BIOLOGICAL DIVERSITY OF THE GUIANA SHIELD (BDG)

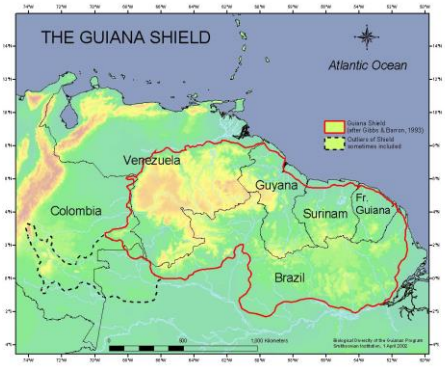
An Introduction

www.mnh.si.edu/biodiversity/bdg

PI: V. A. Funk, Department of Systematic Biology - Botany, NMNH - 31 December 2003
(note: budget is for FY 2003)

The two goals of the Biological Diversity of the Guiana Shield (BDG) program are first, to document, study, and preserve the biodiversity of the Guiana Shield, and in the process to provide the opportunity for excellent scientific research and second, to find ways to make the information generated by these studies useful for conservation and education.

WHY THE GUIANA SHIELD? The Guiana Shield underlies the northeastern corner of South America and includes much of the area east and south of the Orinoco River and east and north of the Rio Negro and Rio Amazonas. The area includes Bolívar, Amazonas, and Delta Amacuro states in Venezuela; most of Guyana, Surinam, and French Guiana; parts of northern Brazil; and parts of southeastern Colombia (Fig. 1). The area has many unusual ecosystems including the famous tepuis of Sir Arthur Conan Doyle's "The Lost World" and the unique "Greenheart" forests of Guyana, both of which are known to be high in species diversity; for many groups the Shield serves as a center of species diversity.



The Shield's igneous-metamorphic basement was laid down in several events from 0.8 to 3.6 billion years ago (Mendoza 1977; Schubert and Huber 1990). This granite basement is easily observed in the many black "hills" of granite that dot the landscape across the Guiana Shield and is also exposed on some of the mountains and massifs. Between 1.6 and 1 billion years ago, sedimentary covers of sand were successively laid down and cemented during thermal events (Huber 1995). The resulting quartzite and sandstone rocks are known today as the Roraima formation. Some recent work has suggested that the eastern rocks are the oldest (Huber 1995), so this would make the Pakaraima Mountains of Guyana and the eastern parts of Venezuela older than the rest of the Roraima formation. Over the last 200 to 600 million years, intrusions of diabases and granite have penetrated both the granitic basement and sedimentary layers.

The most distinctive features of the Guiana Shield are the *tepui*s, the steep-walled table mountains prominently featured in photos and films (see photo, page 6). For many groups of organisms they support a unique flora and fauna (see photos, pages 10 & 13). Tepui elements begin to appear in the biota at around 300-1000 meters in elevation, but predominate above 1500-1800 m. The easternmost peaks reach heights of 2000 meters and include Mt. Ayanganna and Mt. Wokomong in Guyana. The highest tepui, Sierra de la Neblina, just exceeds 3000 m elevation and occurs in the western part of the Shield near Colombia on the border of Venezuela and Brazil. Many other tepuis have summits between 2000 and 2400 meters. There is a large, mid-elevation, sandy plateau between 400 and 1500 called the Gran Sabana that occupies southeastern Venezuela and adjacent parts of Guyana and Brazil, and there are also variously-sized areas of lowland white-sand savannas scattered throughout the Shield.

