Rapid Assessment Program

RAP Bulletin *of* Biological Assessment 39

A Rapid Biological Assessment of the Aquatic Ecosystems of the Coppename River Basin, Suriname

Leeanne E. Alonso and Haydi J. Berrenstein (Editors)

Center for Applied Biodiversity Science (CABS)

Conservation International Suriname

Stichting Natuurbehoud Suriname (Stinasu)

Anton de Kom University of Suriname

National Zoological Collection of Suriname (NZCS)

National Herbarium of Suriname (BBS)

The *RAP Bulletin of Biological Assessment* is published by:
Conservation International
Center for Applied Biodiversity Science
1919 M Street NW, Suite 600
Washington, DC USA 20036
202-912-1000 tel
202-912-1030 fax
www.conservation.org
www.biodiversityscience.org

Editors: Leeanne E. Alonso and Haydi J. Berrenstein
Design: Glenda Fabregas
Map: Mark Denil
Translations: Haydi J. Berrenstein

Conservation International is a private, non-profit organization exempt from federal income tax under section 501c(3) of the Internal Revenue Code.

ISBN #1-881173-96-8

Library of Congress Card Catalog Number 2006933532

RAP Bulletin of Biological Assessment was formerly RAP Working Papers. Numbers 1-13 of this series were published under the previous series title.

Suggested citation:
Alonso, L.E. and H.J. Berrenstein (eds.). 2006. A Rapid Biological Assessment of the Aquatic Ecosystems of the Coppename River Basin, Suriname. RAP Bulletin of Biological Assessment 39. Conservation International, Washington, DC.

We offer our great appreciation to the Rufford Foundation for funding this expedition as part of the South American AquaRAP program. We also thank The Field Museum for their contributions to making this AquaRAP expedition happen. The Gordon and Betty Moore Foundation generously supported the expedition and publication of this report.

Table of Contents

Preface 4

Participants and Authors 5

Organizational Profiles 7

Acknowledgements 9

Report at a Glance 10

Executive Summary 12

Rapportage in een Oogopslag 18

Uitgebreide Samenvatting 20

Sjatu Skrifi 27

Map 29

Photos of the AquaRAP Expedition 30

Chapters 33

Chapter 1. Overview of the Coppename River Basin and the Central Suriname Nature Reserve 33
Haydi J. Berrenstein

Chapter 2. Water Quality of the Coppename River Basin, with notes on aquatic fauna distribution 37
Paul Ouboter and Gwen Landburg

Chapter 3. Plant Diversity of the Central Suriname Nature Reserve: Implications for Conservation and Biogeography 47
David Clarke and Jayne H. Rhodes

Chapter 4. A survey of the aquatic invertebrates of the Coppename River, Central Suriname Nature Reserve 56
Guido Pereira and Haydi J. Berrenstein

Chapter 5. Fishes of the Coppename River, Central Suriname Nature Reserve, Suriname 67
Jan H. Mol, Phillip Willink, Barry Chernoff, and Michael Cooperman

Gazetteer 88

Appendices 85

Appendix 1. Plants collected in the Central Suriname Nature Reserve during the AquaRAP survey 85
David Clarke and Jayne Rhodes

Appendix 2. Checklist of the Plants of the AquaRAP Expedition to the Central Suriname Nature Reserve 94
David Clarke and Jayne Rhodes

Appendix 3. Aquatic invertebrate taxa (family, genus, species) and number of individuals collected in each of the AquaRAP sampling areas 98
Guido Pereira and Haydi J. Berrenstein

Appendix 4. Taxonomic notes on select fishes collected during the 2004 AquaRAP expedition to the Coppename River, Central Suriname Nature Reserve, Suriname 101
Philip W. Willink and Brian L. Sidlauskas

Appendix 5. Collectors of freshwater fishes in Suriname 112
Jan H. Mol

Appendix 6. Fishes and the drainage they were collected in during the 2004 AquaRAP expedition to the Coppename River, Central Suriname Nature Reserve, Suriname 114
Jan H. Mol, Phillip Willink, Barry Chernoff, and Michael Cooperman

Preface

"The greatest wisdom not applied to action and behavior is meaningless data."

(Peter Drucker in *The Effective Executive*)

The data collected and the conclusions drawn by the experts who have conducted the research in the Coppename River are another testimony to the solid scientific foundation on which Conservation International designs its conservation policy and executes its field programs. On behalf of the people of Suriname, Conservation International Suriname expresses its profound gratitude to the inspiring team of Surinamese and international scientists, whose enthusiasm for the object of their research shines through the rigor of their discipline.

This expedition has attempted to describe, more than the total of the species identified, the value of the biodiversity and of the natural systems of this most pristine area left on this planet, the Central Suriname Nature Reserve.

Conservation International's ultimate mission, and challenge, is to be unwavering in our efforts to conserve biodiversity and creating global sustainable development mechanisms that can change the actions of economic man by better understanding the real costs and benefits of our activities. Conservation International Suriname is proud of the role it has played and continues to play in the conservation of this most spectacular resource, the Central Suriname Nature Reserve.

Wim Udenhout
Executive Director
Conservation International Suriname

August 2006

Participants and Authors

Leeanne Alonso, Ph. D. (editor)
Rapid Assessment Program
Center for Applied Biodiversity Science
Conservation International
1919 M Street NW, Suite 600
Washington, DC 20036
USA
E-mail: l.alonso@conservation.org

Haydi J. Berrenstein (aquatic invertebrates, editor)
Conservation International Suriname
Kromme Elleboog Straat No. 20
Paramaribo
SURINAME
E-mail: h.berrenstein@conservation.org

Barry Chernoff, Ph. D. (scientific team leader, fishes)
Department of Biology
Department of Earth and Environmental Sciences
Wesleyan University
Middletown, CT 06459
USA
E-mail: bchernoff@wesleyan.edu

David Clarke, Ph. D. (botany)
Department of Biology
University of North Carolina - Asheville
One University Heights
Asheville, NC 28804
USA
E-mail: dclarke@unca.edu

Michael Cooperman, Ph. D. (fishes)
1314 NW Irving Street #610
Portland, OR 97209
USA
E-mail: michael.cooperman@orst.edu

Peter Hoke (logistics coordination)
Rapid Assessment Program
Center for Applied Biodiversity Science
Conservation International
1919 M Street NW, Suite 600
Washington, DC 20036
USA
E-mail: p.hoke@conservation.org

Gwen Landburg (water quality)
Conservation International Suriname
Kromme Elleboog Straat No. 20
Paramaribo
SURINAME
E-mail: gwenland24@yahoo.com

Jan Mol, Ph. D. (fishes)
Anton the Kom University of Suriname
Universiteitscomplex
Leysweg
P.O. Box 9212
Paramaribo
SURINAME
E-mail: fisheco@celos.sr.org

Paul Ouboter, Ph. D. (logistics coordinator, water quality)
National Zoological Collection of Suriname (NZCS)
Anton the Kom University of Suriname
Universiteitscomplex
Leysweg
P.O. Box 9212
Paramaribo
SURINAME
E-mail: iber@cq-link.sr

Guido Pereira, Ph. D. (aquatic invertebrates)
Instituto de Zoologia Tropical
Facultad de Ciencias Universidad Central de Venezuela
Caracas
VENEZUELA
E-mail: gpereira@strix.ciens.ucv.ve

Jaye Rhodes (botany)
Department of Biology
University of North Carolina - Asheville
One University Heights
Asheville, NC 28804
USA
E-mail: jayerhodes@bellsouth.net

Phil Willink, Ph. D. (fishes)
The Field Museum of Natural History
Roosevelt Road at Lake Shore Drive
Chicago, IL 60605
USA
E-mail: pwillink@fieldmuseum.org

Field Support

Gilijen Akwada (koelaman)
(Kwinti) Witagron (Bitagron) Village
SURINAME

Dennis Boomdijk (boatman)
(Kwinti) Witagron (Bitagron) Village
SURINAME

Theo Boomdijk (Baita) (boatman)
(Kwinti) Witagron (Bitagron) Village
SURINAME

Raymond Clemens (koelaman)
(Kwinti) Nature Conservation Division/ Foengoe Island
SURINAME

Sheik Jozua (koelaman)
(Kwinti) Witagron (Bitagron) Village
SURINAME

Lucien Olijfveld (boatman)
(Kwinti) Witagron (Bitagron) Village
SURINAME

Orlando Prika (game warden)
Nature Conservation Division
Cornelis Jongbaw straat no. 10-12
Paramaribo
SURINAME

Oscar Timo (boatman)
(Kwinti) Witagron (Bitagron) Village
SURINAME

Petrus Tjappa (boatman)
(Paramacan) Nature Conservation Division/Foengoe Island
SURINAME

Cinematography

Ted Jantz (cinematographer)
MediaVision N.V.
Margarethalaan 15
Paramaribo
SURINAME
Email: mediavision@parbo.net

Maikel Schenkers (audio engineer)
MediaVision N.V.
Margarethalaan 15
Paramaribo
SURINAME
E-mail: esencee@hotmail.com

Organizational Profiles

CONSERVATION INTERNATIONAL SURINAME

Conservation International Suriname (CI-Suriname) is a Non-Profit, Non-Governmental Organization established in 1992 in Suriname. Our goal is to promote biodiversity conservation and sustainable use of biodiversity through education, awareness and capacity building science projects, and by stimulating eco-tourism in tribal communities.
Our mission is to conserve Suriname's biodiversity, while demonstrating that humans can live harmoniously with nature.

Conservation International Suriname
Kromme Elleboogstraat no. 20
Paramaribo
Suriname
Tel: 597-421305
Fax: 597-421172
e-mail: wudenhout@conservation.org
Web: www.cisuriname.org

STINASU, FOUNDATION FOR NATURE CONSERVATION IN SURINAME

Stichting Natuurbehoud Suriname (Stinasu) was founded in June 1969 and contributes to the protection of Suriname's natural resources and cultural heritage by supporting local and international partnerships in the fields of scientific research, nature education and ecotourism.

Stichting Natuurbehoud Suriname (Stinasu)
Cornelis Jongbaw straat no. 14
Paramaribo
Suriname
Tel: 597- 427102; 597-427103; 597- 421850; 597-421683
Fax: 597- 421850
e-mail: stinasu@sr.net; ymerton@hotmail.com
website: http://www.stinasu.sr

ANTON DE KOM UNIVERSITY OF SURINAME

Anton de Kom University of Suriname was founded on 1 November 1968 and offers studies in the field of social, technological and medical sciences. There are five research centers conducting research and rendering services to the community. The Center for Agricultural Research (CELOS)is promoting agricultural scientific education at the faculty of Technological Sciences. Institute for Applied Technology (INTEC), Biomedical Research Institute, Institute for Development Planning and Management (IDPM), Institute for Research in Social Sciences (IMWO), The Library of ADEK, University Computer Center (UCC), National Zoological Collection (NZCS) and National Herbarium of Suriname (BBS).

The primary goal of the NZCS and BBS are to develop an overview of respectively the fauna and flora of Suriname and build a reference collection for scientific and educational purposes. The NZCS also conducts research on the biology, ecology and/or distribution of certain animal species or on the composition and status of certain ecosystems.

Anton de Kom University of Suriname
Universiteitscomplex/ Leysweg 86
Building # IV
P.O. Box 9212
Phone: 597 – 465558 ext. 241 or 597- 465497
Fax: 597- 462291
e-mail: adek.bestuur@sr.net or board@uvs.edu
Administration:
Phone: (597) 465558 # 228
e-mail: adek.buro@sr.net

National Zoological Collection of Suriname (NZCS)
Universiteitscomplex/ Leysweg 9
Building # 17
P.O. Box 9212
Phone: 597 - 494756
Fax: 597 – 494756
e-mail: nzcs@uvs.edu

National Herbarium of Suriname (BBS)
Universiteitscomplex / Leysweg
Tel: 597 - 465558 / 597 - 464151
Fax: 597 – 464151
e-mail: Maureen_playfair@yahoo.com or bbs@uvs.edu

Acknowledgments

The AquaRAP was a comprehensive and energy consuming endeavor which was successful thanks to the support and collaboration of various people and institutions. We would like to acknowledge the partners of Conservation International-Suriname, the Foundation for Nature Preservation (STINASU) for providing research permits and the Suriname Forest Service's Nature Conservation Division (NB) for a game warden (D. Prika). Additionally, we thank the Anton de Kom University of Suriname and its institutes, the National Zoological Collection of Suriname and the National Herbarium of Suriname, for preparation and storage of the collected material prior to shipping to the Chicago Field Museum (USA) and the Instituto de Zoologia Tropical, Facultad de Ciencas, Universidad Central de Venezuela.

