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TITLE OF PROPOSED PROJECT **A Survey of the Caddisflies (Trichoptera) of Southeast Brazil**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PREPROPOSAL NO., IF APPLICABLE
$ **482,381 revised: 345,123**	**36** months	**09/01/99**	

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PROJECT SUMMARY

The goal of this project is to survey the caddisfly, or Trichoptera, fauna of southeastern Brazil, including the states of São Paulo, Rio de Janeiro, Espirito Santo, and Minas Gerais. It will be a collaborative effort between the University of Minnesota and the Museu de Zoologia, Universidade do São Paulo, and conducted coordinately with a planned aquatic survey for the state of São Paulo (BIOTASP). The project will establish authoritative collections of specimens, an internet accessible database, and will result in trained systematists in Trichoptera within Brazil. Together, these will provide a foundation of knowledge and resources in Brazil for future study of the taxonomy, ecology, and conservation of this important order of insects.

Trichoptera comprise the largest order of aquatic insects and occur in rivers, streams, and lakes around the world. They are well known because of the remarkable cases and nets built by the aquatic larvae. Larvae are integral components of various ecological processes in aquatic systems. Because of this, and because species vary tremendously in their susceptibility to various pollutants, they are also widely used as key species in water quality programs employing biomonitoring techniques. Use of caddisflies for this purpose is possible in temperate areas because the taxonomy and ecology of the species in this region are relatively well known. Although attempts have been made to employ similar methods in the Neotropics, the fauna is generally too inadequately known, both in the adult and larval stages for these methods to be effectively employed. The project proposed here is designed, in part, to redress this deficiency of knowledge. Of equal importance, this inventory will extend our knowledge of the phylogenetic, evolutionary, and biogeographic relationships of Trichoptera in a region of South America that has never been adequately surveyed, despite the fact that it is an area of geologic antiquity known to possess a diverse and endemic fauna, including relict Gondwanan elements.

The inventory area encompasses the most densely populated part of Brazil, including the cities of Rio de Janeiro, São Paulo, and Belo Horizonte, where the streams have been historically subjected to a wide range of environmental abuses, including deforestation, siltation, contamination from industry, sewage and mining, impoundment, pesticide and herbicide runoff, and, more recently, by acid rain which threatens even pristine headwaters. Included also within this region is a multitude of small parks and protected areas containing the remnants of the Atlantic forest, considered one of the most endangered biomes in the world, and also threatened dryland cerrado forests in the interior of the region. The area encompasses the major mountain ranges of the region, the Serra do Mar, the Serra da Mantiqueira, and the Serra do Espinhaço.

Currently the caddisfly fauna of the entirety of Brazil is scarcely known, with less than 350 species recorded for this huge country. An appreciation for the incompleteness of our knowledge can be gained by comparing this to the known fauna of Costa Rica (463 species), a country with less than 1 percent (actually only 0.6%) of the land area. Of the known Brazilian caddisflies, about 175 species are recorded from southeastern Brazil, but an actual fauna of 750-1000 species is a more reasonable estimate.

The focus of the survey will be on adult caddisflies, because the taxonomy of the species is based on this stage in the life history, but emphasis will also be given to larval taxonomy. Two collecting trips, each of 2 months duration, are planned annually for 3 years. Standard blacklight collecting techniques, augmented by Malaise traps, alcohol pan traps, net, and larval collecting will be employed. All material collected from each trip will be sorted, identified, and the associated information entered into a database. The survey will also incorporate several uncurated collections, including a very large one at the Universidade Federal do Paraná collected as part of a statewide insect survey (PROFAUPAR), and important collections at the Smithsonian Institution, the Universidade do São Paulo, and the Museu Nacional in Rio de Janeiro, as well as material collected during preliminary work in the region. A World Wide Web site will be established to make information from the inventory database available.

Upon its completion, this project will have established a foundation for subsequent study of the Brazilian caddisfly fauna. The majority of the species for the region will be known and it will be possible to identify them. This knowledge will be directly useful in subsequent systematic and biogeographic studies and for establishing biomonitoring protocols. The most tangible product of the survey will be an authoritative collection for future taxonomic and reference use. Equally important will be the trained personnel who will establish within Brazil a lasting presence in the study of Trichoptera.

PROJECT DESCRIPTION

Results From Prior NSF Support

The Caddisflies (Trichoptera) of Costa Rica, Ralph W. Holzenthal, Principal Investigator; DEB-9400632; $184,908+$10,000 REU suppl., 1 June 1994-31 May 1998.

The primary objectives of the project were to investigate the taxonomy and systematics of the Trichoptera or caddisflies of Costa Rica, to train students in entomological systematics, and to prepare research articles, monographs, and manuals on the Trichoptera of Costa Rica. This research was based on approximately 100,000 specimens collected from 179 different localities under a former grant (BSR-8917684 to Holzenthal). These collections represented the most intensive field inventory of Trichoptera ever conducted in the Neotropics. To date, 463 Costa Rican species have been recorded, representing the most diverse caddisfly fauna yet recorded from any area in the Neotropics. About half of these species were undescribed at the time of collection. Illustrations of important taxonomic characters of larvae and adults (some 2000 illustrations) have been completed on over 400 of the species. Material is now being barcoded and databased using the program *Biota* (Colwell 1996). Upon completion, the data will be posted on the WWW. An REU supplement was used to prepare larval illustrations. A subcontract with Clarion University supported research by Dr. Steven C. Harris on the Hydroptilidae or microcaddisflies. One U.S. graduate student completed his Ph.D. under the project and a second, Costa Rican student is nearing completion of his Ph.D. program. Only a few taxonomic impediments remain and Holzenthal, Harris, their graduate students, and professional colleagues are researching these. The approach of our research has been to use the Costa Rican fauna as a bridge to investigate the Neotropical fauna in its entirety, thus resulting in better and more stable taxonomy overall. The planned summary manual on the Trichoptera of Costa Rica will be based on these revisionary works.

Primary research publications

Blahnik, R.J. 1995. New species of *Smicridea* (subgenus *Smicridea*) from Costa Rica, with a revision of the *fasciatella* complex (Trichoptera: Hydropsychidae). Journal of the North American Benthological Society, 14: 84-107.

Blahnik, R.J. 1996. The systematics and biogeography of the genus *Chimarra* subgenus *Chimarra* Stephens for the Neotropics (Trichoptera: Philopotamidae). Ph.D. dissertation, University of Minnesota, St. Paul. 3 vols. xxxiv + 690 pp.

Blahnik, R.J. 1997. Systematics of *Chimarrita*, a new subgenus of *Chimarra* (Trichoptera: Philopotamidae). Systematic Entomology, 22: 199-243.

Blahnik, R.J. 1998. A revision of the Neotropical members of the genus *Chimarra* subgenus *Chimarra* (Trichoptera: Philopotamidae). Memoirs of the American Entomological Institute, 59: 1-318 (in press).

Blahnik, R.J., and R.M. Gottschalk. 1997. New species of *Atopsyche* from Costa Rica (Trichoptera: Hydrobiosidae). Entomological News, 108: 161-174.

Bueno-Soria, J., and R.W. Holzenthal. 1998. Studies in aquatic insects XIV: descriptions of eight new species of *Ochrotrichia* Mosely (Trichoptera: Hydroptilidae) from Costa Rica. Proceedings of the Biological Society of Washington, 111:604-612.

Flint, O.S., Jr., R.W. Holzenthal, and S.C. Harris (submitted). Nomenclatural and systematic changes in the Neotropical caddisflies (Insecta: Trichoptera). Insecta Mundi.

Harris, S.C., and R.W. Holzenthal. (submitted). The genus *Hydroptila* in Costa Rica and Central America (Trichoptera: Hydroptilidae). Studies on the Neotropical Fauna and Environment.

Harris, S.C., and R.W. Holzenthal. 1997. *Mejicanotrichia*, a new genus of caddisflies from Mexico and Guatemala (Trichoptera). Pages 129-137 *in* R.W. Holzenthal and O.S. Flint, Jr. (editors). Proceedings of the 8th International Symposium on Trichoptera. Ohio Biological Survey, Columbus.

Holzenthal, R.W. 1995. The caddisfly genus *Nectopsyche*: new *gemma* group species from Costa Rica and the Neotropics (Trichoptera: Leptoceridae). Journal of the North American Benthological Society, 14: 61-83.