Only a few parts of the Guiana Shield have well known floras, such as Mount Roraima (Venezuela), Iwokrama-Mabura Hill and Kaieteur (Guyana), Tafelberg (Suriname), and Saul (French Guiana). Most areas, such as the lowland forests and tepui slopes are very poorly known. Hollowell et al. (2001) recently published a checklist for about half of the flowering plants of the Guiana Shield (families from A to L). Using this publication and subsequent online updates (see www.mnh.si.edu/biodiversity/bdg) as a guide, we estimate there are 12,500 species of flowering plants currently known for the Guiana Shield (excluding Brazil and Colombia). As an example the Venezuelan Guayana includes 672 species of ferns and fern allies (Berry et al. 1995), while there are 638 species in the three Guianas. The estimated overlap of these two areas is 74%, so that the total number of ferns is predicted to be close to 1,000 species (not including the Brazilian and Colombian parts of the Shield). Thus, an estimate of the total number of vascular plant species from the Guiana Shield is 13,500-15,000 species. Berry et al. (1995) calculated that 40% of the plant species occurring in the Guiana Shield do not occur outside this area. A closer analysis of the flora of **Kaieteur Falls**, Guyana (Kelloff & Funk, in press), showed that 43% of the plant species found there are endemic to the Guiana Shield. Consequently, we can conclude that about 6,000 species of vascular plants are restricted to the Guiana Shield. Considering just the plants of the Pantepui area (over 1,500 m elevation), Berry et al. (1995) found that the percentage of endemics increases to 65%. This level of endemism must be one of the highest for non-insular floras and documents the existence of a "Guiana Shield flora" that is separate from other floras such as the Andean, Amazonian, and Brazilian Shield floras.

Nearly completed is the "Checklist of the Terrestrial Vertebrates of the Guiana Shield" (Hollowell & Reynolds, in prep) and when this is finished similar statistics will be available for the terrestrial vertebrates. A checklist of the fish exists but it needs extensive work over the next year to bring it up to the level of accuracy necessary for publication.

With a few exceptions, such as cities along the Río Orinoco, the Rupununi savanna (Guyana), and the coastal areas of the Guianas, the Guiana Shield has benefited from its isolation and low population density and much of the vegetation is still relatively undisturbed by human activities. This has lead to its designation as a "tropical wilderness" (Mittermeier et al. 1998). Unfortunately, recent acceleration in the pace of disturbance has increased greatly due to logging by Asian and local companies, **gold and diamond mining**, oil drilling, bauxite mining, dams for hydroelectric power, wildlife trade, burning, grazing, and agriculture. If this pace of activity continues, the Guiana Shield will lose its place as part of one of the three remaining "tropical wilderness" areas in the world.

Efforts to conserve this interesting and unique region vary according to country. Since 1962 Venezuela has set up seven national parks, 29 natural monuments, and two biosphere reserves covering 142,280 km² or almost 31% of the Shield that lies in Venezuela and about 15% of the country. In Guyana the totals are much less, with only one major national park, the expanded Kaieteur National Park (627 km² or about 3% of the country). Surinam has 18 conservation areas that have been established or are proposed plus nature or forest reserves and national parks that total 7,290 km² (1,310 km²of which is proposed; Lindeman and Mori 1989). These make up

4.4% of the country. French Guiana has no designated protected areas but there are 18 proposed sites that total 6,710 km² and make up 7.5% (Lindeman and Mori 1989). However, just because an area is marked on a map as a park or reserve does not mean that the area is actually protected. As with many countries in the tropics, areas that are designated as parks are often only "paper" parks because they lack the infrastructure and financial backing necessary for effective protection the areas. As a result, parks often host gold mining, hunting, wildlife trade, and other disruptive activities. Currently, Venezuela and Guyana have the most pressure on their respective biodiversities, while French Guiana is probably the least threatened and has the best chance to protect its environment.

The Guiana Shield encompasses parts of five countries, each with a different administrative structure and official language, there are a number of border disputes and the borders are porous to drug, gold, and wildlife trafficking, and there are serious issues concerning native peoples. All of these issues will have to be overcome in order to design and maintain a viable reserve system for the Guiana Shield. What we are doing is important because we must gain an understanding of the flora and fauna so that decisions can be made on critical areas that have high priority for conservation and so data can be collected from areas that may ultimately be destroyed. In addition, because this region has been long neglected by biologists it is often an area of "missing information" for many biological studies. The program is designed to provide specimens and data to answer biodiversity questions for many groups. Finally, information is being used to produce checklists, vegetation maps, and floristic and faunistic studies. In addition, we are exploring practical applications of the data we have collected.