A special thanks to both Gum-Air and Hi-Jet Helicopter Services for providing safe transport for the team and all of their gear from Paramaribo to Raleighvallen to Tonckens Falls and back.

Because of the low water level and many obstacles, the river was difficult to navigate. Without the skillful navigation of our Kwinti and Aucaner boatmen and koelamen we wouldn't have been able to visit so many sites. Their knowledge of the area was invaluable. Therefore, the AquaRAP team would like to express thanks to Gilijen Akwada, Dennis Boomdijk, Theo Boomdijk, Raymond Clemens, Sheik Jozua, Lucien Olijfveld, Petrus Tjappa, and Oscar Timo.

The river was unforgiving to a couple of our boats and we are grateful to Ted Jantz, Maikel Schenkers, Peter Hoke and the boatmen who patched together the zodiacs damaged by rocks and the one large piranha at Bolletri Falls.

Paul Ouboter, of the National Zoological Collection of Suriname, was the in-country logistics coordinator and did a wonderful job of organizing this AquaRAP. Alemien Bholai also deserves mention for her logistic work assisting Mr. Ouboter. Our scientific team leader, Barry Chernoff, kept the team focused and stimulated spirited conversations. We would also like to recognize Gwendolyn Landburg (Suriname) and Jaye Rhodes (USA), two promising students that gained invaluable experience on the AquaRAP. We also thank the RAP staff, especially Leslie Kasmir for all their support.

The botanical team thanks Conservation International and the New Horizons Fund at the University of North Carolina at Asheville for their generous financial support of this study. Thank you to curators and other specialists at various herbaria and University of North Carolina at Asheville students Renee Testerman, Maya Goklany, and Beniko Takada-Capel for help with plant determinations. The assistance in the field of the Kwinti and Aucaner boatman is acknowledged and last but not least to the AquaRAP team, a wonderful team of friends and scientists.

The fish team would like to also thank the Kwinti and Aucaner boatmen for guiding us through the region, helping us collect fishes, and providing knowledge on the natural history of the region. Guido Pereira, Haydi Berrenstein, Ted Jantz, Peter Hoke, and Orlando Prika also provided valuable help collecting fishes. Mary Anne Rogers and Kevin Swagel supported specimen care and logistics at The Field Museum. Paul Ouboter oversaw the Surinamese shipment of equipment and specimens. Mike Littmann took digital images of some of the specimens. Mark Sabaj commented upon the manuscript.

Funding for the Aqua RAP survey was generously provided by the Rufford Foundation as part of the South American Aqua RAP program. The Gordon and Betty Moore Foundation generously supported the expedition and publication of this report. The AquaRAP team would like to thank the Executive Director, Amabassador Wim Oudenhout, of CI-Suriname and his staff, especially Ms. Annette Tjon Sie Fat for their overall support and advice. They were gracious hosts and made us feel welcome during our stay.

Report at a Glance

A RAPID BIOLOGICAL ASSESSMENT OF THE AQUATIC ECOSYSTEMS OF THE COPPENAME RIVER BASIN, SURINAME

Expedition Dates

February 20 - March 14, 2004

Area Description

The Coppename River travels through pristine forests of the 1.6 million ha Central Suriname Nature Reserve (CSNR) before reaching the Atlantic Ocean. This region contains diverse aquatic and terrestrial ecological communities. The Coppename River is fed from black, white and clear water tributaries, which differ in humic compound content, turbidity, pH and other variables. Many species, such as the CITES I giant river otter find refuge in these undisturbed waters.

The Central Suriname Nature Reserve (CSNR) is a tropical wilderness area, and is considered to be one of the most pristine tropical protected areas left in the world. The Coppename River drains two-thirds of the reserve area, making it a vital part of the entire ecosystem. The health and biodiversity of this river are crucial to sustaining the reserve as a whole.

Reason for the Expedition

The goal of AquaRAP survey was to coordinate local and foreign scientific experts to quickly assess the aquatic biodiversity of the Coppename River and its major tributaries since it had never before been surveyed in any systematic way. During the AquaRAP survey, the team surveyed all three of the upper branches of the Coppename, the Rechter Coppename, Linker Coppename, and the Midden Coppename, down to the mouth. The richness of fishes, plants, crustaceans, benthic invertebrates, and water quality were assessed.

There are very few inhabitants within the Coppename Basin and access is limited to areas reachable by rivers or plane. This has aided in preserving the area, but has also limited research and scientific data collection. The information gained through the month-long assessment will be used in the development of a conservation and management plan for the CSNR and will also feed into conservation planning for the broader Guayana Shield region.

Major Results

The AquaRAP team found this area to be one of the largest, most intact and pristine watersheds they had ever encountered. Water quality is good in all sections of the river surveyed and fishes were large with brilliant colors. Overall species richness recorded is moderate for a Neotropical river. The plants and fishes are comparable in species richness to other lowland forests and rivers of the Guayana Shield. The shrimps and crabs are moderate in species richness. The aquatic insects richness is higher than found in other areas due to the abundance of the macrophytes (Podostemaceae). No exotic or invasive species were recorded in the CSNR up river of Raleighvallen. Several species indicative of pristine forest and high water quality, including Ephemeroptera (mayflies) and freshwater sponges were recorded. Many species of crabs, shrimps, and fishes demonstrated specific habitat requirements that should be considered in conservation planning. The shrimp, *Macrobrachium faustinum*, requires both freshwater and the coastal environment to complete its life cycle, which highlights the connectedness of freshwater and marine ecosystems within the Coppename River Basin.

Number of Species Recorded

Plants - 150 species
Fishes - 112 species
Invertebrates
- Mollusks - 15 species
- Crustaceans - 10 species
- Insects - at least 54 species

Species New to Science

Fishes – 10 species

New Records for Suriname

Fishes – 4 species

Key Conservation Recommendations

(see Executive Summary for further explanation)

1) Prevent activities inside of or external to the Central Suriname Nature Reserve (CSNR) that will lead to degradation of the pristine environmental conditions.
2) Extend the boundary of the CSNR to include the entire Coppename watershed, especially to include the Adampada Creek.
3) Keep watch on and monitor future mining activities in the adjacent Bakhuis Mountains to assess potential impacts on Adampada Creek and other areas of the CSNR.
4) Conduct long-term monitoring in key sites representing several macrohabitats and elevations.
5) Undertake additional floral and faunal surveys of the CSNR.
6) Regulate and monitor hunting and fishing carefully.
7) Monitor and control the access to and especially the export of natural resources from the CSNR at its borders and common access points.
8) Regulate and monitor all tourism carefully.

Executive Summary

THE COPPENAME RIVER BASIN

South America still contains hundreds of thousands of square kilometers of pristine forested areas. This continent harbors the greatest diversity of species and biomass of plants, wildlife, and freshwater ecosystems on the planet. Today, however, increasing world consumptive demands and increasing human populations are accelerating not only the exploitation of this once immense reservoir of food, minerals, scenic beauty, energy, and biogenetics but they are also accelerating the fragmentation of once great tracts of forest. Biodiversity studies in South America, especially in watersheds, are ever more important in order to link economic potential with biological sustainability as a way to reduce actual threats and adverse environmental changes.

In Suriname, several large rivers drain off the Guayana Shield into the Atlantic Ocean, each with complex histories and various connections to the Amazon, Essequibo, or Orinoco basins. In the middle of Suriname is the large Coppename River drainage (see Map). The Coppename River is the third largest in Suriname, draining an area of approximately 21,700 km^2 (13 % of the country) and having an estimated mean discharge of 490m^3/s (peak 2,200 m^3/s). The upper course of the Coppename River, springing from the Emma, Wilhelmina, and Bakhuis Mountains, lies completely within the Central Suriname Nature Reserve (CSNR), which was established in 1998. The CSNR combines three former nature reserves that date from 1966: Raleighvallen/Voltzberg, Tafelberg, and Eilerts de Haan. The Coppename River is fed from black, white and clear water tributaries, which differ in humic compounds content, turbidity, pH and other variables. Many species, such as the CITES I giant river otter find refuge in these undisturbed waters.

The Coppename River watershed contains vast expanses of uninterrupted forest, particularly in the CSNR. This wilderness is one of the few truly pristine areas remaining in the world - an area where biological and environmental processes are almost entirely free of human impact. Except for small areas near Tafelberg, the portion of the watershed above Sidonkrutu is absolutely pristine. Nonetheless, the potential threat of human impact is growing. These threats include bauxite mining in the Bakhuis Mountains, increased potential for tourism, and unregulated hunting and fishing.

CONSERVATION INTERNATIONAL'S RAPID ASSESSMENT PROGRAM (RAP)

The Rapid Assessment Program (RAP) is an innovative biological inventory program designed to use scientific information to catalyze conservation action. RAP methods are designed to rapidly assess the biodiversity of highly diverse areas and to train local scientists in biodiversity survey techniques. Since 1990, RAP's teams of expert and host-country scientists have conducted 56 terrestrial, freshwater aquatic (AquaRAP), and marine biodiversity surveys and have contributed to building local scientific capacity for scientists in 26 countries. Biological information from previous RAP surveys has resulted in the protection of millions of hectares of tropical forest, including the declaration of protected areas in Bolivia, Perú, Guyana, Ecuador, and Brazil and the identification of biodiversity priorities in numerous countries.

AQUARAP SURVEY OF THE COPPENAME RIVER BASIN

Unlike many of the other large Surinamese rivers, relatively little is known about the Coppename River system, especially in the region upriver from Raleighvallen. An aquatic Rapid Assessment Program survey (AquaRAP) was designed to gather crucial biological and environmental information about the Coppename River watershed. The AquaRAP team surveyed all three of the upper branches of the Coppename River: the Rechter Coppename, Linker Coppename, and the Midden Coppename, down to the mouth. Specialists in water quality, botany, aquatic invertebrates, and fishes lived and studied on the river from February 20 - March 14, 2004. In addition to obtaining data for their specific groups, team members also synthesized their data into a set of comprehensive conclusions and recommendations.

The biodiversity of the upper reaches of the Coppename River along with its headwaters have never before been studied. There are very few inhabitants within the basin and access is limited to areas reachable by rivers or plane. This has aided in preserving the area, but has also limited research and scientific data collection. The information gained through the month-long assessment will be invaluable in the development of a regional conservation and management plan for the CSNR.

Survey areas (see Map)

Rechter Coppename River

The Rechter (Right) Coppename River is a large arm of the Coppename River with headwaters originating on the Tafelberg, the easternmost sandstone tepui on the Guayana Shield. This river was the only black water river surveyed during the AquaRAP. It has forested banks along the shores that are undisturbed other than by natural processes as well as several well-defined ecological areas including the main basin, small creeks on both sides of the river, large areas of rocky shores, several waterfalls and large pools above and below the Bolletrie Falls. The remoteness of the Rechter Coppename adds to its importance as a critical conservation area.

