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Point-of-view

BIOTA-FAPESP – supporting biodiversity, building partnerships, and filling the knowledge gaps

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Abstract: ECO92, a United Nations Conference on Environment and Development, hosted by Brazil in 1992 was a catalyst for much activity on biodiversity in the State of São Paulo and eventually led to the establishment of BIOTA-FAPESP. BIOTA-FAPESP quickly evolved into a world-leading research program that has broadened to cover all aspects of biodiversity in the State from genes through species and to ecosystems and the interactions between them. Through the funding of multi-disciplinary projects, the development of collaborative links within the State, nationally and internationally, and the astute use of databases to link the program's project outputs it has set a platform for filling the biodiversity knowledge gaps. Having achieved much in the last two decades, it still has some way to go, but the stage is set.
Keywords: *Biodiversity; BIOTA-FAPESP; SinBiota; SpeciesLink.*

BIOTA-FAPESP – apoiando a biodiversidade, construindo parcerias e preenchendo as lacunas de conhecimento

Resumo: A ECO92, Conferência das Nações Unidas sobre Meio Ambiente e Desenvolvimento, realizada no Brasil em 1992, foi catalisadora de muita atividade sobre a biodiversidade no Estado de São Paulo e levou à criação do Programa BIOTA-FAPESP. O BIOTA-FAPESP rapidamente evoluiu para um programa de pesquisa líder mundial que se ampliou para cobrir todos os aspectos da biodiversidade do Estado, desde os genes, passando pelas espécies, até os ecossistemas e as interações entre eles. Por meio do financiamento de projetos multidisciplinares, do desenvolvimento de parcerias e colaborações estaduais, nacionais e internacionais, e do uso engenhoso de bancos de dados para integrar os resultados dos projetos do programa, o programa estabeleceu uma plataforma para preencher as lacunas de conhecimento da biodiversidade. O Programa BIOTA-FAPESP realizou muito nas últimas duas décadas e ainda tem um caminho a percorrer, mas a estrada já está pavimentada.
Palavras-chave*: Biodiversidade; BIOTA-FAPESP; SinBiota; SpeciesLink.*

Context

My involvement in BIOTA-FAPESP began with early discussions in 1994 and continued to about 2012. I have not been as closely involved over the past decade, and my knowledge of this period is only from what I have read, and from individual discussions with Program participants.

Although being established in 1999, BIOTA-FAPESP had its beginnings seven years earlier when, in June of 1992, Brazil hosted a meeting of the United Nations Conference on Environment and Development which included the goal (among others) of "establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people …" (UN General Assembly 1992). Chapter 40 of the Report of the meeting (known as Agenda 21) included the statement: "There is a general lack of capacity, particularly in developing countries, and in many areas at the international level, for the collection and assessment of data, for their transformation into useful information and for their dissemination. There is also need for improved coordination among environmental, demographic, social and developmental data." The Rio Conference was a catalyst that generated new activities, some of them built on national initiatives from around the world. Early in 1993, Brazil hosted a meeting of information specialists from Australia, Mexico, Costa Rica, Finland, Ecuador, and others. This meeting discussed ways of collaborating on the exchange of information and technology, and methodologies to further the aims of Agenda 21. The 1993 meeting was followed by a second meeting in 1994 where a largely informal collaborative network of like-minded initiatives was established to further the concepts arising out of Agenda 21 – the Biodiversity Information Network (BIN21).

In the last half of the 1990s several meetings were held to discuss the development of biodiversity initiatives within the State of São Paulo. The largest of these, a workshop in 1997, brought together around 100 scientists and others from across all disciplines of biodiversity science in Brazil, as well as experts from overseas. These meetings were lively, and many ideas were put forward. Documents and maps

were perused and discussed with discussions flowing back and forth in Portuguese, Spanish and English. One of the aims of these discussions was to establish a baseline of current knowledge on the State of the Environment, including all aspects of the biota, and to identify the gaps in that knowledge. These meetings were innovative as botanists talked to entomologists, mammologists talked with ichthyologists, and climate researchers talked with bioprospecting experts. Together they identified biodiversity hot spots, gaps in knowledge, and requirements for long-term monitoring. Arising out of these meetings, a series of seven volumes on the current state of biodiversity knowledge in the State named "Biodiversity of the State of São Paulo: a synthesis of knowledge at the end of the 20th century" (*Biodiversidade do Estado de São Paulo: síntese do conhecimento ao final do século XX*) (Joly & Bicudo 1998) and led to proposals for a dedicated biodiversity funding body. This eventually led to BIOTA-FAPESP along with data initiatives such as speciesLink and SinBiota (Canhos et al. in press).

The Convention on Biological Diversity (CBD) was also developing programs to look at the conservation of biodiversity and at filling knowledge gaps. The ideas put forward in the development of BIOTA-FAPESP neatly fitted into the Convention priorities and there was a lot of synergy in discussions by Brazilian biologists at Convention meetings – especially at COP 2 in Jakarta, Indonesia in 1995, and particularly Decisions II/3 and II/4 (CBD 1995) and the development of a Clearing House Mechanism (Canhos et al. 2004).