ABOUT THE PROGRAM. The "Biological Diversity of the Guiana Shield" (BDG) is a field-oriented program of the National Museum of Natural History that has been operating since 1983 (federally funded since 1987). The goal of the BDG is to "study, document and preserve the biological diversity of the Guiana Shield." Originally confined to botany and Guyana, the least well-known, most biologically diverse of the three Guianas and nearly equal to the Venezuelan portion, it has since been expanded to include faunal studies and limited field work in the other countries. In Guyana the BDG operates under the auspices of the University of Guyana (UG). We have a signed *Memorandum of Understanding* with the University of Guyana and with the Guyana EPA. These memoranda stipulate that a set of all collections be deposited in the "Centre for the Study of Biological Diversity" in Guyana and the second set in the NMNH. Additional exchange material is sent to over 50 institutions around the world (Appendix A).

From 1986-1998 we maintained full-time plant collectors in Guyana. These individuals organized **collecting expeditions** (see photos of expedition by Spruce on the left and a recent expedition on the right) and assisted in the field work of visiting scientists. Each year approximately six major expeditions were organized, and other expeditions involving total of 20-30 visiting scientists were assisted. The budget cuts of the 1990's made it impossible to continue that practice and we currently send resident collectors to Guyana for 4-6 months each year. In recent years we have had resident collectors for butterflies & moths, ants, birds, and plants.

Modern day field work is easier on both ends of the trip (e. g., airplanes) and we collect new types of data (e.g., DNA samples) but the main part of the field work is essentially the same as it was during the time of Spruce. The scientists and their assistants haul supplies by dugout canoe and by foot, sleep in hammocks or tents, cook over an open fire, and live for four to six weeks with constant rain and insect infestations.

From the first, all collections made in the BDG were data based and geo-referenced. This decision, made in the early 1980's, was continued and the types of data expanded as the years went by. The result is a great legacy of data. In addition, beginning in the early1990's the BDG began to database specimens from the US National Herbarium. Two recent grants (from the Department of Systematic Biology and the ADRC) made the acceleration of this work possible and it is now complete (except for one family). Over 60,000 Guiana Shield specimens from US have been data based. We are now working on specimens from the Venezuelan portion of the Guiana Shield.

In addition to collecting and research, the BDG Program has helped build the infrastructure necessary for housing the Guyana natural history collections via the construction and enlargement of the "Centre for the Study of Biological Diversity" located on the campus of the University of Guyana. We also help train students and scientists in both the US and Guyana, assist them in their research, and establish or maintain collections. We have organized training classes for Amerindian guides, provided lectures to the public, and helped organize the first scientific meeting held in Guyana in recent memory (October 2001).

The BDG program fulfills the goals of the Institution in that it gathers new information and distributes it to those who use it to produce floras and faunas of a relatively unknown area, participates in training, supplies data for the identification and preservation of biologically diverse areas and provides specimens that are used in systematic studies both within the institution and throughout the world. The data from the program supplies information that formerly has been missing from biodiversity studies of all types.

<u>BDG staff (Washington, D.C.)</u>

V. A. **Funk** is a Curator of Compositae at the US National Herbarium, Research Scientist in the Department of Botany, and Director of BDG. She is responsible for the oversight and direction of the program and the generation of new research projects. She deals with the few problems that cannot be handled by the Assistant Director and offers advice (sometimes when it is not needed). As director she is active in fund raising and is responsible for most interactions with other scientists, agencies, and organizations. She spends about ¼-½ time on the program.