Linker Coppename River

The Linker (Left) Coppename River is narrower than the Rechter Coppename River and originates at the highest elevations in Suriname, the Wilhelmina Mountains. The Linker Coppename has more of the characteristics of a stepped system (pools, rapids) rather than a continuous gradient. There is also more evidence of lateral movement of the river channel, point bars, and cut banks than in the Rechter Coppename. The riparian vegetation overhangs the river and seems to do so to a greater degree than in the Rechter Coppename. The Linker Coppename is a forested river. The shore has terra firme and seasonally inundated forest. There are many rapids, including islands and rock complexes. The water is very lightly colored and slightly turbid (much rain during surveys). The Linker Coppename River appeared to have a smaller volume of water than the Rechter Coppename as well as steeper channel borders and fewer areas of inundation along the edges. It contains scattered riffles that harbor zones with beds of the aquatic plants of the family Podostemaceae that seemed to be more common in the Linker Coppename than in the Midden Coppename. Few creeks came off the main channel.

Midden Coppename River

There was little sampling effort in this region during the AquaRAP survey. The Midden (Middle) Coppename is narrower than the Linker Coppename but similar in some respects, including lower water volume than the Rechter Coppename, steeper channel borders, fewer areas of inundation alongside the river, and zones of Podostemaceae. The river is more quiet upstream without any visible rocks but has rapids downstream. Like the Linker Coppename, the Midden Coppename River also drains the highest elevations in Suriname, the Wilhelmina Mountains.

Adampada Creek

The Adampada Creek is a large tributary of the Coppename River but is comparatively much smaller than the Linker Coppename, Rechter Coppename and Midden Coppename rivers. This creek originates in the Bakhuis Mountains to the West. Its principal characteristics are very clear waters, rocky and sandy beds, as well as several central areas of shallow fast flowing waters with scattered and frequent pools containing boulder rubble and sandy bottoms. These places have patches of Podostemaceae beds in open areas of the system that occasionally become the main bottom type in the shallow fast flowing waters. There are also several small to large islands. The Adampada Creek is forested with terra firme forest. In many stretches the water is very shallow, about one meter. The creek has also a rocky and/ or sandy bottom. Since most of this creek lies outside the CSNR, it could experience greater human disturbance than the other sites surveyed.

Main channel of the Coppename River

The main channel of the Coppename River has a wide riverbed. There are several major waterfalls and riffles with large rocks that create large areas of shallow and medium deep pools as well as shallow waters with riffles and Podostemaceae beds. Water is mainly clear turning to brown in deeper pools. Several of these main open and rocky areas, such as Sidonkroetoe Falls, are places for camping and tourism. The Main Coppename is a forested river, widening in many places where rapids, islands and rocks are present.

OVERALL SUMMARY OF RESULTS

This AquaRAP expedition was the first comprehensive survey of the aquatic ecosystems of the upper Coppename watershed in the Central Suriname Nature Reserve (CSNR) upriver from Raleighvallen. The AquaRAP team found this area to be one of the largest, most intact and pristine watersheds they had ever encountered. It forms an important corridor in two directions between proposed high-priority protection areas of the Guayana Shield. The effects of human impact are extremely low; during one month of field work and extensive traveling by boat, the AquaRAP team did not meet other human beings; this is quite exceptional. The size of trees and the complex structure of the forest are impressive with respect to other areas. The fishes were in excellent condition; the predators such as anjumara (*Hoplias aimara*) and red-eye piranhas (*Serrasalmus rhombeus*) were abundant and of very large size; the colors of the ornamental fishes were brilliant; there were almost no parasites or infections found on the fishes. There are large populations of shrimps and crabs; very heterogeneous populations of aquatic invertebrates, especially aquatic insects, and large colonies of freshwater sponges.

Overall species richness recorded was moderate for a Neotropical river. The plants and fishes are comparable in species richness to other lowland forests and rivers of the Guayana Shield. The shrimps and crabs are moderate in species richness. The aquatic insect richness is higher than found in other areas due to the abundance of the macrophytes (Podostemaceae). No exotic or invasive species were recorded in the CSNR, except at Foengoe Island downstream from Raleighvallen, e.g., mango trees (*Mangifera indica*), cattle egret (*Bubulcus ibis*) etc.

In the surveyed area of the CSNR, the team found unique assemblages of lowland Guayana Shield elements for the riparian forests, aquatic invertebrates, and fishes. For example, the canopy-emergent assemblage of plants was: *Couratari* (ingi pipa) – *Ceiba* (kankantree) – *Licania* (roseappel). The fishes assemblage in the rapids included: *Guianacara owroewefi* (krobia) – *Electrophorus electricus* (stroom fisi) – *Moenkhausia oligolepis* (sriba)/*Gasteropelecus*. The creeks, rapids, main river channel and associated forests had different floras and faunas. Aquatic vegetation (Podostemaceae (koemaloe njang njang) and algae) was extremely well developed in the rapids; these particular taxa are indicators of high water quality. This vegetation provides critical habitat for the diverse and unique communities of fishes and aquatic invertebrates.

The number of macrohabitats for terrestrial and aquatic systems was observed to be relatively low. For example, there were basically creeks, rapids, and main channels in the aquatic environment. The terrestrial ecosystem had low diversity of soil types; hence, the flora is largely dependent on hydrology. The zone of flooding is approximately less than or equal to 200 m, usually forming a broad riparian corridor. The forest, fishes, and inland freshwater shrimps in this corridor require the maintenance of this flooded area for proper reproduction, recruitment, growth, and seed germination.

The water quality was very good. Variations in measurements of water quality parameters were due to the underlying geological formations through which the sources flowed. For example the water in the Rechter Coppename River originates in sandstone. Otherwise, the measurements show that the water is typical of unpolluted waters found on the Guayana Shield: low nutrients, slightly acidic, and with low conductivity and hardness.

The AquaRAP survey team also found evidence of large predators, including otters (2 species), caiman (2 species), and anaconda. Additional species sighted that indicate good ecosystem health included the capybara (*Hydrochaeris hydrochaeris*), agouti, tapir, and the harpy eagle (*Harpia harpyja*). The team had abundant sightings of macaws, parrots, toucans, and migratory birds (e.g., osprey). Other indications of low hunting pressure were observations of iguanas, black curassows (*Crax alector*), and several species of primates; in particular spider monkeys (*Ateles paniscus*) were very common and not shy.

RESULTS BY TAXONOMIC GROUP

Water quality

Water quality was good in all river sections. An abundance of aquatic vegetation (mainly Podostemaceae) leads to lower phosphate levels, because phosphate is easily taken up by plants. In creeks in which few organisms were found, oxygen content was usually lower than in the main river. Differences in microhabitats between river sections can lead to differences in physical and chemical water quality, consequently influencing the distribution of certain organism, for example caiman. Differences in water quality between river sections can be attributed to the geological formations of the drainages of the respective river sections and on some occasions to weather conditions. Despite the highest concentration of dissolved solids, the Adampada Creek had the clearest water. Mining in the upper reaches of the Adampada Creek will almost certainly lead to deterioration of the water quality of this creek and the lower reaches of the Coppename River.

Plants

A total of 349 collections of fertile plants made during the AquaRAP survey revealed 150 species. We found a significant floristic heterogeneity within the CSNR. The plant communities sampled were composed of a unique assemblage of species, and results presented here support the refugia theory. However, it is clear that much more thorough collecting is needed before the CSNR checklist can be considered complete.

The CSNR flora was compared with florulas of five well-collected locations in northeastern South America:

Kaieteur Falls National Park, Mabura Hill, and Iwokrama (Guyana); Reserva Ducke (Brazil); and Saül (Central French Guiana). A strong relationship between the species of the Guyana locations (Kaieteur, Iwokrama, and Mabura Hill) and the CSNR indicates a center of endemism centered between Guyana and Suriname. The top three families within the CSNR differ from the other five florulas, consisting of the Rubiaceae, Cyperaceae, and Araceae (mainly herbaceous species). The CSNR plant list lacks several prominent woody families found within the other five sites, namely the Myrtaceae, Chrysobalanaceae, Annonaceae, and Sapotaceae. However this can be explained by the fact that most of the AquaRAP collections were made within the first 6 m above ground level. Increased canopy collection of the CSNR would increase the numbers of Orchidaceae species and would add several prominent woody families to the list.

Aquatic Invertebrates

A total of 82 samples revealed at least 84 species among Insecta, Mollusca, Crustacea, Annelida and Porifera. The most diverse group recorded was the aquatic insects with nine orders comprising 32 families and at least 54 species. Next were the Mollusks with six families, six genera and 15 species. Crustaceans followed with five families, eight genera and 10 species. Finally, we recorded one species of Hirudinea within the Annelida and one species of freshwater sponge. Many invertebrate groups and species have specific habitat requirements that should be considered in conservation planning. For example pseudotelphusid crabs tend to be associated with rocky habitats while Trychodactylidae crabs are more associated with leaves, muddy beds or fallen logs. The smaller tributaries directly connected to the river channel contained different species in lower densities compared to the main channel. This was particularly true for crabs of the family Trichodactylidae and shrimps of the genera *Palaemonetes* and *Macrobrachium*. Diptera were especially common in the Podostemaceae beds. The shrimp *Macrobrachium faustinum* was recorded only from the rapids area of Bolletrie Falls. It seems that the life cycle of this species might be related to this environment of fast flowing waters and the Podostemaceae beds.

Some species need the entire watershed to complete their life cycle. The shrimp *Macrobrachium faustinum* requires both freshwater and the coastal environment to complete its life cycle, since the larvae hatch and develop in the high salinity range of the marine estuary. This fact highlights the connectedness of freshwater and marine ecosystems within the Coppename River Basin.

Several groups of invertebrates recorded indicate a high-quality pristine environment. Ephemeroptera (mayflies) were present in many habitats, which is a clear indicator of a pristine environment. The frequent presence of freshwater sponges in areas of riffles and fast flowing streams is an exceptional feature that also indicates a healthy, non-polluted environment. There is a rich and diverse community of aquatic invertebrates in the Central Suriname Nature Reserve. However, our taxonomic knowledge of the region is poor and we recommend that a joint project with several specialists be developed to build a reference collection and species check lists for the aquatic invertebrates.

Fishes

The fish fauna of the Coppename River in the Central Suriname Nature Reserve was sampled at 36 sites within the 24 georeference stations of the 2004 Aquatic Rapid Assessment Program expedition. A total of 112 species were identified. Of these, four are new locality records for the country of Suriname and ten are potentially new species to science. The Coppename River has more species than most similar-sized rivers in the world, but its fish fauna is comparable to other Guayana Shield rivers and does not contain the high number of species that typify many other neotropical rivers. However, the Coppename River flows directly into the Atlantic Ocean (i.e., is not part of the Amazon or Orinoco drainages and their associated faunas), and this helps define its uniqueness. Each sub-drainage within the Coppename system has roughly the same number of species per sample and there is no indication that particular species are restricted to particular drainages. No perceptible biogeographic barriers are preventing the dispersal of fishes. Furthermore, there are no great differences in number of species per sample among habitats, although certain species are largely restricted to particular habitats. For example, rapids and creeks have their own unique environmental conditions that limit which species are found there.

A striking aspect of the Coppename fish community is the apparent shift from backwater habitats to primary river channel habitats of some species as compared to the same or closely related species in many other neotropical systems (e.g., the electric eel *Electrophorus electricus*, cichlids). A significant part of the explanation for this phenomenon is the paucity of backwater habitats in this section of the Coppename River. If fishes normally adapted to sluggish backwaters are to survive in river systems like the Coppename drainage, then they have to find a niche in the primary river channel. Also, there is an incredible abundance of large top-level predators, like anjumara (*Hoplias aimara*) exceeding a meter in length and red-eye piranha (*Serrasalmus rhombeus*) with an average size that appears to surpass just about all other localities in South America. We take this as an indication of extremely low fishing pressure, which consists mostly of upstream fishing trips during the low-water season by people from Witagron and Kaimanston and some sport fishing by tourists at Raleighvallen. Although opportunities for conservation of the Coppename River watershed (as part of the Central Suriname Nature Reserve) are good, the potential threat of human impact is growing. Threats include bauxite and gold mining, forestry, increased tourism, and unregulated hunting and (sport)fishing. The pristine wilderness character of the Central Suriname Nature Reserve should be carefully protected, since that is what most differentiates this reserve from others and defines its highest value.