The OECD (Organisation for Economic Cooperation and Development) at this time established a series of Megascience Working Groups to look at large global projects that could only be funded through collaborative global initiatives. Examples were the Halidon Collider and Hubble Telescope (OECD 2022). One of the initiatives was on biodiversity and led to the establishment of the Global Biodiversity Information Facility (GBIF) in 2001 (Edwards et al. 2000).

BIOTA-FAPESP

Following all these discussions, the scientific community in the State of São Paulo worked on the requirements for a research program aimed at furthering the conservation and sustainable use of the State's biodiversity. In March 1999 the State of São Paulo Research Foundation (FAPESP) (http://www.fapesp.br) launched the BIOTA-FAPESP Program: The Virtual Institute of Biodiversity (http://www.biota.org.br); a significant and forward-looking step for the São Paulo State.

Collaborative science was a key theme that ran through the program with large multi-discipline projects that encouraged researchers to collaborate across projects. Similar projects, either geographically or thematically, were encouraged to either collaborate or to combine into larger projects. There was also strong encouragement on developing consistency in methodologies across projects. The thematic approach led to an increase in the overall productivity of the program when compared with similar FAPESP projects not included under the BIOTA umbrella (Chapman et al. 2011) and this coordinated system of funding quickly became the envy of funding systems around the world, especially in Australia, the USA and Mexico. A project in the lowland rainforest of Brazil was encouraged to collaborate with in-shore projects, projects in nearby estuaries and near-shore marine projects so that there was a continuity and consistency of information. Freshwater aquatic projects in one river basin were encouraged to develop consistent methodologies with projects in other river basins so that data was directly comparable allowing long-term monitoring to be consistent and comparable.

The BIOTA-FAPESP program includes several central databases. From the beginning, the program required the integration of data from the projects be funneled through a central database system called SinBiota, leading to output through the Atlas Biota-FAPESP (Joly et al. 2009). The SinBiota database was originally built and managed by the Centro de Referência em Informação Ambiental (CRIA) but was later transferred to the University of Campinas (UNICAMP). In the development of SinBiota and later, SinBiota 2.0, the users' needs were paramount. When SinBiota 2.0 was upgraded from the original version it was largely because there were new requirements from more recent projects. These included fields such as Microbiology and DNA Barcoding. A strength of the BIOTA-FAPESP program from the beginning is in its databases and their links.

The links between the BIOTA-FAPESP databases is complemented by links to external databases such as GBIF, OBIS (Ocean Biodiversity Information System), the Catalogue of Life, Genbank and others. Currently, speciesLink (Canhos et al. 2015, Canhos et al. in press) has those connections through protocols such as Darwin Core (Wieczorek et al. 2012). Similar external links, however, need to be made by SinBiota as new standards and transfer protocols are developed by Biodiversity Information Standards (TDWG) and GBIF for trait data, DNA, machine observation data and images, etc. Where linkages already exist, such as between SinBiota and speciesLink, these links need to be enhanced, and where they don't exist – such as between SinBiota and the BIOprospecTA databases they needed to be developed (Chapman & Tabarelli 2008). Information in one database can be used to the benefit of the projects in the other and to benefit the Program as a whole. An example that could be followed is GBIF's Living Atlas projects (https://living-atlases.gbif.org/) based on the Atlas of Living Australia (https://www.ala.org.au/) where linkages between all types of data is seamless – including biological data (species, taxa, DNA sequences and bar codes, ecological, species distribution models, etc.) linked to non-biotic data such as climate, soils and geographic boundaries (bioregions, local government areas, conservation areas, terrain, roads, rivers, satellite imagery, etc.) (Belbin & Williams 2015).

Methods for managing a distributed virtual database and in managing the data quality led to staff working in the program being invited to take part in projects such as the development of Darwin Core (Wieczorek et al. 2012), BioGeomancer (Guralnick et al. 2006), TDWG (Biodiversity Information Standards) and the Global Biodiversity Information Facility (https://www.gbif.org/).

From the beginning, data quality was seen as an important component. I was contracted in 2003–2004 to examine the Program, including SinBiota and speciesLink and to recommend ways of improving the quality of these and other projects under the BIOTA-FAPESP umbrella (Chapman 2004). The work carried out at the time at the Centro de Referência em Informação Ambiental (CRIA) and previously in Australia at the Environmental Resources Information Network (ERIN), led to three significant publications by the Global Biodiversity Information Facility (Chapman 2005a, 2005b, 2005c). GBIF and others continue to refer to some of the data cleaning tools developed at CRIA as part of the speciesLink project (http://splink.cria.org.br/tools?criaLANG=pt).

A strength of the Program, especially in the early years, was the encouragement (or even demand) for community outreach through education. This outreach encouraged the development of field guides and teaching resources. It was known that many biological scientists had their early interest peaked through such things as guides to backyard birds, or field guides to shells on the beach where they may have taken their holidays. It was hoped that such guides and teaching materials for schools would encourage more young people to get interested in biology and eventually themselves become professional biological scientists.