C. **Kelloff** is the Assistant Director of BDG. She is in charge of the budget as well as the day to day administration of the program and is the first point of contact for all activities, personnel and problems. She conducts research related to BDG issues. She is critical to the management and implementation of the program and acts as Director when Funk is out of town. She is full-time with BDG.

T. **Hollowell** (4 year Term appointment) is the Data Manager and Web Master for BDG. He

maintains the data base, coordinates all information flow to and from collectors and collaborators, supervises data-entry contractors, coordinates the checklist projects, is responsible for all efforts involving graphics and GIS technology, and continually improves the website. He conducts research related to BDG issues. His efforts are crucial for the reliability of the data base and to our efforts to make information available to scientists and the public. He acts as Assistant Director when Kelloff is out of town.

Dodge, J., and D. **Brandan** (p/t contractors) – data basing and specimen processing
Alexander, S. (f/t contractor during FY03; now in Madagascar with Peace Corp)
Hansel, M. (p/t contractor) – data basing, filing specimens, and label typing
Skinner, M. (p/t contractor) – off site plant mounting (US)

Based in Guyana:
Lyle, M. (f/t contractor -Jan-June 2004) - Field collector, resides in Guyana. Organizes targeted expeditions into remote areas, trains staff and students, should collect ca. 3,000 numbers in six months in multiples of ca. 5.

Redden, K. (f/t contractor – Jan-April 2004) - Field collector, resides in Guyana. Organizes expeditions into remote areas, trains staff and students, should collect ca. 2,000 numbers in four expeditions in multiples of ca. 5. (salary and part of expenses paid by George Washington University). [Karen is shown with two of our regular field assistants, Romeo Williams and Claudis Perry (Patamona)].

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Roraima tepui from the Guyana side

REPORT FOR 2003
Biological Diversity of the Guiana Shield (BDG)

PI: V. A. Funk, Department of Systematic Biology - Botany, NMNH - 31 December 2003
(note: budget is for FY 2003)

The Biological Diversity of the Guiana Shield Program (BDG) continues to collect, sort, mount, inventory, and file all plant specimens collected by the program. In addition, we assist scientists from other departments in NMNH (Zooloogy, Entomology, Anthropology), other bureaus at SI (STRI, NZP, NMAH, NASM, CRC), and we collaborate with nearly 100 scientists around the world. In 2003 we awarded six grants for field expeditions and provided logistical support to nine specialists who traveled to NMNH to identify specimens. Also during 2003 we signed a new *Memorandum of Understanding* with the EPA in Guyana. Highlights of the year include:

1. Completion (minus one family we cannot finish) of the databasing of the plant specimens in the US National Herbarium that were collected in the three Guianas (total no. of records = 108,845, made up of 46,125 BDG collections and 62,720 historical specimens);
2. Completion of the **new addition to the Biodiversity Centre** in Guyana (should be handed over to UG in February 2004);
3. Publication of "The use of biodiversity data in developing Kaieteur National Park, Guyana for ecotourism and conservation" (Kelloff, 2003);
4. Establishment of a new publication, *Contributions to the Study of Biological Diversity*, University of Guyana;
5. Near completion of the "Checklist of the Terrestrial Vertebrates of the Guiana Shield" (under final edit).

In the coming year our collecting activities are to increase. In January of 2004 we sent two plant collectors to Guyana, one will stay four months and one six months, so we expect about 5000 plant collections in 2004 (with duplicates a total of 20,000 sheets). Each of these collectors will be focusing on 3-5 areas where we do not have sufficient collections, as determined by Funk, Richardson, and Ferrier (drafted). In addition, the NMNH bird division has an expedition scheduled for the Rewa River area of SW Guyana and possibly an ant collecting trip to Gunn's in the far south. In the past, most of our field work has been in Guyana but we are now moving into other areas of the Guiana Shield. In 2004 plans have been made for a bird expedition in French Guiana, a plant expedition to Surinam, and a plant expedition to northern Brazil to an extinct volcano near the border with Venezuela. This latter expedition depends on whether or not the Brazilian government moves forward with its promise to allow state universities to grant collecting permits. The border area between Brazil and Venezuela and Brazil and Guyana is one of the least studied areas in South America. There is also a possibility of a spider expedition to French Guiana in late 2004 or early 2005. All of the collectors who work through the BDG are required to process the collections as quickly as is reasonably possible and to provide agreed upon specimens and copies of reports and publications for the host country, as well as training for students and public lectures. Finally, two NSF proposals that