CONSERVATION RECOMMENDATIONS

The CSNR is a pristine tropical wilderness protected area and the Coppename River may be one of the largest and most pristine protected tropical watersheds on Earth. Therefore, we recommend continued and enhanced protection of the pristine wilderness character of the CSNR, which differentiates this reserve from any other and defines its highest value in terms of development and use, including research and ecotourism. The CSNR is a key component of a larger, international protection plan for the Guayana Shield. The CSNR is located in a critical position, serving as a connection between the northwest-southeast highland corridor and the north-south lowland-coastal corridor to the Amazon.

The overall condition of the flora and fauna in the CSNR and the Coppename River watershed downstream of Raleighvallen upon which human populations rely is dependent upon the preservation of the healthy and pristine condition of the Coppename River watershed.

General Recommendations

1) **Prevent activities inside of or external to the Central Suriname Nature Reserve (CSNR) that will lead to degradation of the pristine environmental conditions**, especially those activities that lead to: erosion, siltation, sedimentation, changing the natural hydrological cycle of the river, and pollution (including heavy metals). Such impacts have the capacity to diminish forever the pristine character and the biological value of the CSNR and, as importantly, the contribution of the Coppename watershed to the health and sustenance of the communities of people downstream.

2) **Extend the boundary of the CSNR to include the entire Coppename watershed**. We believe that the buffer zone currently delineated in the CSNR management plan does not provide adequate protection. This is especially true for Adampada Creek, which we find to be of exceptionally high biological value and is highly threatened by potential bauxite mining in the Bakhuis Mountains.

3) **Keep watch on and monitor future mining activities in the adjacent Bakhuis Mountains** to assess potential impacts on Adampada Creek and other areas of the CSNR. Work with the mining companies and the Government of Suriname to assess potential impacts and put preventative measures in place before mining occurs.

4) **Select sites representing several macrohabitats and elevations for long-term monitoring** (though the monitoring should have as little environmental impact as possible). The CSNR is so pristine that it offers the world an important opportunity to learn about long-term biological and ecological processes in the Neotropics.

5) **Undertake additional floral and faunal surveys of the CSNR** as the preliminary first step for ecological monitoring because the present data are insufficient. This includes the aquatic fauna and flora.

6) **Develop the CSNR into a world-class opportunity for education** about Neotropical ecology, environmental science, and conservation biology. This opportunity includes developing the following:
   a) an educational program, in collaboration with existing international programs, such as Organization for Tropical Studies;
   b) the capacity of Surinamese scientists, including development of graduate studies programs, to study and monitor the ecology and environments of the CSNR;
   c) a well-equipped field station within the CSNR;
   d) public outreach educational and partnership programs, including those for primary schools, for communities of people along the Coppename River in order to recruit their participation in conservation and protection of the entire watershed and to increase their net benefits from the CSNR;
   e) public awareness programs about CSNR for Suriname and the world.

7) **Regulate and monitor hunting and fishing carefully**. The flora and fauna of the CSNR, though now pristine and healthy, is very fragile. This process should involve local peoples as partners in the setting of regulations or limits. In particular, fishing and hunting for commercial activities should be prohibited. Sportfishing should be prohibited above Raleighvallen and daily catch limits for all species should be set and strictly monitored. Restrict fishing by resident staff, ban all trap and net fishing within the reserve and sport fishing above Raleighvallen. Strictly enforce the ban on hunting and hunting implements within the reserve. Catch limits and management policies must be based upon sound scientific data.

8) **Monitor and control the access to and especially the export of natural resources** from the CSNR at its borders and common access points (by boat at the Coppename River boundary and by air at Zorg en Hoop airstrip).

9) **Regulate and monitor all tourism carefully**. Ecotourism is excellent for developing public awareness and appreciation of the CSNR. However, ecotourism can easily have a negative impact upon the CSNR because of its fragility. Tours should not extend upriver

from Dreefoetoe Soela, though some limited tourism can be established in a higher elevation area, such as near the Rudi Kappel airstrip. Evaluate all uses (including research and ecotourism development) for appropriateness, and plan for and carry them out at the very highest international standards:

a) ensure that all uses are designed to take advantage of the highest possible valuation of the reserve (its pristine wilderness character) and minimize the impacts of use,
b) prohibit inappropriate use and non-native introductions,
c) manage carefully solid and liquid waste to minimize any possibility of degrading the water quality of the Coppename River,
d) manage all engine use and fuel and lubricant transportation and use on the river in order to avoid degrading the water quality of the Coppename River.

Taxon Specific Recommendations

Fishes

1) The current abundance of fishes, especially sport fishes, upstream from Raleighvallen could be impacted easily. We do not believe that the fish populations can sustain heavy impact through harvesting from sportfishing, or commercial and ornamental fisheries.

2) Future research should include surveys of small, high-gradient headwaters in the upper Coppename watershed (i.e., mountain streams draining Tafelberg Mountain, Bakhuis Mountains or Wilhelmina Mountains). We did not visit the headwaters of any of the three branches of the Coppename system, the upper reaches of Adampada Creek, or the Coppename River and its tributaries below Dreefoetoe Soela. Data on the fish diversity and fisheries resource condition of the Central Suriname Nature Reserve would be largely improved with additional fish sampling in the higher and lower elevations of the watershed. Surveys downstream from the Central Suriname Nature Reserve are also important, since rivers are continuums and fishes routinely swim in and out of the reserve.

Invertebrates

1) Main channel. The fact that large areas of the main channel may serve as places for tourist camping and human settlement means that measures for conservation should be carefully planned especially for these areas. The main channel of the river also has areas of high productivity with large standing biomass and an accumulation of energy in the biota and as such, is important to the energy flow of the ecosystem. These areas present the most appropriate sites for monitoring of invertebrate communities.

2) Rechter Coppename. This region is a very important area for conservation for several reasons: it is a pristine environment, has the unique nature of being a black water system, has high ecological significance for shrimps and crabs, and a high diversity of other invertebrates.

3) Linker and Midden Coppename. These two river branches seem to have a different community structure of aquatic insects as compared to the Rechter Coppename. Future research is needed to confirm this but it should be considered during conservation planning.

4) Adampada Creek. This area has outstanding scenic value due to the combination of crystal clear waters, large shallow habitats with Podostemaceae beds, islands, and thick riparian vegetation. This is one of a few small sub-tributary creeks in the area that may act as a refuge for inland water species of shrimps. The water quality and micro-habitats of the creek should be protected to ensure the life cycle of several shrimp species.

Rapportage in een Oogopslag

DE COPPENAMERIVIER IN ÉÉN OOGOPSLAG

Een kort verslag van het onderzoek van het aquatisch ecosysteem van het stroomgebied van de Coppenamerivier in Suriname

Expeditiedagen

20 februari – 14 maart, 2004

Beschrijving van het gebied

De Coppenamerivier stroomt, voordat zij uiteindelijk in de Atlantische Oceaan uitmondt, door ongerept bos van het Centraal Suriname Natuurreservaat, een reservaat met een oppervlakte van.6 miljoen hectaren. Er is een verscheidenheid aan aquatische, terrestrische en ecologische gemeenschappen van dit enorme gebied. De Coppenamerivier wordt gevoed door zijrivieren die donker, wit en helder water aanvoeren en die verschillen in humusbestanddelen, troebelheid, pH en andere variabelen. Vele biologische soorten, zoals de reuzenrivierotter die op de CITES I lijst voorkomt, vinden een onderkomen in deze ongerepte wateren.
Het Centraal Suriname Natuurreservaat (CSNR) is een tropisch wildernisgebied en wordt beschouwd als een van de meest ongerepte tropische gebieden ter wereld. De Coppenamerivier en haar zijtakken stromen door tweederde van het reservaat, waardoor de rivier een vitaal onderdeel vormt van het totale ecosysteem. De gezondheid en biodiversiteit van de rivier zijn dan ook cruciaal voor het behoud van het geheel.

Reden voor de expeditie

Het doel van het AquaRAP onderzoek was om, in nauwe samenwerking tussen lokale en buitenlandse deskundigen, heel snel een inschatting te maken van de aquatische biodiversiteit van de Coppenamerivier en haar belangrijkste zijtakken, aangezien er nooit eerder op systematische wijze onderzoek heeft plaats gevonden. Tijdens het AquaRAP onderzoek heeft het team vanaf de drie bronrivieren, namelijk de Rechter-Coppename, Linker-Coppename, en Midden-Coppename, tot aan de monding onderzocht. De soortenrijkdom van vissen, planten, crustacea, benthische invertebrata en waterkwaliteit zijn ingeschat.
Er wonen weinig mensen in het stroomgebied van de Coppenamerivier en de toegang tot het gebied is beperkt tot mogelijkheden via het water of de lucht. Dit helpt om het gebied te behouden , maar heeft tevens onderzoek en dataverzameling beperkt. De informatie verkregen uit het AquaRap onderzoek, zal worden gebruikt bij de ontwikkeling van een biologisch monitoring plan voor het CSNR en voor de planning van het behoud van het gehele Guyanaschild.

Belangrijkste resultaten

Volgens AquaRAP teamleden is dit gebied een van de grootste en meest intact gebleven, ongerepte wildernisstroomgebieden die zij ooit zijn tegengekomen. De kwaliteit van het water is in alle onderzochte rivierdelen goed en de aangetroffen vissen waren groot en hadden heldere kleuren. Het algemeen beeld van de soortenrijkdom is matig voor een Neotropische rivier. De soortenrijkdom van planten en vissen is vergelijkbaar met die van andere laaglandbossen en -rivieren van het Guyanaschild. Ook de soortenrijkdom van garnalen en krabben is matig. De aquatische insektenrijkdom daarentegen is hoger dan wat in andere gebieden is gevonden, vanwege de overvloed aan macrophyten (Podostemaceae). Bovenstrooms van de Raleighvallen zijn er geen exotische of invasieve species aangetroffen. Verder zijn verschillende species, die indicatief zijn voor ongerept bos en een zeer goede waterkwaliteit, inclusief Ephemeroptera (meivliegen) en zoetwatersponzen, vastgelegd. Veel van de krabben, garnalen en vissen vertoonden specifieke habitatvereisten, en dit zal in overweging genomen dienen te worden bij het plannen van behoud van het gebied. De garnaal, *Macrobrachium faustinum*, heeft zowel zoetwater als het milieu van de kust nodig om haar levenscyclus te voltooien, wat de verbondenheid van zoetwater en mariene ecosystemen binnen het stroomgebied van de Coppenamerivier aangeeft.

Vastgelegd aantallen species
Planten – 150 species
Vissen – 112 species
Invertebrata:
  Mollusca – 15 species
  Crustacea – 10 species
  Insecta – ten minste 54 species

Nieuwe soorten voor de wetenschap
Vissen – 10 species

Nieuwe vondsten voor Suriname
Vissen – 4 species

Belangrijkste aanbevelingen voor behoud
(zie Uitgebreide samenvatting voor verdere uitleg van aanbevelingen)

1) Voorkomen dat activiteiten, binnen of net buiten het Centraal Suriname Natuurreservaat (CSNR), zullen leiden tot degradatie van de ongerepte milieucondities.
2) Uitbreiding van de grenzen van het CSNR om het gehele stroomgebied van de Coppenamerivier binnen het reservaat te krijgen, vooral om ook de Adampadakreek op te nemen.
3) Monitoring van mijnbouwactiviteiten in het belendend Bakhuis gebergte, om potentiële gevolgen voor de Adampadakreek en andere gebieden van het CSNR in te schatten.
4) Uitvoeren van langetermijn monitoring in sleutelgebieden, die verschillende macrohabitats en hoogten vertegenwoordigen.
5) Uitvoeren van additioneel flora- en faunaonderzoek van het CSNR.
6) Zorgvuldig reguleren en monitoring van jacht en visvangst.
7) Controle aan de grenzen en toegangspunten van het reservaat om toegang tot en in het bijzonder de export van natuurlijke hulpbronnen van het CSNR te monitoren.
8) Zorgvuldig reguleren en monitoren van alle vormen van toerisme.