Projects under the BIOTA-FAPESP Program were also encouraged to have a social science aspect. One early project looked at the effect of closing National Parks to subsistent agriculture such as the growing of yams – where traditionally yams were cultivated in the rainforest and would move every couple of years to a new area, allowing the rainforest to regenerate. Once these areas were closed off, the farmers had no alternative but to grow their yams in open fields where many of the varieties did not do well, and this resulted in a significant loss in biodiversity.

The BIOTA-FAPESP program has always looked to evolve, and from the beginning established annual evaluations by external reviewers. These evaluations weren't meant to evaluate individual projects, but to use those projects to identify gaps in methodologies, gaps in data, or gaps within the program itself, and looking to where the Program may be improved. Each year a different group of reviewers would be invited with one being brought back each year to provide continuity. In this way the external reviewers were able to impart knowledge from a wide range of biological disciplines. After about seven or eight years, the external evaluations were moved to biannual evaluations with internal evaluations in the alternate years. Many gaps (taxonomically, regionally, and ecologically), which were identified during the evaluations, were addressed in later projects.

In recent years, an increasing emphasis has been given to broadening the scope to fill more knowledge gaps – including marine conservation (noting that over 50% of the State's waters have been identified as protected areas) (Chapman et al. 2011), microbiology (an often-neglected field worldwide) (Chapman et al. 2011), DNA barcoding, pollination (including links to global initiatives and bee conservation), human dimensions of the environment (through applied ecology and conservation, ecosystem function and services as well as the human modified landscape) (Chapman & Tabarelli 2008), climate change studies (including carbon emission and carbon capture and storage in various landscapes) (Chapman & Tabarelli 2008), traits and organism-organism interactions (pollination, parasitology, etc.), links to public policy, and with Citizen Science.

BIOTA-FAPESP has been strengthened through linkages with initiatives with other Brazilian States, the region through IABIN (Inter-American Biodiversity Information Network) and internationally with GBIF, TDWG, OBIS, GEO BON (The Group on Earth Observations Biodiversity), the CBD, GenBank and others (Bolzani 2017). In 2012, a joint meeting was held between BIOTA-FAPESP and the US National Science Foundation (NSF). Arising out of this meeting was an agreement for joint funding of projects involving researchers from both countries. It would be good to see similar links with other countries, for example with the Atlas of Living Australia.

One significant outcome of the program is the encouragement and support for young scientists to present and publish in high-impact journals in English and Portuguese. When the project began, young scientists showed reluctance to attend international conferences as they were not confident in presenting in English. Since the recommendations in the 4th Evaluation of the Program for symposia, mini courses, thematic workshops, and the expansion of the Young Investigators Programs (Chapman et al. 2003), there has been a significant improvement where regular BIOTA-FAPESP symposia have enabled students to gain valuable knowledge and experience in presenting their research and exchanging ideas with other projects. Collaboration between young Brazilian scientists and external biologists (such as those developed under the NSF collaboration) is also helping break down the barrier to publishing in these Journals, and in English.

By supporting the speciesLink project, vast amounts of legacy data in museums and herbaria have been digitized and made openly available. In addition, collaboration with external institutions, such as the New York Botanical Garden has led to priorities being given by those institutions to digitizing and making available data on Brazilian specimens, and in the case of the New York Botanical Garden – photographs of type specimens (Canhos et al. in press).

BIOprospecTA

For the first few years of the BIOTA program, bioprospecting projects were included with other projects. As the number of bioprospecting projects increased, it became difficult to evaluate them in the same way as most of the other projects. In 2002 the bioprospecting projects were separated into a sub-project called BIOprospecTA. This allowed for the sub-program to have more specialized external reviewers and to develop commercial agreements to the benefit of the program. Especially where this allowed for the whole process from prospecting through product development and marketing to be carried out within Brazil. This was novel, as previously, nearly all the later stages were carried out overseas by large multinational companies.

Biota Neotropica

In 2001, the Journal Biota Neotropica (https://www.biotaneotropica.org.br) added to the BIOTA-FAPESP stable. Biota Neotropica has become one of the most significant Biodiversity Journals in the Neotropics.

Conclusion

I am honored to have had a small part in the development of what is an amazing program, and I will watch with interest its continued development. If one looks back on the goals of Agenda 21 mentioned in the second paragraph of this paper, one can see that the BIOTA-FAPESP program is contributing strongly toward "the collection and assessment of data, their transformation into useful information and their dissemination". However, there is still a lot to be done and many gaps to fill. It is estimated (Lewinsohn & Prado 2005) that only about 9–10% of Brazil's estimated biota of 1.8 to 2.4 million species have been described in the last 250 years. We can't wait another 2,500 years to describe the remainder. There is a need for increasing funding and more efficient methods to document Brazilian biodiversity. Programs like BIOTA-FAPESP are a good start.

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Conflicts of Interest

The author declares that he has no conflict of interest related to the publication of this manuscript.

Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

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