Holzenthal, R.W. and S.C. Harris. (submitted). The genus *Costatrichia* in Costa Rica and the Neotropics (Trichoptera: Hydroptilidae). Proceedings of the Entomological Society of Washington.

Holzenthal, R.W., and O.S. Flint, Jr. 1995. Studies of Neotropical caddisflies, LI: systematics of the Neotropical caddisfly genus *Contulma* (Trichoptera: Anomalopsychidae). Smithsonian Contributions to Zoology, 575: 1-59.

Holzenthal, R.W., and R.J. Blahnik. 1995. New species of *Smicridea (Rhyacophylax)* (Trichoptera: Hydropsychidae) from Costa Rica. Entomological News, 106: 213-223.
Muñoz-Quesada, F. 1997. Five new species and a new record of Costa Rican *Leptonema* Guérin (Trichoptera: Hydropsychidae). Proceedings of the Entomological Society of Washington, 99: 115-132.
Muñoz-Quesada, F. 1999. El género *Leptonema* (Trichoptera: Hydropsychidae) en Costa Rica, con la descripción de una nueva especie. Revista de Biología Tropical (in press).
Muñoz-Quesada, F., and R.W. Holzenthal. 1997. A new species of *Xiphocentron* (*Antillotrichia*) from Costa Rica with a semi-terrestrial larva (Trichoptera: Xiphocentronidae). Pages 355-363 *in* R.W. Holzenthal and O.S. Flint, Jr. (editors). Proceedings of the 8th International Symposium on Trichoptera, Ohio Biological Survey. Columbus.

Research in Progress [most in manuscript form]

Blahnik, R.J. The *Oecetis* (Trichoptera: Leptoceridae) of Costa Rica, with a revision of the *avara* complex. [all material examined, determined, and illustrated]
Blahnik, R.J. Systematics of *Otarrha*, a new subgenus of *Chimarra* (Trichoptera: Philopotamidae). Systematic Entomology. [manuscript fully complete, awaiting submission]
Flint, O.S., Jr., R.W. Holzenthal, and S.C. Harris. Systematic catalog of the Neotropical Trichoptera. Special Publication, Ohio Biological Survey. [final draft complete]
Harris, S.C., and O.S. Flint, Jr. The Neotropical Stactobiini (Hydroptilidae) with the description of new genera. [all material examined, determined, and illustrated; first draft written]
Holzenthal, R.W., and T. Andersen. The genus *Triaenodes* in the Neotropics (Trichoptera: Leptoceridae). [all material examined, determined, and illustrated; first draft written]

Associated Research and Publications [research published, although not supported by the grant, but which used substantial Costa Rican material collected by us during the inventory]

Contreras-Ramos, A. 1995. New species of *Chloronia* from Ecuador and Guatemala, with a key to the species in the genus (Megaloptera: Corydalidae). Journal of the North American Benthological Society, 14: 108-114.
Contreras-Ramos, A. 1998. Systematics of the dobsonfly genus *Corydalus* (Megaloptera: Corydalidae). Thomas Say Publications in Entomology (Monographs). Entomological Society of America, Lanham, Maryland. 360 pp.
Contreras-Ramos, A. (in press). The immature stages of *Platyneuromus* (Megaloptera: Corydalus). Journal of the North American Benthological Society.
Flint, O.S., Jr. 1998. Studies of Neotropical caddisflies, LIII: a taxonomic revision of the subgenus *Curgia* of the genus *Chimarra* (Trichoptera: Philopotamidae). Smithsonian Contributions to Zoology, 594: 1-131.
Lugo-Ortiz, C.R., and W.P. McCafferty. 1995. New species, stage description, and records of *Baetodes* (Ephemeroptera: Baetidae) from Mexico and Central America. Entomological News, 106: 81-86.
Lugo-Ortiz, C.R., and W.P. McCafferty. 1996. New species of Leptophlebiidae (Ephemeroptera) from Mexico and Central America. Annals de Limnologie, 32: 3-18.
Stark, B.P. 1998. The *Anacroneuria* of Costa Rica and Panama (Insecta: Plecoptera: Perlidae). Proceedings of the Biological Society of Washington, 111: 551-603.

Introduction

Trichoptera, or caddisflies, are an important component of aquatic ecosystems around the world and are especially abundant in rivers and streams. Among the orders of aquatic insects, it is the most species diverse. The larvae are most familiar because of the interesting silken nets and portable cases they construct. Like Lepidoptera caterpillars, Trichoptera larvae produce silk, and it is due to the diverse ways in which silk is used to exploit various aquatic niches that the order owes its evolutionary success (Mackay & Wiggins 1978). Caddisfly larvae are of fundamental importance in aquatic food webs where they serve primarily in nutrient processing and cycling (Resh & Rosenberg 1984). Adults, which are terrestrial and usually short lived, often go unnoticed, but it is this stage on which the taxonomy of the order is based.

Currently about 10,000 species of Trichoptera are known worldwide (Morse 1997). Species in temperate regions, especially in North America and Europe are well known (Merritt & Cummins 1996; Malicky 1973, 1983). Knowledge of the taxonomy and ecology of the species has proven valuable in

biomonitoring programs, because of the very different susceptibility of the various species to pollutants and other types of environmental disturbance (Rosenberg & Resh 1993). Together with the orders Ephemeroptera (mayflies) and Plecoptera (stoneflies), Trichoptera are considered primary indicator species in the monitoring of water quality, collectively constituting an “EPT” index, one of a number of biotic indices using Trichoptera (Rosenberg & Resh 1993). These indices depend on at least family level determinations, but more often on species level identification of aquatic stages (Resh & Unzicker 1975). However, immature stages cannot be determined until positive associations have been made with the taxonomically important adult male through rearing or other methods of associating immatures and adults (e.g., the “metamorphotype” method in Trichoptera, Wiggins 1996). Rivers in South America are currently affected by a wide range of environmental influences, including deforestation and siltation, pesticide and herbicide runoff, organic enrichment, thermal pollution, sewage contamination, and, potentially, acid rain, which even affects pristine headwaters (Dean 1995, NGS 1992). Biomonitoring programs would be very useful in helping to monitor, and potentially regulate, the impacts of these abuses. However, current attempts to implement such programs are fraught with difficulty because of the very inadequately known fauna. Before biomonitoring protocols can be practically implemented in the Neotropics, the identity of the aquatic insect fauna must be determined (Ballesteros Navia et al. 1997, Resh 1995).

In contrast to the good state of knowledge of the caddisfly fauna of northern temperate zones, the fauna of tropical regions is very incompletely known. Currently 2,160 species have been recorded from the Neotropics (Flint, Holzenthal, & Harris, in prep.). A common belief is that diversity in tropical streams is probably not significantly greater than in temperate ones, largely because the potential range of habitats is similar. This idea was supported by studies of McElravy et al. (1981, 1982). On the other hand, other studies suggest that species diversity is higher (Stout & Vandermeer 1975). However, no census of regional diversity for the Neotropics has been available until recently. A survey of the diversity of Trichoptera in Costa Rica by Holzenthal has so far produced a fauna of 463 species, which is almost a third of the total diversity known for all of North America (ca. 1,600 spp.), and much more diverse than any comparable area in the temperate zone. Surely, the disparity in size between the known fauna of Costa Rica (463 species in an area less than 1/4 the size of Minnesota) compared to that of the whole country of Brazil (336 species in an area slightly larger than the contiguous United States) represents a major deficit in our knowledge of the Neotropical fauna.

The forests of the coastal and inland mountain ranges of Brazil, including the well known Atlantic forest and the currently threatened “cerrado”, are among the most fragmented and highly endangered ecosystems in South America (Myers 1988, Dean 1995, BDT 1998). Much of the remaining Atlantic forest is protected and was named a Biosphere Reserve in 1992 (BDT 1998), but this has hardly guaranteed permanent protection for the remaining remnants (about 5% of the original forested area) (Dean 1995). Although primary consideration is usually paid to the terrestrial flora and fauna, the rivers and streams of the area are also characterized by a rich endemic fauna (Banarescu 1995, Dov Por 1992, S.H. Weitzman, Smithsonian Institution, pers. comm.)