Uitgebreide Samenvatting

HET STROOMGEBIED VAN DE COPPENAMERIVIER

Zuid - Amerika kent nog steeds honderden duizend vierkante kilometers ongerepte, bosrijke gebieden. Dit continent heeft de grootste diversiteit aan biologische soorten en plantenbiomassa, fauna en zoetwaterecosystemen op aarde. Maar vandaag aan de dag heeft de stijgende wereldconsumptie en de toenemende menselijke populatie niet alleen tot gevolg de toenemende exploitatie van dit eens immense reservoir van voedsel, mineralen, natuurschoon, energie en biogenetica, maar ze bespoedigen ook de fragmentatie van de eens zo gigantische, uitgestrekte bossen. Biodiversiteitstudies in Zuid-Amerika, voornamelijk in rivierstroombeddingen, worden steeds belangrijker omdat zij een verband leggen tussen het economisch potentieel en de biologische duurzaamheid, als een manier om actuele bedreigingen en ongunstige milieuveranderingen te reduceren.

In Suriname stromen verscheidene grote rivieren van het Guyanaschild naar de Atlantsche Oceaan, elk met een eigen complexe geschiedenis en verschillende van deze, met verbindingen naar de Amazone, de Essequibo, of het Orinocobekken. In het centrum van Suriname ligt het grote stroomgebied van de Coppenamerivier (zie kaart). Door de Coppenamerivier, de derde grootste rivier van Suriname, wordt een gebied van ongeveer 21.700 km^2 (13 % van het land) afgewaterd, met een geschatte gemiddelde lozing van 490 m^3/s (met een piek van 2.200 m^3/s). De bovenloop van de Coppenamerivier, die ontspringt in de Emma-, Wilhelmina- en Bakhuisgebergten, ligt volledig in het Centraal Suriname Natuurreservaat. (CSNR). Het CSNR, die in 1998 werd ingesteld, wordt gevormd door drie natuurreservaten, die dateren van 1966: Raleighvallen/ Voltzberg, Tafelberg en Eilerts de Haan. De Coppenamerivier wordt gevoed door zijtakken van donker, wit en helder water, die verschillen in humusbestanddelen, troebelheid, zuurgraad (pH) en andere variabelen. Veel biologische soorten, zoals de reuzenrivierotter die op de CITES I lijst voorkomt, zoeken hun toevlucht in deze onverstoorde wateren.

Het stroomgebied van de Coppenamerivier kent enorme ononderbroken bossen, vooral in het CSNR. Deze wildernis is een van de weinig waarachtig ongerepte gebieden die nog over zijn in de wereld – een gebied waar biologische en milieuprocessen bijna geheel vrij zijn van menselijke beïnvloeding. Met uitzondering van kleine gebieden rond de Tafelberg, is het deel van het stroomgebied boven Sidonkroetoe volkomen ongerept. Niettemin neemt de potentiële bedreiging van menselijke invloeden toe, namelijk het mijnen van bauxiet in het gebied van het Bakhuisgebergte, verhoogde toerisme en ongereguleerd jagen en vissen.

CONSERVATION INTERNATIONAL'S RAPID ASSESSMENT PROGRAMMA (RAP)

Het RAP is een innovatief biologisch inventarisatieprogramma, dat speciaal ontwikkeld is om wetenschappelijke informatie te vergaren, die als catalysator kan dienen bij natuurbehoud. RAP-methoden zijn ontworpen om heel snel de biodiversiteit van gebieden met een grote verscheidenheid in te schatten en om lokale wetenschappers te trainen in technieken die worden gebruikt bij het verkrijgen van een overzicht van de biodiversiteit. Vanaf 1990 hebben deskundigen van het RAP-team samen met wetenschappers van de respectieve gastlanden, 56 overzichtsstudies van de terrestrische, zoetwater- (AquaRAP) en mariene biodiversiteit uitgevoerd. Deze hebben bijgedragen aan het opbouwen van de lokale capaciteit van wetenschappers in 26 (zesentwintig) landen. Biologische informatie van eerdere RAP overzichtstudies hebben geresulteerd in het beschermen van miljoenen hectaren tropisch bos, inclusief de instelling van beschermde gebieden in Bolivia, Peru, Guyana, Ecuador en Brazilië en de identificatie van biodiversiteitsprioriteiten in vele landen.

AQUARAP OVERZICHTSTUDIE VAN HET STROOMGEBIED VAN DE COPPENAMERIVIER

In tegenstelling tot veel andere grote Surinaamse rivieren, is er relatief weinig bekend over het stroomgebied van de Coppenamerivier, voornamelijk het gebied bovenstrooms van de Raleighvallen. Er werd daarom een Aquatisch Rapid Assessment Programma (AquaRAP) ontworpen om cruciale biologische en milieuinformatie over het stroomgebied van de Coppenamerivier in te zamelen. Het AquaRAP -team onderzocht vanaf de drie bronrivieren van de Coppenamerivier, de Rechter-, Linker- en Midden-Coppename, tot naar de monding toe. Specialisten in waterkwaliteit, botanie, aquatische ongewervelde dieren, en vissen hebben van 20 februari – 14 maart 2004 op en aan de rivier geleefd en gestudeerd. Naast het verzamelen van gegevens voor hun specifieke groep, hebben de teamleden hun gegevens ook vertaald naar veelomvattende conclusies en aanbevelingen.

De biodiversiteit van het bovenste bereik van de Coppenamerivier en haar hoofdwateren zijn nooit eerder bestudeerd. Er wonen weinig mensen in het stroomgebied en toegang is alleen mogelijk via de rivier of de lucht. Dit heeft het gebied helpen beschermen, maar heeft ook onderzoek en wetenschappelijke datavergaring beperkt. De informatie, die gedurende een maand verzameld is, zal van onschatbare waarde zijn voor de verdere ontwikkeling van het beheers- en monitoringplan voor het CSNR.

Onderzochte gebieden (zie kaart)

Rechter-Coppename

De Rechter-Coppenamerivier is een grote arm van de Coppenamerivier met hoofdwateren, die ontspringen op de Tafelberg, de meest oostelijk gelegen zandsteen tepui in het Guyanaschild. Deze rivier is de enige zwartwaterrivier die tijdens de AquaRAP is onderzocht. De rivier heeft bosrijke oeverbanken die alleen worden verstoord door natuurlijke processen, en kent verder verscheidene goed gedefinieerde ecologische gebieden, inclusief het open stroomgebied, kleine kreken aan beide zijden van de rivier, grote gebieden met rotsige oevers, verscheidene watervallen en grote poelen boven en benedenstrooms van de Bolletrievallen. Het feit dat de Rechter-Coppenamerivier afgelegen is, draagt bij aan haar belang als kritisch beschermd gebied.

Linker-Coppenamerivier

De Linker-Coppenamerivier is smaller dan de Rechter-Coppenamerivier en ontspringt op de hoogste hoogten van Suriname, namelijk het Wilhelminagebergte. De Linker-Coppename heeft meer de karakteristieken van een trappensysteem (poelen en stroomversnellingen), dan van een constante gradiënt. Er is ook meer bewijs van laterale beweging van de rivier, van zandbanken en steilere oevers dan bij de Rechter-Coppename. De oevervegetatie hangt over de rivier, meer dan in de Rechter Coppename. De Linker-Coppename is een beboste rivier. De oever heeft *terra firme* bos, dat seizoengewijs overstroomt. Er zijn veel stroomversnellingen, inclusief eilanden en rotscomplexen. Het water is erg licht gekleurd en een beetje troebel (er was veel regen tijdens het onderzoek). De Linker-Coppenamerivier schijnt qua volume minder water te bevatten dan de Rechter-Coppename, alsook steilere kanaalgrenzen en minder gebieden die aan de randen overstromen. De rivier bevat verspreide, onstuimige gebieden, met aquatische plantenbedden van de familie Podostemaceae, die veel meer schijnen voor te komen in de Linker-Coppename dan in de Midden-Coppename. Er monden weinig kreken uit in de rivier.

Midden-Coppename

Tijdens het AquaRAP onderzoek is er in dit gebied weinig verzameld. De Midden-Coppename is smaller dan de Linker-Coppename, maar komt hiermee enigszins overeen: er is minder watervolume dan in de Rechter-Coppename, steilere kanaalgrenzen, minder gebieden die overstromen langs de rivier, en Podostemaceaebedden. De rivier is bovenstrooms rustiger, zonder zichtbare rotsen, maar heeft benedenstrooms stroomversnellingen. Net zoals de Linker-Coppename, ontstaat de Midden-Coppenamerivier vanuit het hoogste gebied van Suriname, het Wilhelminagebergte.

Adampadakreek

De Adampadakreek is een grote zijtak van de Coppenamerivier, maar is veel kleiner dan de Linker-, Rechter- en Midden-Coppename. Deze kreek ontspringt in het Bakhuisgebergte in het westen. Zijn belangrijkste karakteristieken zijn erg helder water, rots- en zandbedden, alsook verscheidene centrale gebieden met ondiep, snelstromend water met verspreide, frequente poelen met grote stenen en zandbodems. Er zijn gebieden van Podostemaceaebedden in de open delen van de kreek, die soms de voornaamste bodemsoort vormt in het ondiep, snelstromend water. Er zijn ook verscheidene kleine tot grote riviereilanden. De Adampadakreek stroomt door *terra firme* bos. In veel delen is het water ondiep, ongeveer een meter. De kreek heeft ook een rots en/ of zandbodem. Aangezien het grootste deel van deze kreek buiten het CSNR ligt, kan er grotere verstoring door menselijk handelen worden ervaren dan de andere onderzochte gebieden.

Het open water van de Coppenamerivier
Het open water van de Coppenamrivier heeft een brede rivierbedding. Er zijn verschillende grote watervallen en onstuimige gebieden met grote rotsen, waar ondiepe en minder diepe poelen zijn ontstaan, alsook ondiep onstuimig water en Podostemaceaebedden. Het water is voornamelijk helder, veranderend in bruin in de diepere poelen. Verscheidene van deze open, rotsachtige gebieden, zoals de Sidonkrutuvallen, zijn goede plekken om te kamperen en voor toerisme. Het open water van de Coppename is een beboste rivier, die breed wordt in veel gebieden waar stroomversnellingen, eilanden en rotsen voorkomen.

SAMENVATTING VAN DE RESULTATEN

Deze AquaRap expeditie was het eerste uitgebreide onderzoek van het stroomgebied van het aquatisch ecosysteem van de Boven-Coppename in het Centraal Suriname Natuurreservaat (CSNR), bovenstrooms van Raleighvallen. Volgens het AquaRap team is dit gebied een van de grootste, meest intact gebleven en ongerept stroomgebieden, die zij ooit zijn tegengekomen. Het vormt een belangrijk tweerichtingspad tussen gebieden van het Guyanaschild met voorgestelde hoge prioriteit voor bescherming. De effecten van menselijke invloeden zijn extreem laag: gedurende een maand van veldwerk en intensief reizen per boot, is het AquaRap team geen andere mensen tegengekomen. Dit is exceptioneel. De grootte van de bomen en de complexe structuur van het bos zijn indrukwekkend in vergelijking met andere gebieden. De conditie van de vissen was zeer goed; de predatoren zoals de anjumara (*Hoplias aimara*) en rood-oog pireng (*Serrasalmus rhombeus*) waren overvloedig aanwezig en zeer groot; de kleuren van de siervissen waren helder; er zijn bijna geen parasieten of infecties waargenomen op de vissen. Er zijn grote garnalen- en krabbenpopulaties; erg heterogene populaties van aquatische ongewervelde dieren, voornamelijk aquatische insecten, en grote kolonies zoetwatersponzen.

