology analyses and ecological modelling. From these studies new information about the vulnerability of some aquatic systems of our country has become available. Related to this topic, there is also an ongoing research sponsored by the Uruguayan Antarctic Institute to address the seasonal distribution of cyanobacterial mat communities in the Antarctica.

Overall, the advancement in microbial ecology research and the growth of the

research groups in this area in Uruguay during the last 10 years has encompassed the availability of new molecular techniques, sequencing technologies and bioinformatics.

Education: characteristics, current situation and opportunities.

Education in microbial ecology in Uruguay is performed through Microbiology courses in the different carriers dictated by the national University involving this discipline. Particularly, the degrees in Biology and in Biochemistry (Faculty of Science and Faculty of Chemistry) have a Microbiology course within which microbial ecology is introduced in several lectures (<http://iqb.fcien.edu.uy/paginas/estructura/quimica/microbiolo.html>). During this year a new carrier on environmental management having microbial ecology as a curricular course has been created (www.cure.edu.uy). Specific knowledge on microbial ecology (from environmental processes to emerging new research technologies) is given through postgraduate courses belonging to PEDECIBA (the basic sciences postgraduate program). This program includes the microbiology area, which is in charge of giving courses and offering training lab-stays in microbial ecology to Master and PhD students (www.pedeciba.edu.uy/biologia).

In this regard, the Regional School of Microbiology is proposed as a venue of intensive training at the postgraduate level. The main objective is to integrate young researchers in Microbiology from Uruguay and other countries of the region, and to provide knowledge and training in the state of the art in different fields of Microbiology. The First Regional School of Microbiology was organized by the Institute for Biological Research Clemente Estable (Instituto de Investigaciones Biológicas Clemente Estable, IIBCE) in 2009, focused on three modules covering different aspects of microbiological sciences: microbial interactions, microbial ecology and biotechnology. In that instance, national and foreign teachers, students from MERCOSUR and other countries of Latin America (Colombia, Venezuela, Chile and Costa Rica) participated. The success and positive feedback generated from this first edition has motivated the organizers to perform these meetings every two

years. The consolidation of this School in Uruguay will provide a biannual instance of reunion and teaching in Microbiology issues for researchers and students of the region. The Second Regional School of Microbiology, scheduled for September 2011, will be focused on microbial interactions, meaning all the interactions: between microorganisms, between microorganisms and different hosts and interactions with the environment (environmental microbiology). In this edition, the program includes subjects covering topics such as how microbes shaped the Earth, adaptation of microorganisms to anthropogenically-disturbed environments and practical work using different microscopy techniques to analyze them (www.iibce.edu.uy/IIEscuelaRegionalMicro.html).

Practical applications

Although in Uruguay several aspects of microbial ecology are being extensively studied, the results are not always easily applied or the resulting technologies are not always taken up by the industry. The government intention of strength the link between research and industry is expressed in the National Strategic plan for Science, Technology and Innovation, where it is stated that one of its main objectives is to help the scientific system of Uruguay to contribute with the productive system. Despite the authorities effort to fill this gap, either by investing important amounts of financial resources in research-industrial alliances or in grants for applied science, the main problem persists.

A possible explanation to this might be the lack of an industry matrix accustomed to perform research and development (R&D) in Uruguay. However, there are few local industries, mainly from the agriculture (inoculants, bio-fertilizers, etc) and from the food industries (wine, citric, honey, cheese, etc.) that slowly started to improve their products by the application of new technologies based on the knowledge of the role of microbes in different processes.

In the field of food-waste treatments, different approaches concerning microbial consortia and new technologies are being applied to several field sites. As well, new

partnerships between abattoir industry and research groups applying metagenomics to find new enzymes with interesting biotechnological capacities have established.

Being a country having important rivers, fisheries and a growing development of aquaculture facilities, a special concern should exist about water quality monitoring, especially in the control of harmful algal blooms. However, the environmental microbiology area dealing with aquatic processes has little attention from the government and the new discoveries occurring at the academic level and technologies available are not being especially applied to environmental monitoring yet.

Future opportunities and international relations

Nowadays, the growth and development of microbial ecology in Uruguay has two different components: on one side the agriculture-related microbial ecology and in the other side the environmental microbial ecology, which trend is to grow integrated into networks composed by different ecological sciences. It is expected that in the future microbial ecology research in Uruguay will integrate all the knowledge about the interactions taking place between the different components of biological systems, including the human systems.

Uruguayan microbial ecologists have established international cooperative networks. Most of them started as informal relationships between researchers or institutions and later established as official cooperation. For example, there are several collaborations with Brazilian institutions through research grants with EMBRAPA-Agrobiology, the State University of North Fluminense and the State University of Sao Paulo. There are also well-established cooperation's with the Max Planck Institute for Marine Microbiology (MPI-Bremen, Germany) and with the Institute for water research (IRSA, Italy), among others. These partnerships have produced several international courses and research projects and have also made easy the way to students from Uruguay to perform post grades and short stays abroad. These young researchers are slowly coming back to the national science system and are

important human resources for microbial ecology.

Uruguay was also included in the ICOMM project (International Census of Marine Microbes) through the LACar (Latin America and Caribbean) programme, to analyze the coastal microbial diversity of the Atlantic Ocean and the Caribbean Sea through 454 pyrosequencing technology. One of the outcomes from this network was the finding that bacterioplankton diversity in the wide assessed region may be influenced by anthropogenic disturbance, pointing at the relevance of performing integrative studies involving several countries and researchers trained in disciplines dealing with environmental issues, such as microbial ecology and environmental monitoring.

Microbial ecology in Uruguay started to increase the growth rate during the last 5-6 years, being this growth driven in part by local interest in new biotechnologies and in part by researchers efforts in increasing the knowledge about the ecology and vulnerability of our ecosystems. The intrinsic complexity of macro and microbial communities and their interactions needs research teams allowing the participation of specialists covering several scientific areas, including social sciences. This kind of integrative research started to be supported locally and could be the future of microbial ecology research in our country.