The region itself is part of the ancient Brazilian shield, characterized by several mountain ranges, some of considerable elevation. Drainage from this region is directly into the Atlantic ocean via a number of rivers. The largest of these rivers in the north is the Rio São Francisco. Westward drainage from the highlands is largely captured by the upper Rio Paraná. In addition to these major rivers, a large number of smaller rivers and streams, including the Rio Doce, Rio Jequitinhonha, and Rio Paraíba do Sul, flow directly from the mountains into the Atlantic.

The major goal of our proposed faunistic inventory is to survey the Trichoptera of the watersheds of this important region. Primary attention will focus on the rivers and drainages originating in the mountain ranges in the Brazilian states of São Paulo, Rio de Janeiro, Minas Gerais and Espirito Santo. This region includes the cities of Rio de Janeiro, São Paulo, and Belo Horizonte and is the most densely populated area in Brazil. It is also a major academic center and a focal point of conservation and ecological studies (Dean 1995). We believe that a survey of the Trichoptera of this region, at this time, will both fill a major gap in our knowledge of the fauna, and also provide information invaluable in research aimed at understanding and maintaining the aquatic ecosystems of the region.

Urgency of the Project

Brazil is a country dominated by a vast network of rivers. These rivers and the organisms that inhabit them form an important element of the ecology of the whole region and an unparalleled

natural history legacy. The ecosystems of the southeastern states of Brazil, including the Atlantic forest, are among the most endangered in South America (NRC 1980). What is less well documented is the extent to which past and continuing activities have impacted the aquatic environment within this region. A baseline of data is needed both to assess future impacts on rivers and streams, and also to plan for environmental restoration. Basic questions about the fauna, such as its diversity, endemism, or susceptibillity to various sorts of disturbance have hardly been investigated. This baseline of data begins with a knowledge of the fauna and its taxonomy, and this is sorely lacking. Only a small fraction of the aquatic entomofauna is currently described (Froehlich, pers. comm.). For some small rivers and second order streams a gradient of disturbances exists, suggesting that it is still possible to establish this baseline. For larger lowland rivers a true baseline may be impossible to establish. However, it is still possible to establish the relative effects of disturbance on faunal composition, much as has been done for many rivers in temperate areas, where a true baseline of data is also lacking. Regardless of the changes that may have already occurred in faunal composition, there is no better or more critical time to establish a baseline than at present.

Regrettably, following the first submission of this proposal, Prof. Rosalys Guahyba, the only practicing trichopterologist in Brazil, and our primary liaison for the project, died. She was herself in the initial stages of learning the taxonomy of the group and struggling to develop a nascent research program in Trichoptera. Her untimely death presented an obstacle to the continuation of the project, and is primarily responsible for the delay of a year in the resubmission of the proposal. Despite this setback, several individuals, including Henrique Paprocki, currently working with CEMIG (Companhia Energetica do Estado de Minas Gerais), have maintained an interest and enthusiasm for the project. Mr. Paprocki has subsequently expressed an interest in obtaining a graduate degree in the systematics of Trichoptera with Holzenthal. Partly in a effort to rebuild an infrastructure for the continuation of the project, Holzenthal took a sabbatical to Brazil from October ‘97-May ‘98. During this time he taught courses and workshops in aquatic entomology at the Universidade Federal do Paraná in Curitiba and at other institutions, which were enthusiastically received. A second student, Gisele L. de Almeida, who was looking for a research project for her Masters’ thesis, became interested in working on Trichoptera and subsequently, under Holzenthal’s guidance, began work on the Trichoptera collected in the state of Paraná during the PROFAUPAR project (see the section on “Coordination with Other Surveys in the Region”, p. 8). Ms. Almeida has also expressed an interest in obtaining a Ph.D. in insect systematics, and in continuing her work on Trichoptera. During his sabbatical, Holzenthal was able to do additional preliminary collecting in southeastern Brazil and also established contact with personnel at the Universidade do São Paulo, which houses the largest, most important, and best curated collection of insects in Brazil. He was also invited to participate in the proposed BIOTASP inventory, which includes a project to survey the aquatic macroinvertebrate fauna of the state of São Paulo. As a result of this work, a new foundation has been laid for the resubmission of the project to inventory the caddisfly fauna of southeastern Brazil; the proposal submitted here is a direct result of that effort. However, this foundation has a tenuous basis, dependent on financial support. In addition to the urgency of the project in terms of destruction of habitat and the direct and immediate applicability of results to developing a biomonitoring program in Brazil, we see the need for financial support for the infrastructure already built as also constituting an additional kind of urgency. It cannot be expected that this kind of infrastructure can be rebuilt at a future date without a reinvestment of time, money, and personal commitment. It is impossible to predict if these elements will juxtapose themselves again. Support for the project at this time would allow for the graduate training of Brazilian students who are already interested in devoting their careers to studying Trichoptera. It would also provide these students with access to literature, training, an introduction the the world community of trichopterologists, and perhaps more importantly, to a Brazilian based collection of Trichoptera to continue their research. It cannot be emphasized too strongly that the growth of interest in a subject begins with a critical nucleus of devoted individuals who seed their interest in a subject to future generations. As much as anything else, we view the opportunity to develop this nucleus as an important and urgent part of the project’s goal.

Definition of the Inventory Area

The area for the proposed survey corresponds to a geographically recognized region of Brazil referred to as the Southeast, and includes the states of São Paulo, Rio de Janeiro, Espirito Santo, and Minas Gerais. The region has a unity in the same sense that New England in the United States refers to a recognized geographical region with a distinct character, but without any concomitant

political identity. It contains the most densely populated part of the country, encompassing over 40% of the population of the whole country, and also some of the most critically endangered habitats in Brazil. The region we are defining is natural in the sense that it encompasses many of the coastal mountain ranges and drainage basins associated with the Atlantic forest, including headwaters of two major non-Amazonian rivers, the Rio Paraná and Rio São Francisco. The primary mountain ranges included are the Serra do Mar, including the Serra do Paranapiacaba and Serra dos Órgãos, the Serra da Mantiqueira, and the Serra do Espinhaço. Furthermore, the area includes a diversity of forest types, including dense mesic forest (submontane and montane subtypes), open mesic forest, mixed mesic forest (= *Araucaria* forest) (montane and high montane subtypes), as well as semideciduous seasonal forest (cerrado) and savanna (IBGE 1988). The survey area also includes the state of Paraná, as discussed below, in the sense that existing collections of Trichoptera collected during an extensive insect survey of the state will also receive taxonomic attention. Although SE Brazil represents a very large inventory area, about 900,000 km^2, a survey of the entire region would have maximum utility to Brazilians interested in monitoring environmental change and assessing water quality. Much of the area, like the eastern United States, is already heavily impacted, but many pristine habitats remain. Most of the remaining diversity for the entire region is probably concentrated in identified federal, state, and private conservation areas. While we will not limit ourselves to collecting in these sites, focusing on these areas will expedite our survey and they will therefore receive our primary attention.

The region is serviced by an excellent highway system connecting major cities and is entirely accessible by road. Admittedly, some back-road travel will be necessary to reach some collecting sites. An area-wide survey will make the most strategic use of the resources made available to us by the project. An additional consideration is that identification manuals for Trichoptera stemming from the project are likely to have maximum utility by encompassing an entire region.

Biogeographic Affinities of the Fauna

The Trichoptera fauna of the Neotropical region can be divided into two distinct faunal subregions, the Brazilian and the Chilean (Flint 1976). The former includes the wetter areas of southern Mexico and all of the Antilles, Central America, and South America, except for the southern tip of the continent. The Chilean subregion begins at about the level of the Río Negro in Argentina and extends to the tip of Tierra del Fuego.

The caddisfly faunas of the two Neotropical subregions are almost totally different, with that of the Chilean subregion having a very close faunistic and historical relationship to New Zealand and Australia (the so-called transantarctic distribution) (Brundin 1966, Illies 1969, Holzenthal 1986). Within the Brazilian subregion the fauna in the mountains of southeastern Brazil, while typical of the Brazilian subregion, contains a distinct endemic element (e.g., Holzenthal 1989), with several species not closely related to anything else in South America. These species seem to be ancient relicts of a Gondwanan fauna (Flint 1976). Some, for example *Grumicha* (Sericostomatidae), *Barypenthus* (Odontoceridae), and *Neoathripsodes* (Leptoceridae), show affinities with the South African fauna (Holzenthal 1989, de Moor 1997). One genus, *Neoatriplectides* (Atriplectididae) has relatives in The Seychelles and Australia (Holzenthal 1997). Others show a distinct relationship to Australian groups. Interestingly, only a few Brazilian endemics, for example *Dolophilodes* (*Sortosa*) and *Triplectides*, have congeners in the Chilean fauna. Other taxa, for example *Notalina* (Leptoceridae) (Holzenthal 1986) and the Grumichellini (Leptoceridae) (Holzenthal 1988b), show strong connections with the transantarctic biota, but, surprisingly, have no relatives in Chilean South America. The complex nature of the distributional patterns within the caddisfly faunas of Australia, New Zealand, Patagonia, southeastern Brazil, and South Africa suggest a complex geologic history for the southern landmasses (Amorim & Pires 1996, Crisci et al. 1991).