De vastgestelde soortenrijkdom was matig voor een Neotropische rivier. De planten en vissen zijn qua soortenrijkdom vergelijkbaar met andere laaglandbossen en -rivieren van het Guyanaschild. De garnalen en krabben zijn ook matig in soortenrijkdom. De aquatische insektenrijkdom, daarentegen, is hoger dan wat gevonden is in andere gebieden, vanwege de overvloed aan macrofyten (Podostemaceae). Er zijn geen exotische of invasieve species aangetroffen in het CSNR, behalve op Foengoe eiland, benedenstrooms van Raleighvallen, waar onder meer manjabomen (*Magnifera indica*) en koereigers (*Bubulcus ibis*), werden aangetroffen.

In het onderzochte gebied van het CSNR, vonden wij unieke samenstellingen van elementen van het laagland Guyanaschild voor het oeverbos, aquatische invertebraten en vissen. Bijvoorbeeld, de boven het bladerdak uitstekende groep planten bestond uit: *Courtari* (ingi pipa) - *Ceiba* (kankantrie) - *Licania* (roosappel). De samenstelling van vissen in de stroomversnellingen was: *Guianacara owroewefi* (krobia) – *Electrophorus electricus* (stroomfisi). – *Moenkhausia oligolepis* (sriba)/ *Gasteropelecus*. De kreken, stroomversnellingen, open rivier en de daarmee geassocieerde bossen hadden verschillende soorten flora en fauna. De aquatische vegetatie (Podostemaceae (kumalu nyangnyang) en algen) was zeer goed ontwikkeld in de stroomversnellingen; deze taxa zijn indicatoren voor een zeer goede waterkwaliteit. Deze vegetatie vormt een kritieke habitat voor diverse en unieke gemeenschappen van vissen en aquatische invertebrata.

Het aantal macrohabitats voor terrestrische en aquatische systemen was relatief laag. Er waren, bijvoorbeeld kreken, stroomversnellingen en open kanalen in het aquatisch milieu. Het terrestrisch ecosysteem had een lage diversiteit aan bodemtypen; de flora is daardoor voor een groot deel afhankelijk van de hydrologie. Het gebied dat in de regentijd overstroomt, is naar schatting kleiner of gelijk aan 200m en vormt meestal een brede oevergang. Het bos, de vissen en inlandse zoetwatergarnalen in deze oevergang vereisen behoud van dit gebied voor een goede reproductie, verjonging, groei en zaadkieming.

De waterkwaliteit was erg goed. De variaties in metingen van parameters van de waterkwaliteit komt door onderliggende geologische formaties, waar de bronnen doorheen vloeien. Bijvoorbeeld, het water van de Rechter-Coppenamerivier ontspringt in zandsteen. De metingen tonen voor het overige aan dat het water typerend is voor onvervuild water, dat gevonden wordt in het Guyanaschild: weinig voedingsstoffen, een beetje zuur en een lage conductiviteit en hardheid.

Het AquaRAP-onderzoeksteam vond ook bewijzen van grote predatoren, inclusief otters (2 species), kaaiman (2 species) en anaconda. Andere waargenomen species, die duiden op een goed en gezond ecosysteem, zijn de capybara (*Hydrochaeris hydrochaeris*), aguti, tapir, en de gonini of harpij-arend (*Harpia harpyja*). Het team noteerde een overvloed aan ara's, papegaaien, toekans, en migrerende vogels (o.a. de visarend). Andere indicaties van een lage jachtdruk waren waarnemingen van leguanen, powisi (*Crax alector*) en verschillende soorten apen; vooral de kwatta apen (*Ateles paniscus*) waren vrij algemeen en niet schuw.

RESULTATEN PER TAXONOMISCHE GROEP

Waterkwaliteit

De kwaliteit van het water was in alle rivierdelen goed. Vanwege de overvloedige aquatische vegetatie (voornamelijk Podostemaceae) is er een laag fosfaatniveau, omdat fosfaat gemakkelijk door planten wordt opgenomen. In kreken met organismen was er gewoonlijk minder zuurstof dan in de open rivier. Verschillen in microhabitats tussen rivierdelen kan leiden tot verschillen in fysische en chemische waterkwaliteit, met als gevolg dat de distributie van bepaalde organismen, bijvoorbeeld de kaaiman, beïnvloed wordt. De verschillen in waterkwaliteit tussen rivierdelen kan worden toegeschreven aan de geologische formaties van de uitstroom van de respectieve rivierdelen, en in bepaalde gevallen aan de weercondities. Ondanks dat de Adampadakreek de hoogste concentraties opgeloste delen vertoonde, had zij het helderste water. Het mijnen in de bovenste stroomgebieden van de Adampadakreek zal bijna zeker leiden tot achteruitgang van de waterkwaliteit van deze kreek en van de lager gelegen delen van de Coppenamerivier.

Planten

Uit het totaal van 349 fertiele planten, verzameld gedurende het AquaRAP onderzoek, zijn 150 soorten uit voortgekomen. We vonden een significante floristieke heterogeniteit binnen het CSNR. De plantgemeenschappen die zijn verzameld, hadden een unieke samenstelling van soorten, en de hier gepresenteerde resultaten ondersteunen de "schuilplaats" theorie. Uiteraard zal er veel grondiger verzameld moeten worden, voordat de CSNR-checklist als compleet kan worden beschouwd.

De CSNR flora is vergeleken met planten van vijf locaties in het noordoosten van Zuid-Amerika, waar uitgebreide collecties zijn gedaan: Kaieteur Falls National Park, Mabura Hill en Iwokrama (Guyana); Reserva Ducke (Brazil); and Saul (Centraal Frans-Guyana). De sterke relatie tussen species van de Guyanese locaties (Kaieteur, Iwokrama en Mabura Hill) en CSNR vormen een indicatie voor een centrum van endemisme tussen Guyana en Suriname. De top drie families binnen het CSNR verschillen van de andere vijf planten, bestaande uit Rubiaceae, Cyperaceae and Araceae, voornamelijk kruidachtige planten. Op de CSNR plantenlijst komen bepaalde prominente houtige families niet voor, die in de vijf andere gebieden voorkomen, namelijk Myrtaceae, Chrysobalanaceae, Annonaceae en Sapotaceae. Dit kan echter liggen aan het feit dat de meeste AquaRAP verzamelingen zijn gedaan binnen een gebied van 6m boven grondniveau. Bij een verhoogde kronendakcollectie binnen het CSNR zullen de aantallen Orchidaceae soorten toenemen en zullen verscheidene prominente houtige families aan de lijst worden toegevoegd.

Aquatische invertebraten

In 82 veldmonsters zijn ten minste 84 species gevonden, waaronder Insecta, Mollusca, Crustacea, Annelida en Porifera. De meest diverse groep die werd vastgelegd was die der aquatische insecten, met 9 orders, bestaande uit 32 families en ten minste 54 soorten; daarna de Mollusca met 6 families, 6 geslachten en 15 soorten, gevolgd door de Crustacea met 5 families, 8 geslachten en 10 soorten. Ten slotte is ook één Hirudinea soort verzameld binnen de groep der Annelida, en één soort zoetwaterspons.

Veel invertebratengroepen en soorten hebben specifieke habitiat vereisten en deze dienen in acht genomen te worden bij het plannen van het behoud ervan. Bijvoorbeeld: Pseudothelphuside krabben schijnen geassocieerd te zijn met rotsige habitats, terwijl Trychodactylidae krabben meer geassocieerd worden met bladeren, modderige bodems of omgevallen bomen. De kleinere zijtakken, die direct in verbinding staan met de hoofrivier, bevatten verschillende species in lagere dichtheden in vergelijking met de open rivier. Dit gold vooral voor krabben van de familie Trychodatylidae en garnalen van het geslacht *Palaemonetes,* en *Macrobrachium* soorten. Diptera waren vooral algemeen in de Podostemaceae bedden. De garnaal *Macrobrachium faustinum* is alleen waargenomen in de stroomversnellingen van de Bolletrievallen. Het schijnt dat de levenscyclus van deze soort gerelateerd is aan het milieu van snelstromend water en Podostemaceae bedden.

Sommige species hebben het heel stroomgebied nodig om hun levenscyclus te voltooien. De garnaal *Macrobrachium faustinum* vereist zowel zoetwater als het kustmilieu om haar levenscyclus te voltooien, aangezien de eieren ontluiken en de larven zich ontwikkelen in water met een hoog zoutgehalte van het marien estuarium. Dit benadrukt de verbondenheid van zoetwater- en mariene ecosystemen binnen het stroomgebied van de Coppenamerivier.

Verscheidene groepen verzamelde invertebraten zijn een indicatie van een ongerept milieu van hoge kwaliteit. Ephemeroptera (eendagsvliegen) kwamen in veel habitats voor, hetgeen een duidelijke indicator is van een ongerept milieu. De frequente aanwezigheid van zoetwatersponzen in onstuimige, snelstromende rivierdelen is een exceptioneel kenmerk, dat ook een indicatie is van een gezond, niet vervuild milieu. Er is een rijke, diverse gemeenschap van aquatische invertebraten in het Centraal Suriname Natuurreservaat. Onze taxonomische kennis van het gebied is echter arm en we adviseren, dat een gezamenlijk project wordt ontwikkeld met verschillende specialisten, om een referentiecollectie en een checklist voor aquatische invertebraten op te bouwen.

Vissen

De visfauna van de Coppenameriver in het Centraal Suriname Natuurreservaat is bemonsterd op 36 locaties binnen 24 georeferentiestations tijdens het aquatisch Rapid Assessment Programma in 2004. In totaal zijn 112 soorten geïdentificeerd. Hiervan zijn vier nieuwe vindplaatsen voor Suriname geregistreerd en tien zijn potentiële nieuwe soorten voor de wetenschap. De Coppenamerivier heeft meer soorten, dan rivieren met dezelfde grootte in de wereld, maar haar visfauna is vergelijkbaar met die van andere rivieren in het Guyanaschild en bevat niet de hoge aantallen species die typerend zijn voor vele neotropische rivieren.. Maar de Coppenamerivier mondt rechtstreeks uit in de Atlantische Oceaan (dus geen deel van de Amazone- of Orinoco-stroomgebieden en hun geassocieerde fauna), en dit helpt bij het vaststellen van het unieke ervan. Elk sub-stroomgebied binnen het Coppenamesysteem heeft ruwweg hetzelfde aantal soorten per monster en er is geen indicatie dat bepaalde soorten gebonden zijn aan een bepaald stroomgebied. Er zijn geen waarneembare biogeografische belemmeringen, die de verspreiding van vissen voorkomen. Verder zijn er geen grote verschillen in soortenaantallen per monster tussen habitats onderling, hoewel bepaalde species voor een groot deel verbonden zijn aan bepaalde habitats. Bijvoorbeeld, de unieke eigen milieucondities van stroomversnellingen en kreken bepalen welke soorten daar gevonden worden.

Een opvallend aspect van de visgemeenschap van de Coppename is de duidelijke verschuiving van bepaalde soorten, van nietstromend binnenwater habitats naar het open rivierkanaal, in vergelijking met gerelateerde soorten in veel andere neotropische systemen (bijvoorbeeld de sidderaal *Electrophorus electricus*, cichliden). Een belangrijke verklaring van dit verschijnsel zou kunnen zijn de armoede van de niet-stromende binnenwateren van dat deel van de Coppenamerivier. Als vissen die normaal aangepast zijn aan traag stromende binnenwateren moeten overleven in riviersystemen zoals de Coppename-uitstroom, dan moeten zij een niche vinden in de open rivier. Er is ook een ongelooflijke overvloed van toppredatoren , zoals de anyumara (*Hoplias aimara*), die meer dan een meter groot was, en de roodoog pireng (*Serrasalmus rhombeus*) met een gemiddelde grootte die zowat alle andere localiteiten in Zuid-Amerika overschrijdt.