contain field work in the Guiana Shield area in collaboration with BDG are to be submitted this year.
[For justification and explanation of program see 1994 RI proposal and subsequent yearly Progress Reports.]

Summary of Specimen and Database work.

Database Records: The program's databases now contain **108,845** plant records and **10,439** fish records. **Bird, Mammal, herpetofauna,** and **Lepidoptera** records, although supported by BDG, are maintained by the respective units here at NMNH.

Plant Specimen Processing for 2003: Specimens determined - **1300**; Specimens sent as gifts/loans for determination: **742** (this count does not include determinations from curators and specialist at the U.S. National Herbarium); Duplicates sent out as exchange: **3401**; Approximately **1933** single (new determinations) and ca. **5,725** duplicate labels have been prepared; **2830** sheets (new mounted specimens) have been barcoded and inserted into the U.S. National Herbarium. **12,215** sheets (historical collections from the U.S. National Herbarium) have been inventoried and barcoded.

Lepidoptera Specimen Processing for 2003: The BDG program has provided funding towards the spreading, barcoding, and databasing the butterflies and moths collected in Guyana. To date **7400** lepidoptera specimens have been barcoded and sorted to family, **1100** have been spread and are ready for processing; **1530** microlepidoptera have been double mounted and are ready for processing.

Ant Specimen Processing for 2003: The BDG program has provided funding towards the processing of the nearly **75,000** specimens collected in leaf-litter during 2002. The material has almost all been prepared and sorted to genus, examples of each morphospecies mounted, all vials labeled and databased, and the ants are all sorted to genus. The task of giving each a species name or morpho-species number is scheduled for 2004 (pending funding from BDG).

Specimen Collecting: 14 visiting scientists have collected approximately **1393+** plant numbers (ca. **5291** sheets). The September bird expedition was cancelled and no other animal expedition took place during this year.

In 2003, because of the cuts in funding, we postponed sending another resident collector to Guyana and focused on reducing our plant and animal specimen backlog. Various specialists were invited to identify plants in their area of expertise: Dr. H. Carnevali (Orchidaceae), Mr. M. Alford (Flacourtiaceae), Dr. D. Clarke with students (Clarke collection - general), Ms. Karen Redden (Fabaceae), Dr. G. Lewis (Fabaceae), Ms. E. Tripp (misc. families), Mr. M. Sewell (Myristiaceae) and Dr. H. Kennedy (Marantaceae). Other tactics for reducing the backlog have been to sort the collections with less than a case of specimens to the family level and to identify the specimens in-house. The backlog of plant specimens has been reduced from over 30 to 19 herbarium cases. The bulk of the backlog is attributed to our last two resident collectors (Henkel and Clarke) who continue to collect plants specimens in the Guianas for their own research. Contact money was made available to identify lepidoptera specimens and to sort ant specimens.

Plant Expeditions (Guyana):

Clarke number series: (9918 - 11035) Mt. Wokomong, with Romeo Williams, Claudius Perry, Diana Gittens, Erin Tripp, Stephen Stern, Josh Kelly, 15 June - 23 July 2003: 1118 numbers, 4472 sheets.

Henkel number series: (8521-8644) Mt. Ayanganna, with M. C. Aime, J. Hernandez, J. Mayor, L. Wooley, N. Hasebe, C. McClure (Guyanese counterpart), 15 June - 15 August, 2003: 124 numbers, 369 sheets (fungi collections).