The faunas of southern Chile and Argentina are fairly well known (Flint, pers. comm.) as are the faunas of Australia, New Zealand, and southern Africa. By stark contrast, the Trichoptera fauna of southeastern and southern Brazil is almost wholly unknown. Furthermore, the phylogenetic relationships among the Trichoptera species in all these areas remain largely unresolved. A major objective of our inventory is to establish a firm taxonomic base and knowledge of the Brazilian fauna so that phylogenetic and historical biogeographic studies of the entire austral caddisfly fauna can proceed. It should be stressed that for many Brazilian taxa our current knowledge of species diversity is so inadequate that it is almost impossible to make even the most speculative statements about distributional patterns and faunal relationships. For example, the distinctive Neotropical endemic family Anomalopsychidae was first described by Flint (1981a), based on 2 species, each placed in its

own genus, *Anomalopsyche* and *Contulma*, and both known from Chile, suggesting that the family was endemic to the Chilean subregion. Two additional species of *Contulma* were subsequently described from Colombia (Flint 1991). In a recent revision (Holzenthal and Flint 1995), 18 additional *Contulma* were described, 6 from Costa Rica, 11 from Colombia, Ecuador, and/or Peru, and a single species from SE Brazil (from within the city limits of Rio de Janeiro!).

Taxonomic History of the Fauna

Foundations for our current knowledge of the caddisfly fauna of Brazil were laid by Müller (1879, 1880), who described a number of species from the state of Santa Catarina in the late 1800's (see below). In the early 1900's Ulmer (1905) and Banks (1924) described a number of additional species. After the early work of Müller, Banks, Ulmer, and some others, notably Mosely (1939), little additional taxonomy was done on Brazilian Trichoptera until the 1970's, when O.S. Flint, Jr., working at the Smithsonian Institution, began his intensive studies of the Neotropical fauna. Early in his investigations, Flint reexamined the types and determined the identity of many of the earlier described species (Flint 1966, 1967). In 1977 Flint conducted a short, 3 week collecting expedition to SE Brazil, which included scattered collections from the southeastern states of São Paulo, Rio de Janeiro, and Espirito Santo. This was Flint's only visit to SE Brazil and one of only three to Brazil during his 35 years of research on the Neotropical fauna (the others to Manaus and the Rio Xingu). Important papers by Flint dealing with the Brazilian fauna are those of 1971, 1978, and 1983. Other papers describing significant portions of the Brazilian fauna, and based on material collected or accumulated by Flint, are discussed in the next section. Flint himself has described 45% of the Brazilian fauna and most of the types designated by him and other investigators are housed at the Smithsonian Institution. However, considering the size of the country, the Brazilian fauna has received relatively limited attention. Except for the early work by Müller in Santa Catarina and the recent work of Guahyba (1991) in Rio de Janeiro, there has been no resident Brazilian working on Trichoptera taxonomy (Marinoni 1996). Only two other Latin Americans are actively engaged in systematic studies of Trichoptera, these being Dr. Joaquín Bueno-Soria in Mexico and Dr. Elisa Angrisano in Argentina.

Status of Brazilian Trichoptera Taxonomy

Currently only 336 species of caddisflies are recorded from the whole country of Brazil. North American museum material is also relatively well worked, as evidenced by the recent monographic treatments of Schmid (1989) on the genus *Atopsyche*, Holzenthal (1985, 1986, 1988a, 1988b) on the Leptoceridae, and by Flint (1998) and Blahnik (1997) on two subgenera of the large genus *Chimarra*. Because the Atlantic coast of Brazil was one of the first regions settled, has a high population density and numerous roads, it is not surprising that a rather large percentage of the species of caddisflies known from Brazil were described from the region (about 50% of the species known from the country). Despite this, the caddisfly fauna of the region is very poorly known and it is certain that only a small fraction of the real diversity is currently described (see section on "Estimate of Species Diversity", p. 7). As is often the case, among the species of Trichoptera first described were the larger or showier species of Hydropsychidae, Leptoceridae, Calamoceratidae, and Odontoceridae. The small to minute species, especially among the Glossosomatidae and Hydroptilidae, are disproportionately under represented in the early descriptive works and also in collections. For example, to date we have recorded 143 species of microcaddisflies from Costa Rica; only 40 are known from the whole of Brazil. If the southeastern region seems rich in described species compared to the rest of Brazil, it is only because the fauna of the entire country is so poorly known.

Status of Existing Collections and Inventories

Caddisflies are rarely well represented in collections unless a trichopterologist has resided at the institution, in part because the insects are fragile and their mode of collection and curation specific for the group, but also (undoubtedly) because the insects themselves are relatively drably colored, unspectacular in morphology, and mostly small or minute in size. We might add that this lack of representation of Trichoptera in collections is true not only of South America, but also of North America. Fortunately, there do exist some caddisfly collections from the survey region which we propose to study. These include both historically important collections as well as more recently collected, but as yet undetermined, material.

The most historically important collection from the region is that of Fritz Müller from the latter half of the 19th century (Möller 1921, Werneck de Castro 1992, Zillig 1997). Müller, an expatriate German naturalist and namesake of Müllerian mimicry, collected and described Trichoptera from the region around Blumenau, Santa Catarina, Brazil. Some of the genera he described, including *Nectopsyche* (Leptoceridae), *Marilia* (Odontoceridae), and *Phylloicus* (Calamoceratidae) are among the most well known and conspicuous members of the Neotropical Trichoptera fauna. However, most of his descriptions were based on larval specimens or cases and no type species were designated (although type species were established or designated by several subsequent authors). The identities of several of Müller's genera, including, among a few others, *Dicaminus* (Hydroptilidae), *Eutonella* (Ecnomidae or Xiphocentronidae), and *Peltopsyche* (Hydroptilidae) are not known with certainty, but it is likely that these are senior synonyms of subsequently described genera. Similarly, several species described by Müller remain unidentified (for proposed solutions, see p. 12 "Clarification of Taxonomy").

Additional material from Santa Catarina was collected by Fritz Plaumann from the mid-1930's into the 1980's from the area around Nova Teutonia, where Plaumann, another expatriate German, worked as a pharmacist. His Trichoptera collections were sold to the Natural History Museum, London, in the 1930's and to the Smithsonian Institution in the 1960's. All of the species described by Mosely (1939) were based on Plaumann's material. Most of Plaumann's material, some 100 lots (we define a lot to be one or a series of specimens of a species from a locality from a specific date) of alcohol and pinned material is at or on long term loan to the Smithsonian. It has been examined and mostly described (Flint 1983). We will examine the Plaumann collection during our study and work up any additional undescribed taxa.

Also at the Smithsonian are the specimens collected by Flint from his visit to SE Brazil in 1977. This material, about 5 drawers of pinned specimens and 200-300 lots in alcohol, has been partially worked on (Blahnik 1997, Flint 1983, Holzenthal and Flint 1995, Holzenthal 1988a, b, among others). Again, we will examine this material during this survey and incorporate it into subsequent descriptive and revisionary studies.

In Brazil, an important Trichoptera collection exists at the Museu de Zoologia, Universidade do São Paulo. This material was largely accumulated by Dr. Claudio Froehlich during his research on the Brazilian Plecoptera. During his 1977 visit, Flint examined and sorted to genus most of the approximately 500 lots of this alcohol preserved material. Some has been included in revisionary studies, most notably by Blahnik (1997, 1998), Flint (1998), Holzenthal (1986) and Schmid (1989), but much of the material remains unstudied. Dr. Froehlich and the MZUSP will make this material available to us.