Wij nemen aan dat dit een indicatie is van extreem lage visserijdruk, dat bestaat uit bovenstrooms vissen in het laagwaterseizoen door mensen van Witagron en Kaaimanston, en enkele sportvissende toeristen te Raleighvallen. Hoewel de gelegenheid voor behoud van het stroomgebied van de Coppenamerivier (als deel van het Centraal Suriname Natuurreservaat) goed is, neemt de potentiële bedreiging van menselijke aard toe. De bedreigingen zijn o.a. de bauxiet en goudmijnbouw, bosbouw, een toename van het toerisme en ongereguleerd jagen en (sport) vissen. Er is waakzaamheid geboden bij de bescherming van het kenmeerk van ongerepte wildernis van het Centraal Suriname Natuurreservaat, want dit is juist wat dit reservaat onderscheidt van andere en zijn grootste waarde bepaalt.

AANBEVELINGEN VOOR NATUURBEHOUD

Het CSNR is een ongerept, tropisch beschermd wildernisgebied en de Coppenamerivier is misschien wel een van de grootste en meest ongerepte tropische stroomgebieden op Aarde. Daarom stellen wij voor dat er een constante en verhoogde bescherming plaats vindt van het ongerept wilderniskarakter van het CSNR, dat dit reservaat onderscheidt van alle andere en zijn hoogste waarde is in termen van ontwikkeling en gebruik, inclusief onderzoek en ecotoerisme. Het CSNR is een sleutelcomponent van een groter, internationaal beschermingsplan voor het Guyanaschild. Het CSNR is op een kritischelocatie, die de verbinding vormt tussen de noordwestelijke-zuidoostelijke hooglandcorridor en de noordzuidelijke laaglandcorridor naar de Amazone.

De algehele conditie van de flora en fauna in het CSNR en van het gebied benedenstrooms van de Raleighvallen, dat door mensen wordt gebuikt, zijn afhankelijk van het behoud van een gezonde en ongerepte conditie van het stroomgebied van de Coppenamerivier.

Algemene aanbevelingen

1) **Activiteiten voorkómen, die binnen of buiten het Centraal Suriname Natuurreservaat (CSNR) leiden tot degradatie van het ongerepte milieu,** vooral activiteiten die leiden tot erosie, verzilting, sedimentatie, veranderingen van de natuurlijke hydrologische cyclus van de rivier, en vervuiling (inclusief zware metalen)**.** Zulke impacts kunnen voorgoed het ongerept karakter en de biologische waarde van het CSNR verkleinen en, belangrijker nog, de bijdrage verminderen die het Coppenamestroomgebied levert aan de gezondheid en het voortbestaan van de gemeenschappen van mensen die benedenstrooms leven.

2) **Uitbreiding grenzen van het CSNR om het gehele stroomgebied van Coppenamerivier te omvatten.** Wij geloven dat de bufferzone, die momenteel is aangegeven in het CSNR beheerplan, geen adequate bescherming biedt voor het gehele stroomgebied, en vooral voor wat de Adampadakreek betreft, die naar onze mening een uitzonderlijk hoge biologische waarde heeft en zwaar bedreigd wordt door potentiële mijnbouwplannen nabij het Bakhuisgebergte.

3) **De toekomstige mijnbouwactiviteiten in het belendend Bakhuisgebergte nauwlettend in de gaten houden,** om mogelijke invloeden op de Adampadakreek en andere gebieden van het CSNR in te schatten. Werken met de mijnbouwmaatschappijen en de Surinaamse overheid om deze potentiële impacts in te schatten en preventieve maatregelen te treffen voordat een aanvang wordt gemaakt met het mijnen.

4) **Selectie van gebieden van verscheidene macrohabitats en hoogten voor langetermijn monitoring,** (monitoring moet echter zo min mogelijk milieu impact hebben). Het CSNR is zo ongerept, dat het de wereld een belangrijke gelegenheid biedt om inzicht te verkrijgen in langetermijn biologische en ecologische processen in de Neotropen.

5) **Additioneel onderzoek van flora en fauna** van het CSNR doen, als eerste stap naar ecologische monitoring, omdat er onvoldoende data beschikbaar zijn. Dit behelst ook onderzoek van de aquatische fauna en flora.

6) **Het CSNR ontwikkelen als een educatiemogelijkheid van wereldklasse formaat over Neotropische ecologie,** milieuwetenschappen en natuurbehoudsbiologie. Dit geeft Suriname de volgende belangrijke mogelijkheden:
   a) een educatieprogramma, in samenwerking met bestaande internationale programma's, zoals de Organisatie voor Tropische Studies;
   b) capaciteitsversterking van Surinaamse

wetenschappers, inclusief het ontwikkelen van een Graduate Studies programma, om de ecologie en het milieu van het CSNR te bestuderen en monitoren;
   c) een goed uitgerust veldonderzoeksstation binnen het CSNR;
   d) educatieve programma's voor het algemeen publiek en het versterken van partnerschappen, vooral voor basisscholen en gemeenschappen aan de Coppenamerivier, om hen te laten participeren in natuurbehoud en bescherming van het geheel stroomgebied en ter verhoging van de voordelen die het CSNR hen biedt;
   e) educatieve programma's over CSNR voor Suriname en de wereld

7) **Regulering en zorgvuldige monitoring van jacht en visvangst.** De flora en fauna van het CSNR, ofschoon nu ongerept en gezond, zijn erg kwetsbaar. De lokale gemeenschappen en partners moeten betrokken worden bij het vaststellen van regels en limieten. Vooral vissen en jagen voor commerciële doeleinden zouden in het CSNR verboden moeten worden. Ook het sportvissen boven Raleighvallen zou verboden moeten worden, terwijl dagelijkse vanglimieten voor alle species vastgesteld en strak gemonitord dienen te worden. Verder zullen ook restricties moeten gelden op visvangst door werknemers die binnen het reservaat gestationeerd zijn; terwijl visvangst met vallen en netten binnen het reservaat verboden moet worden. Het verbod op jacht en visvangst moet streng worden nageleefd binnen het reservaat. Vanglimieten en beheer moeten gebaseerd zijn op deugdelijke wetenschappelijke data.

8) **Monitoring van en controle op de toegang tot en vooral de export van natuurlijke hulpbronnen van het CSNR** bij de grenzen en algemene toegangspunten ervan (met de boot op de Coppenamerivier tot aan de grens van het reservaat en op de luchthaven Zorg en Hoop).

9) **Zorgvuldige regulering en monitoring van toerisme.** Ecotoerisme is een uitstekend middel om de algemene bewustwording en appreciatie van het CSNR te ontwikkelen. Vanwege de fragiliteit van het CSNR, kan ecotoerisme gemakkelijk ook een negatieve impact hebben. Tours zouden niet bovenstrooms van de Dreefoetoe Soela mogen worden uitgevoerd, hoewel toerisme op kleine schaal wel ontwikkeld zou mogen worden in hoger gelegen gebieden, zoals nabij het Rudi Kappel vliegveld. Evaluatie van alle bestemmingen op geschiktheid (inclusief onderzoek en ecotoerisme) en deze plannen en implementeren volgens allerhoogste internationale standaarden:
   a) verzekeren dat alle aanwendingen zodanig worden ontworpen dat voordeel wordt gehaald van de hoogst mogelijke waarde van het reservaat (zijn ongerept wilderniskarakter) terwijl de gevolgen van zijn gebruik worden geminimaliseerd;
   b) onjuist gebruik en de introductie van vreemde planten en dieren verbieden;
   c) zorgvuldig beheer van vaste en vloeibare afval, om mogelijke degradatie van de goede waterkwaliteit van de Coppenamerivier te minimaliseren;
   d) motorgebruik, alsook brandstof en smeermiddelentransport en gebruik op de rivier beheren, om degradatie van de waterkwaliteit van de Coppenamerivier tegen te gaan.

Taxon-specifieke aanbevelingen

Vissen

1) De huidige overvloed van vissen bovenstrooms van Raleighvallen, vooral de soorten die populair zijn bij sportvissers, kan gemakkelijk worden beïnvloed. Wij denken niet dat de vispopulaties een zware impact vanwege sportvissen of commerciële en siervisserij kunnen weerstaan.

2) Onderzoek in de toekomst zou ook moeten plaatsvinden in de kleine, hoog-gradiënt hoofdwateren van het Boven-Coppenamestroomgebied (d.w.z. bergstroompjes die van de Tafelberg, Bakhuis- of Wilhelminagebergten afvloeien). We zijn niet naar de hoofdwateren geweest van de drie bronrivieren van het Coppenamesysteem, of de bovenste strekking van de Adampadakreek, of de Coppenamerivier en zijtakken beneden de Dreefoetoe Soela. Data over de visdiversiteit en de conditie van visserijbronnen van het Centraal Suriname Natuurreservaat zouden in hoge mate verbeterd kunnen worden met additionele visbemonstering in de hogere en lagere delen van het stroomgebied. Onderzoek benedenstrooms van het Centraal Suriname Natuurreservaat is ook belangrijk, want rivieren vormen een onafgebroken geheel en vissen zwemmen constant in en uit het reservaat.

Invertebraten

1) **Hoofdrivier.** Het feit dat grote delen van de hoofdrivier dienen als plaatsen voor toeristenkampen en menselijke vestiging, betekent dat er een zorgvuldige planning moet plaatsvinden voor behoud van voornamelijk deze gebieden. De hoofdrivier kent ook gebieden met hoge productiviteit, met veel staande biomassa en een accumulatie van energie van de biota en is daarom belangrijk voor de energiestroom van het ecosysteem. Deze gebieden zijn het meest geschikt voor monitoring van invertebratengemeenschappen.

2) **Rechter-Coppename.** Het behoud van dit gebied is om verschillende redenen erg belangrijk: het is een ongerept gebied, heeft de unieke natuur van een zwartwatersysteem, heeft hoge ecologische waarde voor garnalen en krabben en een hoge diversiteit van andere invertebraten.

3) **Linker-en Midden-Coppename.** Deze twee bronrivieren schijnen een ander gemeenschapstructuur van aquatische insecten te hebben, dat verschilt van die van de Rechter-Coppename. Toekomstig onderzoek is nodig om dit te bevestigen, maar dit moet meegenomen worden bij de planning voor natuurbehoud.

4) **Adampadakreek.** Dit gebied heeft opmerkelijke, waardevolle natuurschoon vanwege de combinatie van kristalhelder water, grote ondiepe habitats met Podostemaceaebedden, eilanden en dikke oevervegetatie. Dit is een van de weinige, kleine zijkreken in het gebied, die als schuilplaats fungeren voor inlandse garnalensoorten. De waterkwaliteit en microhabitats van de kreek moeten beschermd worden, teneinde de levenscycli van verschillende garnalensoorten te garanderen.

Sjatu Skrifi

ONDROSUKU INI COPPENAME LIBA NANGA KRIKI, SRANAN

Ondrosuku Ten
20 februari – 14 maart, 2004

Fa a presi tan
Coppename liba e lon psa mindri a moro bigi Reservaat fu Sranan go na se. Na ini bakra tongo wi sabi en leki "Centraal Suriname Natuurreservaat," noso "CSNR", di de na mindrisei fu a kondre. A bigi 1,6 miryun ha. No wan sma no e tan dape. A pisi busi dati tan leki fa Gado meki en.

A watra fu Coppename liba e komopo fu moro pikin liba di habi blaka watra, witi watra nanga krin kloru watra. Den watra disi no de a srefi te ju marki den, so leki afasi fa a trubu, a swa nanga ete wan tu tra sani moro. Furu meti, so leki a bigi watradagu, e libi na ini den liba dati.

CSNR na wan pisi prenspari busi, di kande na en wawan libi na heri gron tapu. Moro leki afu fu a watra di de ini a pisi busi disi e lon psa na ini Coppename liba go na se. Dati meki a de wan prenspari liba fu a pisi kontren. A liba disi musu tan krin so meki meti, fisi, libisma nanga den bon kan tan gosontu.