Aime number series: (2216-2366) Mt. Ayanganna, with T.W. Henkel, J. Hernandez, J. Mayor, L. Wooley, N. Hasebe, C. McClure (Guyanese counterpart), 15 June - 15 August, 2003: 151 numbers, 450 sheets (fungi collections).

Specimens returned to Guyana (Figure 1):

ca. 3,000 plant specimens (BDG) are being held pending the opening of new building (specimens will be sent early 2004)

280 fungi collections, Henkel (temporarly held)

51 bird specimens (Milensky)

98 Lycaenids and 65 Noctuids (moths and butterflies)

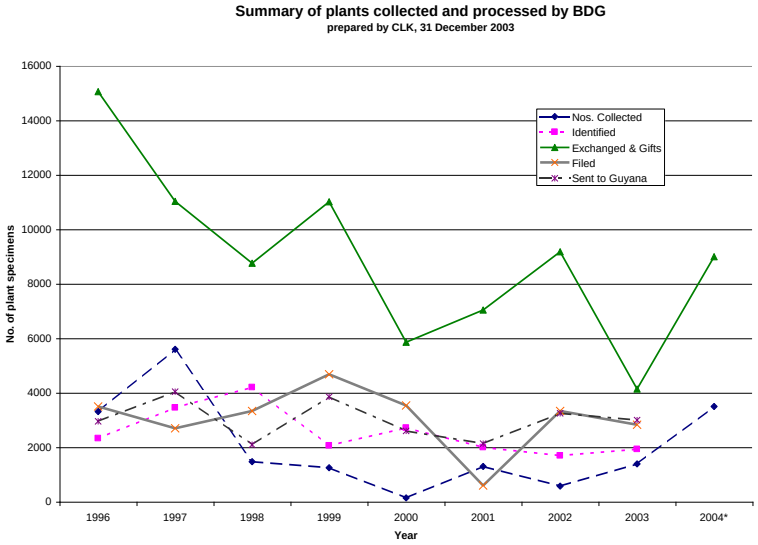

Figure 1: Summary of plants collected and processed by BDG

Other activities:

1) The publication "The use of biodiveristy data in developing Kaieteur National Park, Guyana for ecotourism and conservation" was completed and sent to press (Kelloff 2003).

2) A new publication series was started "*Contributions to the Study of Biological Diversity*, University of Guyana" sponsored by the Centre for the Study of Biological Diversity.

3) In FY03 Calvin Bernard, Head of Biology, University of Guyana was brought to NMNH to work on fish he collected in Guyana. New and interesting things were discovered.

4) The mounting of plant specimens for the Guyana National Herbarium continues at the Centre for the Study of Biological Diversity (CSBD, Guyana). The Program has supplied all mounting materials including paper, glue, thread, tape, and fragment pockets. Currently the Guyana National Herbarium has about **35,000** mounted and filed specimens. This is the largest and best maintained collection in the country.

5) C. Kelloff (SI) assisted the Guyana National Herbarium with curating the lichen collection (512 packets mounted and accessioned); accessioned 158 pigeon holes (7 cases) of flowering plants.

6) Kelloff and Funk assisted the CSBD by developing and drawing out a floor plan for the herbarium in the new building extension and the zoological collections in the two collection halls of the old building.

7) H. Carnvali (CICY) visited US to work on unidentified Orchidaceae (plant) specimens for the BDG Program and other botany staff.

8) H. Kennedy (UBC) visited US to work on unidentified Marantaceae (plant) specimens for the BDG Program and other botany staff.