A smaller collection of Trichoptera is housed at the Museu Nacional in Rio de Janeiro and includes some of Müller's material as mentioned above. Flint in 1977, Holzenthal in 1996, and Guahyba over the last 10 years, sorted and identified this material and it is now available for taxonomic study. Also at the MNRJ is a well curated, alcohol preserved collection of adult caddisflies resulting from Guahyba's dissertation research in the Serra dos Órgãos. This material, several thousand specimens, was sorted to morphospecies by Guahyba before her death, and awaits specific determination. Holzenthal recently examined and determined about 2 dozen lots of this material. The remainder will be worked up in conjunction with our proposed survey.

A recent collection of considerable value is that made by Holzenthal during an initial three week trip to Brazil in 1996, and again during a half year sabbatical in 1997-1998. The value of this material to the project is the primary reason for the proposed reduction of field collecting from 4 years in the original proposal to 3 years in the current proposal. Material from the latter trip remains unworked (Holzenthal only recently returned from his sabbatical), but will be treated with the other material collected during the project.

The only other collection of Trichoptera from the survey area is fully discussed under the section entitled "Coordination with Other Surveys in the Region", p. 8.

Estimate of Species Diversity in the Survey Area

Although Flint has produced a number of papers dealing with faunas of various restricted regions in South America (Flint 1981b, 1991), and also more intensive monographs of particular genera (e.g., Flint et al., 1987), these have generally been based on limited collecting from the respective areas, and on material borrowed from various local museums and individuals. For this reason, the respective regional works and collections can hardly be expected to be comprehensive in scope or to provide sufficient basis for estimating faunal sizes in the Neotropics.

The only comprehensive survey of Neotropical regional caddisfly diversity against which to measure the potential species diversity in the inventory area is Holzenthal's inventory of Costa Rica. From Holzenthal's survey, 463 species are known to date. The original number of species recorded in the literature from the country prior to the survey was about 100. During the survey an additional 102 previously described species were collected (or twice the number recorded in the literature), representing new country records. The remaining 261 species (56% of the total) are new species that have been or will be described by Holzenthal and his colleagues. The real diversity, including species that remain uncollected and additional microcaddisflies likely to be added from incomplete taxonomic investigations on the material, is undoubtedly higher, likely near 500 species.

Currently 176 species of caddisflies have been recorded in the literature from southeastern Brazil. Comparing this to the number of species originally known from Costa Rica, and assuming a similar proportion of described, but unrecorded species and undescribed species in the southeastern Brazilian fauna, the projected total for the region would be 815-880 species. This total, however assumes comparable levels of endemism and also assumes that the faunas are equally well known. In fact, the fauna of SE Brazil has been much less intensively collected than Costa Rica had been, and is likely to have a higher rate of endemism.

The only available sample against which to test these assumptions is Holzenthal's March 1996 trip to Brazil, where collections were made in three separate regions. Species composition from the three regions, Serra do Cipó, Campos do Jordão, and Cachoeiras de Macacú, were almost totally different. Both expectations: higher endemism, and a fauna less well known than Costa Rica were supported by the sample. A total of 89 species were collected, among which 19 species (21%) were previously known from the region, 6 species (7%) were previously unrecorded from the region, and 64 species (72%) were undescribed. Assuming that the species collected were representative of the three groups (described species known from the area, described species previously unknown from the area, and undescribed species), and using the number of species currently known from the region as a reference for scaling an estimate, total species diversity should be just over 700 species. For various reasons this is likely to be a significant underestimate. Among those caddisflies collected by Holzenthal, microcaddisflies (Hydroptilidae and Glossosomatidae) were particularly under represented; only 13 species (15% of the total), compared to 186 species (40% of the total) known from Costa Rica. This group accounted for a very disproportionate percentage of the undescribed species in Costa Rica, and this is equally likely to be true in Brazil. The estimate of 72% of the fauna undescribed is also likely to be an underestimate, because it is based on the assumption that all species are equally likely to be represented in the initial sample. In fact, common and abundant species, the ones most likely to be already described, are likely to constitute a disproportionate number of the species in the sample. The true percentage of the fauna that is undescribed is a number approached asymptotically only after continued collecting. This value could significantly alter the estimate of species diversity. For instance, using 80% for the percentage of the fauna that is actually undescribed would result in an estimate of 930 species for the area. Taking all this into account, we estimate a fauna in the survey area of 750-1000 species.

Coordination with Other Surveys in the Region

The Trichoptera survey of southeastern Brazil will be fully coordinated with two existing faunal surveys in the region, PROFAUPAR and BIOTASP. PROFAUPAR ("Projecto de Levantamento da Fauna Entomológica do Paraná) was a statewide faunistic survey conducted in the state of Paraná from August 1986 to July 1988. Eight localities from across Paraná were selected as representative of the habitat diversity of the state. Light and Malaise trap collections were made monthly at each site over 2 years. Associated ecological and climatic data and species totals by order for the collection sites were presented by Marinoni and Dutra (1991). Only results of the 1st year's collections have been quantified and published, but all of the material from both years has been sorted to order. Over 126,000 Trichoptera specimens were obtained during the 1st year, with approximately the same amount accumulated during the 2nd year. Trichoptera specimens from the survey are excellently curated and in good condition for alcohol preserved material. During Holzenthal's 7 month sabbatical to Brazil he met with the project director and participants in the faunal survey. A student, Gisele L. de Almeida, was recruited to work on a portion of the Trichoptera material for her Master's thesis at the Universidade Federal do Paraná (UFPR). Profesora Luciane Marinoni and Holzenthal agreed to serve as her co-advisors. Holzenthal trained Ms. Almeida in Trichoptera taxonomy and identification during his sabbatical and provided her with necessary literature. Ms. Almeida has nearly completed analysis of the Leptoceridae and Hydropsychidae, two

of the most species diverse families in the Neotropics, collected during the first year of the project. She has identified all material to species (including new species), and calculated relative abundances, seasonal distributions, and diversity indices. She will present and defend her thesis in December, 1998. Ms. Almeida plans to enter the Ph.D. program in Entomology at UFPR, with the intention of expanding her studies to include taxonomic and systematic work on the remaining Trichoptera material from the PROFAUPAR project. She will apply for (and certainly receive) a doctoral “sandwich” fellowship available through the graduate program in Entomology at UFPR. This fellowship includes provisions for study abroad for up to 2 years during the middle of the fellowship. Ms. Almeida plans to study in Minnesota to receive additional, intensive training in Trichoptera taxonomy and systematics. As such, the analysis of the Trichoptera material collected during the PROFAUPAR inventory will be fully incorporated into data generated during our proposed inventory. The PROFAUPAR material is unlikely to be a comprehensive representation of the caddisflies of the state of Paraná, considering that the survey localities in the project were not specifically selected to collect aquatic insects. However, it will represent the most complete faunal survey in the area, and we do not propose to duplicate efforts by doing additional collecting in Paraná at this time. Furthermore, Ms. Almeida, who was trained by Holzenthal in collecting techniques for Trichoptera, plans to augment material from the PROFAUPAR project with additional material collected at sites located near streams during her Ph.D. dissertation research. The advantages of incorporating material from the PROFAUPAR project into our survey, in addition to the training of a Ph.D.-level Brazilian Trichoptera systematist, is that it will allow us to concentrate our efforts in other states where no survey of Trichoptera has ever occurred.

The second regional survey, BIOTASP (Biota do Estado do São Paulo) grew from a discussion between university and research scientists in the state of São Paulo and the state’s scientific and technological organization (FAPESP) about the need for a coordinated inventory and management plan for the state’s biota. These discussions had as their basis the Convention on Biological Diversity established at the United Nations Conference on the Environment and Development in Rio de Janeiro in 1992. A full introduction to BIOTASP can be found on the project’s web page at <www.bdt.org.br/bdt/biotasp/projects/english>. Specifically, a subproject was established entitled "Survey and Biology of Freshwater Benthic Macroinvertebrates from São Paulo State”, coordinated by Dr. Claudio G. Froehlich <www.bdt.org.br/bdt/biotasp/projects/bivlave-e>, and including emphasis on freshwater crustaceans, Mollusca, and aquatic insects. In 1997, Dr. Froehlich invited Holzenthal to participate in the project as a taxonomic specialist for Trichoptera and agreed to facilitate Holzenthal and Blahnik’s additional interest in studying the Trichoptera fauna of SE Brazil. Accordingly, we will fully coordinate and integrate our activities, collections, and data into the BIOTASP project. Of great benefit to our proposed research is the inclusion in the BIOTASP project of an online information system including an on-line journal and a geo-referenced information system, coordinated through the Base de Dados Tropical (see <www.bdt.org.br/bdt>) at the University of Campinas. Furthermore, the deposition of our material will be in accordance with protocols established in the BIOTASP project and Brazilian law (see BIOTASP home page).

Our proposed caddisfly survey directly ties in with a research need already identified by the Brazilian academic and scientific community. Brazilian commitment to the project is demonstrated by supporting letters in the Special Information and Supplementary Documentation section. The partial support of Holzenthal’s 1996 visit to the MNRJ, and also support received for his sabbatical through a CAPES (Coordenadoria de Aperfeiçoamento de Pessoal de Nível Superior) Visiting Professorship (ca. US $12,000), also demonstrate Brazilian interest in the study of Trichoptera. A similar visiting professorship grant from CNPq had also been approved, but was withdrawn in favor of the CAPES fellowship. Graduate student Gisele L. de Almeida’s M.Sc. thesis research was supported by a CAPES graduate fellowship at UFPR, and it is likely that her Ph.D. research will be similarly supported. In total, Brazilian support and interest in a study of the Trichoptera fauna of the region has been strong, and our invitation to join the BIOTASP project is a further sign of interest and commitment.

PROJECT MANAGEMENT PLAN

Collecting Strategy and Protocols

In previous collecting in Costa Rica, Peru, and Venezuela as well as experience gained during Holzenthal’s recent sabbatical to Brazil, we have found it most efficient to establish regional bases of operation (lodges, field stations, biological stations) in “core areas” that reflect the habitat diversity of

the region. These bases are then used to explore streams in the core area (within 1-2 hours drive or walk from the base). Because of this need for mobility, having access to a vehicle dedicated to the project for the duration of the inventory is essential. We will identify core areas ahead of time, with the help of our Brazilian colleagues, so that the diversity of habitats in the inventory area is represented. Certain core areas will be visited on several occasions to assess seasonal diversity.

We will remain in each core area for 4-7 days, collecting at an individual site 1 or 2 nights. By carefully choosing sites representing the diversity of habitats, we anticipate that two trips to Brazil, each of 2 month's duration, for each of the 3 years of the project will capture the majority of the Trichoptera diversity of this large inventory area, while still giving us time in the lab for processing and identification. As material is processed and entered into the *Biota* database (discussed below), we can export *Biota* specimen records into Colwell's *EstimateS*, a *Biota* companion software tool that computes several species richness estimators based on species accumulation curves. At our current state of knowledge of the fauna, however, we consider completeness of collection secondary to the accumulation of specimens representing within species and between region diversity.

From personal experience, each 60 day trip will require about 5 days on each end for administration and organization and to return material previously collected, among other preliminaries. About 10 days will be lost traveling to and between bases, which leaves 40 days for collecting. Because we may collect at some sites for more than one day, we expect to collect at about 30 different sites distributed among 5 or 6 core areas over the 2 month period. During one of the two month field seasons in the 1st year we will visit the area frequented by Müller in the vicinity of Blumenau in the state of Santa Catarina.

Collecting Methods

A standard method of collecting Trichoptera is the use of a blacklight (ultra-violet light) and bed sheet erected near a stream. Primary flight time of caddisflies begins about sunset and continues for several hours after dark, but rapidly tapers off in the later evening. A second flight period occurs near dawn for some species. A 12 volt car battery, which can be recharged as necessary, provides enough energy to run a blacklight for several nights. However, use of a portable generator allows the possibility of also running a mercury vapor light, which gives off a much brighter light. Simultaneous use of both a mercury vapor light and blacklight maximizes their effectiveness. A tarp suspended over the sheet will provide protection from rain and keep the sheet dry. With such a precaution, flight of caddisflies to the sheet will continue during mild or even moderate rainfall. The best and most effective way to collect caddisflies is directly from the sheet with use of cyanide jars. If tissue is placed in the bottom of the jar and the jar not allowed to become too full of insects, the hairs on the wings of the specimens, which are easily removed using general collection techniques or by rough or careless handling, will be retained. The hairs on the wings, much like the scales on the wings of Lepidoptera, are very useful diagnostic characters (Holzenthal 1995, Blahnik 1995). Because the specimens are fragile and desiccate quickly, it is important that they be pinned promptly. Usually all of the specimens collected during a single night can be easily pinned the following morning, using stainless steel pins or minutens. Fortunately, it is not necessary to spread the wings of Trichoptera. While requiring extra effort in the field compared to collecting specimens in alcohol, specimens collected this way are also the most valuable for systematic work. When it is considered that a large percentage of the specimens collected will constitute type series, the value of carefully pinning them should be evident. The Smithsonian collection and that at the University of Minnesota are among the few major collections in the western hemisphere in which pinning is a usual mode of curation. The value of specimens preserved this way is apparent to anyone who has done systematic research on the insects.

We typically augment collecting at a sheet with other collecting techniques, including the use of alcohol pan traps. While it is possible to do systematic work on specimens stored in alcohol, and even some advantages (more pliability, less shrinkage), they lose their color more rapidly than specimens on pins. Ideally both methods of preservation should be used. Use of alcohol collecting as an adjunct method is especially important for species in the family Hydroptilidae (the so called microcaddisflies), especially at a site where they are very abundant. This is because "micros" usually appear at a sheet in a pulse shortly after sunset and time limits the number of specimens that can be manually collected at a sheet. Use of an alcohol pan trap guarantees that species that may have been missed at the sheet are still collected. Also, these traps can be run all night and thus may collect species with unusual flight periods. Although it is necessary to collect hydroptilids in alcohol to capture total diversity, every effort is still made to collect and pin as many specimens as possible.

Other adjunct collection techniques include use of Malaise traps and day collecting (sweeping) with a net, which are useful in collecting day active species and those not readily attracted to lights. It is important to also collect larval specimens from a site for eventual association with adult material. A traditional method for associating larval and adult material is by use of a “metamorphotype” (Vorhies 1909, Milne 1938, Ross 1944, Wiggins 1996). It requires the fortuitous collection of a mature pupa, or pharate adult, in which the genitalic characters are already formed. Larval sclerites for most species are retained within the pupal case and form the basis for making associations. Rearing of larvae is also useful, but requires controlled laboratory conditions. Fortunately, we will have working with us on the project an incountry project manager, based at CETEC (Fundação Centro Tecnologico de Minas Gerais), who will have a specific focus on larval rearing and collection of larval material, this in consonance with CETEC’s goal of developing biomonitoring protocols for use in water quality studies. This associated larval material will also be invaluable for circumscribing generic limits and in phylogenetic studies (Wiggins 1981). Additionally, Blahnik, who has developed expertise in molecular phylogenetic techniques, is in the process of developing protocols for using molecular sequence data to associate larvae and adults. Experience has demonstrated that specimens that are either pinned or collected in alcohol can be directly used for this purpose, but efforts will also be made to collect specimens in fluids especially designed for their suitability for preserving DNA, with the eventual goal of making adult-larval associations.

At the time of collecting and for each locality we will use GPS technology to record latitude, longitude, and elevation. Elevation will be double checked with a standard altimeter. We will make heavy use of topographic maps to locate and identify sites and watercourses. Also, at each watercourse, we will measure pH, temperature, dissolved oxygen, conductivity, and flow.

Other Aquatic Taxa

The primary goal of the project will be to survey the Trichoptera of southeastern Brazil. This is a broad and comprehensive survey, when it is considered that it represents an entire order of insects, and one which is also the most species diverse of the aquatic orders of insects. However, while the method of collecting at lights described above is specific for surveying Trichoptera, it is also effective for collecting other aquatic insects, including Plecoptera (stoneflies), Ephemeroptera (mayflies), and Megaloptera (dobsonflies). Specimens collected this way from the Caddisflies of Costa Rica project were directed toward specialists in the groups, and resulted in a number of associated publications (e.g., Stark 1998). Aquatic beetles, aquatic hemiptera, chironomids, and other aquatic diptera are also frequently collected in pan traps. Additionally, immatures of the orders mentioned above, and also odonates are frequently encountered while collecting immatures of Trichoptera. While we do not propose to work on these groups of insects, it will be possible to collect them and sort them to order from samples of Trichoptera. This material will be deposited at the Universidade do São Paulo and other institutions and coordinated with material collected from BIOTASP. It will be made available to appropriate workers in these respective groups, subject to the discretion of the Brazilian curators.