9) H.D. Clarke and a few of his students visited US and identified collections from plant families

collected by the Clarke expeditions.
10) G. Lewis (K), P. Herrindeen and K. Redden (George Washington U.) identified Fabaceae (plant) family for the BDG Program.
11) C. Kelloff (SI) assisted the Guyana National Herbarium in supervising 3 students at UG filing the backlog of plant specimens (ca. 500 sheets).
12) With funding from ADRC and the Department of Systematic Biology the BDG was able to complete databasing (minus one family we cannot finish) the US specimens from the three Guianas. These records are not geo-referenced unless the information was on the labels. The BDG Program has now begun barcoding and databasing the specimens from the Venezuelan Guayana area so that our database will cover a natural area. Based on funding, the expected completion of this project is 2006.
13) T. Hollowell attended a "Workshop on Geographic Distribution of Neotropical Trees" 22-25 July 2003, Smithsonian Tropical Research Institute. This workshop initiated a project to assemble a single species list of Neotropical woody species to facilitate comparison of ecological datasets. While there he presented a talk, "Sampling Biodiversity: Perspective from Guyana."
14) V. Funk participated in a discussion group with Paul Berry (MO) and others on biodiversity issues during the trip to Copenhagen, Denmark, May 23 - June 5, 2003.

Golden Frog, endemic to Kaieteur Falls area, lives in bromeliads

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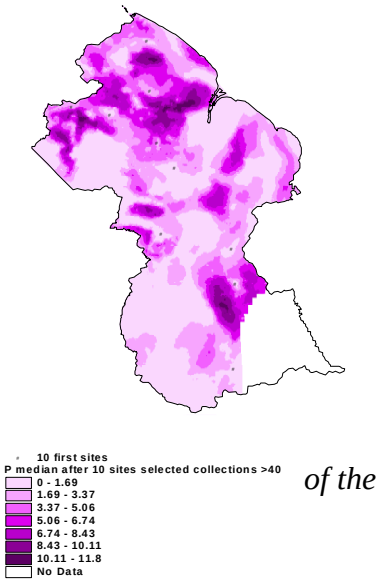

Figure 2: 10 recommended plant collecting sites based on past collections and environmental factors (Funk, Richardson & Ferrier, drafted).

Collaboration Outside the BDG Program

1. **USAID**: USAID provided the funding for the building extension of the Centre for the Study of Biological Diversity, University of Guyana. The extension has been completed and is awaiting final approval of the University of Guyana. This expansion has doubled the collection space of the Centre allowing for at least another 10 - 15 years of growth. The grant also allowed for supplies, shelving, and equipment to be purchased to accommodate this growing herbarium and zoological collections.

2. **Flora of the Guianas:** The BDG is one of the major sources of recent collections relied on by specialists preparing family treatments for the Flora of the Guianas project. The Flora of the Guianas project, which started in 1984, aims at publishing treatments of plant families occurring in the region. It is a cooperative project involving organizations focusing on systematic botany including Berlin, Cayenne (IRD), Georgetown (Guyana), Kew Gardens, New York Botanical Garden, Paramaribo, Paris, Utrecht, and the US National Herbarium (Smithsonian). The Editorial Office in charge of publication is housed at the NHN-Utrecht. The BDG also collaborates with the Smithsonian Botany Floristics Unit (R. DeFilipps & S. Maina) by assisting with management of their database and the production of data reports for their Flora of the Guianas publications.

3. **Preliminary checklist of the plants of the Guiana Shield**: This checklist is the product of and collaboration between the Biological Diversity of the Guianas Program and the Flora of the Venezuelan Guayana Project (Missouri Botanical Garden - MO). The database for the *Checklist of the Plants of the Guianas* (Boggan *et al*., 1992, 1997) and the database drawn from treatments published in the *Flora of the Venezuelan Guayana* (Steyermark, Berry, and Holst, 1995 – 2003) has produced a preliminary combined checklist for all flowering plant families from Acanthaceae through Lythraceae. The BDG Program is currently working on the second volume (M-Z) and the combined list of the pteridophytes (ferns).

Centre for the Study of Biological Diversity (pre-expansion)

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Hummingbird pollinated Compositae from Mt. Ayanganna, Guyana