Collecting Permits

The sanction and support of this research by the Museu de Zoologia, Universidade do São Paulo will initiate the process of obtaining the necessary collecting and export permits. The proposal will be submitted for approval to the Conselho Nacional do Pesquisa (CNPq) and the Instituto Brasileiro do Meio Ambiente (IBAMA). Our status as a cooperating scientific organization involved in a bilateral scientific and educational activity will facilitate acquisition of permits. We will start the process immediately after submission of this proposal to NSF. Mr. Paprocki has already obtained the application materials. A summary of Brazilian regulations regarding collection of insects for scientific purposes can be found at <www.sede.embrapa.br/ice/>.

Processing of Material

The timely completion of the inventory will require that the processing and identification of specimens keep pace with their collection. As discussed above, we anticipate an average of about 30 sites collected in each 2 month collecting trip. Based on actual amounts of specimens collected and processed from recent trips to Venezuela and Brazil, each site will average about 150 pinned specimens, 500 adult specimens in alcohol, and 200 larval specimens (for totals of 27,000 pinned adults, 90,000 alcohol adults, and 36,000 larval specimens for the 3 year project). The focus of attention in Minnesota between collecting trips will be on the pinned material, which should include the majority of the species diversity. Specimens from alcohol will also be sorted in Minnesota,

primarily by graduate students and an undergraduate technician, as time permits. It should be possible to process all of the pinned material and the bulk of the alcohol collected material in the intervals between trips.

Processing of the pinned material should require about 24 person hours per site collected (2 hours to label and barcode specimens [see “Information Management”, below], 2 hours to sort to morphospecies and sex, 8 hours to prepare genitalia of representative specimens, 10 hours to determine to species, and 2 hours to enter material into the database). Any one of these steps can be done by trained student assistants and the effort will be shared among the principal researchers and the graduate and undergraduate student research assistants. Sorting of alcohol material from a site takes about the same amount of time (24 person hours), on average, but requires a slightly different protocol. The amount of time to sort a given sample from alcohol may vary greatly, because the number of specimens collected by a pan trap at a site can vary up to several orders of magnitude. Alcohol specimens of Trichoptera will be barcoded by lot (specimens of one species from the same locality in the same vial) and entered as such into the database. Sorted non-trichoptera specimens will be returned to the Universidade do São Paulo at each return visit, with a sufficient number of labels to permit sorting of specimens to individual vials. It is not practical for the University of Minnesota to track and assume responsibility for the databasing of these samples. However, all Trichoptera specimens, including those returned to the Universidade do São Paulo, will be databased at the University of Minnesota, where we will assume permanent responsibility for the database.

The method of curation described above will allow us to employ our taxonomic expertise to rapidly build an identified collection, capture images on the database, and begin to prepare material for species descriptions. Descriptions of new species will begin by the later stages of the project. This will be expedited by channeling specimens to ongoing taxonomic studies by various colleagues.

Deposition of Specimens

Material collected during this project will be deposited primarily in the Museu de Zoologia, Universidade do São Paulo (MZUSP). Additional material will be housed in the University of Minnesota Insect Collection (UMSP) which maintains a large and important collection of Neotropical caddisflies and where active work on their systematics is being done. Additionally, we anticipate that the survey will generate a sufficient number of specimens so that duplicate collections can be housed at other institutions, particularly the National Museum of Natural History, Smithsonian Institution (NMNH), and the Museu Nacional, Rio de Janeiro (MNRJ). Material from the PROFAUPAR project will remain at the Universidade Federal do Paraná (UFPR), with reference specimens deposited at UMSP. Holotypes of newly described species from our collecting will be deposited at MZUSP, or other Brazilian institutions, as appropriate and in accordance with Brazilian laws and regulations. Paratypes, if sufficient specimens exist, will be deposited at UMSP and NMNH. We have received assurances from our Brazilian collaborators that they are willing and able to accept and safeguard these collections (see “Special Information and Supplementary Documentation”).

Clarification of Taxonomy

Although Müller’s historical collections of Trichoptera lie outside the bounds of the proposed survey area, the inability to identify some of Müller’s species creates potential nomenclatural instability, especially since a number of these represent genus-level taxa. We propose to rectify this situation using two approaches, direct examination of Müller’s material and field work to collect specimens for making associations. First, Holzenthal, Blahnik, and Flint, will attempt to borrow and examine all of Müller’s material at one time. Much of his material is in the Museu Nacional, Rio de Janeiro, and the Smithsonian Institution (on long term loan from the Museum of Comparative Zoology, Harvard University), with lesser amounts in the Naturhistorisches Museum, Vienna, and the Natural History Museum, London. Flint (pers. comm.) has seen some of Müller’s material from the other depositories and Holzenthal recently examined some of it at the MNRJ. It includes some pinned adults, but consists mostly of larvae and pupae glued to cards. While the latter is not the preferred manner of preservation of immature Trichoptera, the material is in good condition and could be easily rehydrated and examined. Pupae can be checked for the presence of pharate adult males, upon which species determinations can be made. Larvae can be identified after adult associations are made. Toward the latter goal, we propose to direct some field effort to the Rio Itajaí basin near Blumenau where Müller collected Trichoptera. Müller’s collection sites can be determined with some accuracy from specimen labels and his notes and letters published by Möller (1921). We

will especially concentrate on collecting immatures, in addition to adults, again in the hope of encountering pharate adult males. We anticipate that one 2-week trip to the area will be sufficient to gather material to aid us in identifying Müller's taxa.

Information Management

We propose to process, manage, and publish information in two interrelated formats. First, we will enter specimen-level locality and taxonomic information into *Biota*, the biodiversity database manager developed by Robert K. Colwell, University of Connecticut. This database was developed in conjunction with the NSF sponsored Arthropod Survey of La Selva project (ALAS). It is currently in use at the University of Minnesota to database specimens from the Trichoptera of Costa Rica project. This database is designed for recording and analyzing locality or collection-based survey data. Among other features, it has capabilities for recording specimen-level data and images for revisions and taxonomic studies. The University of Minnesota Insect Collection owns a Power Macintosh 8500/120, barcoding equipment from Intermec Corporation, and an associated HP laser printer. This hardware is dedicated to the museum's collections management program and *Biota* databases. The University of Minnesota is currently using Code 49 barcode labels, in accordance with standards set by the Entomological Collections Network, to label, database, and track Trichoptera specimens in the *Biota* program.

A database of material from the proposed Brazilian inventory will be established and maintained at the University of Minnesota Insect Collection. This database will be at the specimen level, and will include associated images (photographs and line drawings of identifying characters). Barcode labels will be added to pinned specimens at the time they are labeled. Each specimen is then uniquely identified by its bar code, and all information associated with that specimen is retrievable by that code. For alcohol preserved material, one vial of multiple individuals will be functionally equivalent to an additional specimen in a series. We plan to use *Biota* to capture specimen data and images, particularly of genitalia and other taxonomic characters. In order to minimize confusion in the management of the database, all entry of data will occur in Minnesota.

The second major application of the database will be to establish a World Wide Web site for the project. The *Biota* program includes a function for producing web pages containing any level of taxonomic or specimen data, and we will use this function to generate species lists for the region, by locality, or by taxonomic group. A preliminary species list, based on published records and Holzenthal's recent collections, is already prepared and can be published electronically at any time. Once established, this database of species and images can form the basis of an interactive identification system. As the fauna becomes known, we will develop taxonomic keys containing hyperlinks to images and specimen/collection data for each taxon. The site will be similar in design to those established for the ALAS project, <http://viceroy.eeb.uconn.edu/ALAS/ALAS.html>. Our web site and associated database will be of use not only to systematists, but to conservationists, resource managers, and policy makers to access information about the newly discovered aquatic biota of Brazil. The web pages will reside on a server maintained by the College of Agriculture at the University of Minnesota. Copies of the database will be archived in Brazil with the MZUSP and the Base de Datos Tropical.

Collecting Schedule, Localities, and Timetable for Completion

Because of the size of the area and its topographic and habitat diversity we conclude that a minimum of 3 years will be necessary to survey the region. The proposed collecting regime involves 2 collecting trips of 2 months duration in each of the 3 years of the project. Coverage of the area in this amount of time has been facilitated by preliminary collections already made by Holzenthal during his sabbatical and during his 1996 trip to Brazil. Furthermore, we are efficient field researchers with almost 15 years of experience in the Neotropics. All of the personnel included in the project are already trained in field work. The project includes sufficient personnel for both field and subsequent laboratory work. We have strong institutional support in Brazil through the MUZSP, BIOTASP, CETEC, UFPR, etc. Drs. Claudio Froehlich, C.R.F. Brandão, and Marilia Junqueira are experienced researchers and will be valuable resources for answering scientific and bureaucratic questions. Internet resources are well established in Brazil. Finally, the country's museums and insect collections, especially those at MZUSP and UFPR, are excellent. These factors combined will guarantee an efficient inventory

The field schedule will be affected to some degree by the seasonality of the fauna. Froehlich (1991) reported that the stonefly fauna of the area has a distinct seasonal component, with peak

emergence occurring in spring, shortly after the onset of the rainy season (Nov-Dec). Flight season is most prolonged in the wetter coastal areas (extending into March), and begins and ends earlier in the seasonally drier interior. Temperature also has an effect on emergence and varies more than one might suppose, with the most pronounced seasonal differences affected by both latitude and elevation. We suspect that Trichoptera will follow an emergence pattern similar to Plecoptera, but the extent to which faunal composition varies by season remains to be determined. We will plan the 1st trip to Brazil for a 2 month period between September - December, 1999. The 2nd trip will be scheduled during a different season (March - May) to test for seasonality. Schedules for the subsequent years will be adjusted for seasonality. Between the 1st and 2nd trips during year 1, we will have established the web site. Also, between each trip, we will have processed and databased all material collected during previous trips.

As discussed above, the exact details of areas to be surveyed and timing will be affected by experience gained during early collecting and logistical support from colleagues in Brazil. Efforts during the 1st trip of the 1st year (Sept.-Dec, 1999) will concentrate on the mountains of São Paulo and Rio de Janeiro, principally the Serra do Mantiqueira (Campos do Jordão State Park, Itatiaia National Park) and the Serra do Mar (Intervales State Park, Boraceia Biological Station). For reasons discussed earlier, a trip to the state of Santa Catarina to the historical collecting sites of Fritz Müller may also be accommodated in this 1st trip (Spitzkopf Ecological Park [private]). The 2nd trip will be scheduled between March and June of the year 2000. It is anticipated that the timing of trips in subsequent years will follow a similar pattern. Principal sites of focus during the 2nd trip will be the Serra do Espinhaço (Serra do Cipó National Park) of Minas Gerais and also sites in the threatened cerrado forest in the northern part of Minas Gerais (Rio Preto State Park, Peruaçu State Park). Trip 3 (Sept.-December, 2000) will focus on western Minas Gerais (Serra da Canastra National Park) and interior areas of the state of São Paulo. The 4th trip (March-June, 2001), will focus on the Serra do Mar of eastern Rio de Janeiro (Serra dos Órgãos National Park) and Espirito Santo (several small private reserves). During this trip, we are also proposing a collecting trip to the southern part of Bahia. While technically outside the area of our survey, no Trichoptera have ever been collected from the state of Bahia. The “Cocoa” region of this state is cited by NRC (1980) as a critical area for collecting, and we consider determining whether the fauna of this region is substantially different from that of the collecting region to be extremely important in extending our knowledge of the caddisflies of the Neotropical region. Trip 5 will focus on the cerrado, “campos de altitude”, and “campos rupestres” of Minas Gerais (e.g., Itacolomi and Ibitipoca State Parks) and scheduling for the last trip is left open to cover areas determined to be inadequately collected in the previous trips. We should note that collecting in São Paulo will be coordinated with Dr. Froehlich and the BIOTASP project. Finally, many of the southern and southeastern Brazilian states are establishing new parks and reserves. Park administrators that Holzenthal met during his sabbatical expressed great interest in a survey of aquatic invertebrates of their parks and invited him to visit these areas in the future. A certain degree of flexibility in the collecting schedule will help us meet these requests.

Project Personnel and Their Roles

• Dr. Roger Blahnik will be supported by the project full-time. He will be the project manager and will be primarily responsible for administering the budget, planning field trips, identifying collecting sites, and obtaining collecting permits for sites located in National Parks and other restricted areas. He will also assist in processing material and curating the collection in Minnesota. He will manage the database and the web page and also help advise graduate students associated with the project. Finally, he will undertake systematics research based on the material collected.

• Dr. Ralph Holzenthal will assist Blahnik with administration of the grant when needed and with project management. He will assist Blahnik in initiating the project in Brazil. Also, he will supervise the Minnesota based graduate students. He will participate in collecting as time permits. Throughout the project he will participate in systematics research based on the material collected.

• Graduate Students (Minnesota): Two graduate students will be supported through the project; they have already been recruited and accepted into the graduate program at the University of Minnesota, dependent on funding. One, Henrique Paprocki, currently working with CEMIG completed his M.Sc. at USP under the direction of Dr. C. G. Froehlich. Mr. Paprocki has had a long interest in aquatic entomology and water quality monitoring. He will assist with field work and subsequent processing and identification of material. A second, U.S. student, David Houghton, completed his M.S. at the University of North Texas under Dr. K.W. Stewart. Mr. Houghton is also interested in Trichoptera systematics and its relation to biodiversity and water resource issues. His

duties under the grant will be similar to those of Paprocki. It is anticipated that these students will undertake a major revisionary study on the systematics of the Neotropical caddisfly fauna, for example as Blahnik did for his dissertation research under Holzenthal's Costa Rican project (Blahnik 1996). A third graduate student, Gisele L. de Almeida, will also be associated with the project. She will be funded in Brazil by a fellowship available through the Graduate Program in Entomology at UFPR. While not directly supported by this NSF request, she will be an integral member of the project. Holzenthal will likely serve as her co-advisor.

• Student Technician (Minnesota): A Minnesota undergraduate student assistant, working under flexible hours (no more than 20 hours per week), will be needed to label, prepare, and curate material as well as enter information, including images, into the database.

• Project Manager (Brazil): We will hire a Brazilian based project manager through a subcontract with CETEC. Holzenthal has identified a very capable individual who has agreed to act in this capacity. He will assist with logistic arrangements, permits, field assistance, etc. In addition, he will be responsible for collecting, processing, and rearing larval material for larval/adult associations as well as taking physico-chemical measurements at sites. CETEC has a newly established insect rearing facility for his use.

All of the academic personnel, including the graduate students, that we have been associated with in Brazil speak English. In as much as they will be associated in all aspects of the project, we expect no difficulties in communication. Holzenthal speaks Spanish and has a solid foundation in Portuguese. Blahnik also speaks some Spanish and plans to learn Portuguese.

Products of the Survey and Their Value

The most tangible and immediate product of the survey will be the generation of a collection of caddisflies that will comprehensively, or nearly comprehensively, represent the diversity for an important area of Brazil. The collection will serve as reference for subsequent work in systematics, larval associations, and ecological studies. We anticipate that a value added component of this information is that it will attract a number of people interested in water quality studies – individuals who would find the field too intimidating under current conditions. While revisionary and monographic systematics studies are not planned as a direct component of this project, specimens collected will feed into ongoing systematics research by us and others. A review of the contributors to the taxonomic literature generated from Holzenthal's caddisfly survey in Costa Rica demonstrates how the specimens collected from an intensive survey can be of value to other systematists and augment their phylogenetic and biogeographic studies. Additionally, descriptions of larvae collected or reared during the course of the project will begin as the project progresses. Larval identifications, and information gathered on their habitat preferences, will be of indispensable value in both phylogenetic studies and in establishing biomonitoring protocols.

An additional major product of the survey will be the generation of a database on the composition and distribution of the caddisfly fauna of southeastern Brazil. We anticipate that this will be of value for a number of purposes besides its primary taxonomic function. For instance, it could be used by conservationists interested in patterns of endemism associated with particular watersheds, or by biogeographers interested in speciation patterns. Possibly its most valuable use, however, will be to establish a historical base of information about species composition in particular river systems, for comparing pristine and compromised habitats, and for monitoring future impacts on the environment.

In addition to the generation of an authoritative collection and database of Trichoptera, of funadamental importance will be our interactions with Brazilian scientists and the training of graduate students to continue research on the systematics and ecology of Brazilian caddisflies. It is the generation of these trained professionals that will ultimately be the most valuable product of the survey.

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