Fu San Ede Wi Ondrosuku a Presi
A presi wi ondrosuku fu di noiti bifo disi ben psa. Ondrosukuman nanga uma fu Sranan nanga dorosei kondre ben kon makandra, fu du a pisi wroko disi ini wan sjatu pisi ten. Den ben luku a watra, den fisi, bon, grun wiwiri, sarasara, krabu, watra freifrei, mira, nanga so moro, san den pikin fisi e nyan. Dati ben du na ini Coppename liba srefi, den seitaki: Reti Coppename, Kruktu Coppename nanga Mindri Coppename

Furu sma no e libi na Coppename liba. Sma no man go na furu presi bikasi boto nanga opolangi no e go tumsi fara. Dati meki, a pisi busi disi ben man tan leki fa Gado meki en, ma so srefi furu ondrosuku no ben man feni presi.

A koni nanga sabi di kon na krin sa kebroiki fu meki wan buku pe ala sma o sa man lesi fa den musu libi nanga a pisi busi disi, fu a kan tan fa a de fu tego. Sosrefi a koni sa man kebroiki gi moro bigi kontren na ini a pisi fu grontapu pe wi kondre knapu.

Prenspari Feni
Den ondrosukuman nanga oema taki dati Coppename liba nanga den kriki na a moro bigi pisi watra di den si na grontapu di de ete leki fa Gado meki den.

Loktusei fu Raleighvallen a watra bun ete na ini ala pisi fu a liba. Den fisi bigi èn abi krin kloru. Furu sortu meti, fisi nanga bon no de ini a presi leki ini tra liba na grontapu, di gersi di fu wi. Den watra sani nanga siksi futu e monyo fu di koemaloe nyangnyang de furu furu ini a liba. Wi no feni sortu di no de fu a presi srefi. Wan tu sortu leki den switi watra spons nanga den mei-freifrei ben de furu furu. Dati e sori taki a watra krin èn bun fu dringi. Furu krabu nanga sarasara sortu e sori taki den abi spesrutu presi fanowdu fu kan abi wan bun libi. Disi wi sa musu hori na wi ede te wi o luku fasi fa wi kan seti a presi fu a tan bun. A sarasara, *Macrobrachium faustinum*, abi liba watra nanga se watra fanowdu fu meki eksi te leki den broko meki pikin sarasara. A sabi disi e meki wi denki taki a se, nanga Coppename liba tai kon na wan wan sortu fasi.

Den sortu san wi feni
Bon nanga wiwiri - 150 sortu
Fisi - 112 sortu
Sani sondro bakabonyo:
Pakro - 15 sortu
Sarasara / Krabu - 10 sortu
Sani nanga siksi futu, insect - 54 sortu (a kan de moro srefi)

Nyun sortu gi Grontapu
Fisi - 10 sortu

Nyun sortu gi Sranan
Fisi - 4 sortu

Prenspari sani san wi musu du fu kibri CSNR
(luku owktu a langa pisi skrifi ini bakra tongo nanga engrisman tongo, di habi moro langa, dipi bere taki, abra san wi sa musu fu du, fu kibri a pisi kontren)

1) Wi no musu du sani ini Centraal Suriname Natuurreservaat (CSNR), noso krosibei fu en, san kan meki a bun fasi fa a de, kon kenki kon tron wan takru fasi

2) Meki a Reservaat kon moro bigi, fu meki a heri Coppename liba nanga Adampada kriki kan de na ini a Reservaat

3) Luku fini-fini san e go psa na Bakhuis Bergi te den e go diki, nanga wroko a redi doti (bauxiet), di de krosibei fu Adampada kriki nanga den tra presi fu a Reservaat

4) Luku fini-fini san e psa na prenspari presi, leki son héi presi ini a Reservaat

5) Moro ondrosuku musu du fu luku moro fara, sortu bon nanga meti de ete

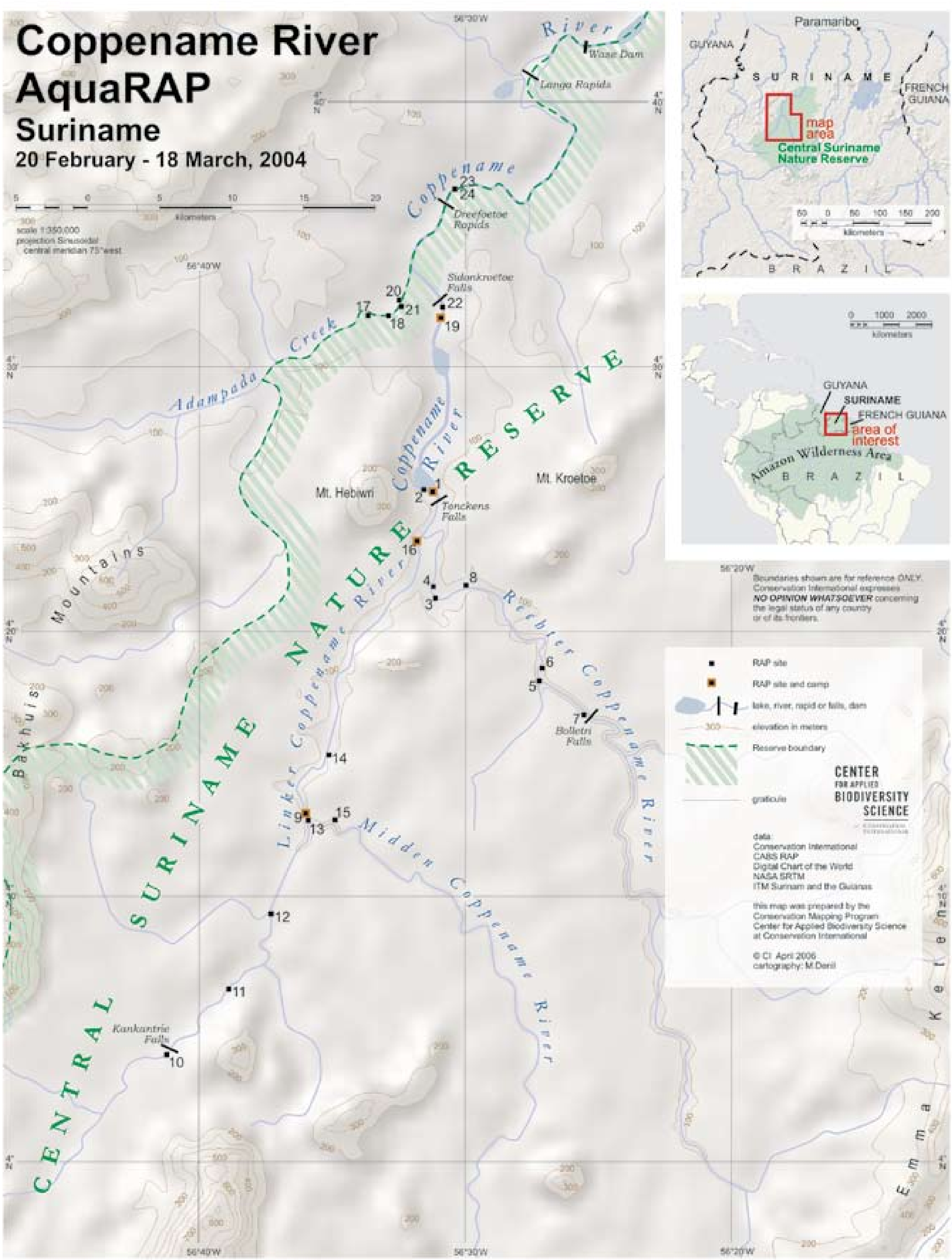
6) Poti skrifi na papira, abra a fasi fa, nanga oten ontiman musu sutu meti, sortu meti den abi primisi fu sutu nanga oten, nanga a fasi fa fisiman musu fanga fisi. Busi-skowtu musu go na a presi fu luku efu den sma e du san skrifi na papira

7) Luku tapu Zorg en Hoop opolangi presi nanga pe boto, nanga wagi e psa fu si san sma e teki komopo fu a presi tja gwe

8) Poti skrifi na papira fu luku ala den fasi fu toerisme ini a kontren

LITERATURE CITED:

Kramp, A.A. *et al.*, 2004. Woordenlijst Sranan-Nederlands met een lijst planten- en dierennamen. 4e druk. Vaco N.V. Uitgeversmaatschappij, Paramaribo.


Coppename River
AquaRAP
Suriname
20 February - 18 March, 2004
kilometers
Mt. Hebiwri
Mt. Kroetoe
Adampada Creek
Coppename River
Linker Coppename River
Midden Coppename River
Rechter Coppename River
Wase Dam
Langa Rapids
Dreefoetoe Rapids
Sidonkroetoe Falls
Tonckens Falls
Bolletri Falls
Kankantrie Falls
CENTRAL SURINAME NATURE RESERVE
Bakhuis Mountains
Emma Keten
Paramaribo
GUYANA
SURINAME
FRENCH GUIANA
BRAZIL
map area
Central Suriname Nature Reserve
area of interest
Amazon Wilderness Area
Boundaries shown are for reference ONLY.
Conservation International expresses
NO OPINION WHATSOEVER concerning
the legal status of any country
or of its frontiers.
RAP site
RAP site and camp
lake, river, rapid or falls, dam
elevation in meters
Reserve boundary
graticule
CENTER FOR APPLIED BIODIVERSITY SCIENCE
data:
Conservation International
CABS RAP
Digital Chart of the World
NASA SRTM
ITM Surinam and the Guianas
this map was prepared by the
Conservation Mapping Program
Center for Applied Biodiversity Science
at Conservation International
© CI April 2006
cartography: M.Denil

Philip Willink

This new species of catfish, *Peckoltia* sp., is the only known specimen of this species in any museum anywhere in the world. The unofficial common name is 'Tonckens Vallen Peckoltia', because that is where the solitary specimen was collected.

Mike Littmann

Described by Linnaeus in 1758, *Anostomus anostomus* was one of the first officially described species in the world.

Peter Hoke

Serrasalmus rhombeus (red-eyed piranha) caught at Bolletri Falls.

Peter Hoke

Sidonkroetoe Falls on the Coppename River.

Peter Hoke

Hoplias aimara (anjumara) is one of the largest fishes in the Coppename River, reaching lengths of over 1 meter. It is prized as food and commonly fished for with large hooks and chunks of meat as bait.

Peter Hoke

The AquaRAP team leaving for a day of surveying.

Peter Hoke

A helicopter shuttled people and supplies to our first base camp.

Peter Hoke

Boatmen/Koelamen (left to right) – D. Boomkijk, T. Boomdijk, L. Olijfveld, P. Tjappa, G. Akwada, S. Jozua, J. Rhodes, O. Timo, R. Clemens.

Peter Hoke

G. Landburg conducting a water quality test.

Peter Hoke

D. Clarke and J. Rhodes collecting flowering plants along the river.

Peter Hoke

R. Clemens, J. Mol and B. Chernoff removing a *Serrasalmus rhombeus* (red-eyed piranha) from a seine net at Bolletri Falls in Rechter Coppename.

Peter Hoke

P. Ouboter and G. Landburg taking water quality samples in a small tributary of the Rechter Coppename.

Peter Hoke

G. Pereira collects aquatic invertebrates with a dip net.

Peter Hoke

P. Willink, J. Mol, M. Cooperman, B. Chernoff seining for fish in Adampada Creek.

Peter Hoke

J. Rhodes climbs up a tree to collect seeds.

Peter Hoke

AquaRAP Team (left to right) D. Clarke, O. Prika, G. Pereira, P. Hoke, H. Berrenstein, Ambassador Udenhout, B. Chernoff, G. Landburg, P. Willink, J. Rhodes, M. Copperman, P. Ouboter, J. Mol.

Chapter 1

Overview of the Central Suriname Nature Reserve and the Coppename River Watershed

Haydi J. Berrenstein

INTRODUCTION

The Central Suriname Nature Reserve (CSNR) is located in the District of Sipaliwini, about 200 km southwest of the capital Paramaribo, and lies between the Amazon and Orinoco River Basins. The area of the CSNR is 1.6 million ha and covers 10 % of Suriname's land surface, with an altitudinal range of 25 m to 1,230 m. The CSNR protects the upper watershed of the Coppename River and also includes the headwaters of the Kabalebo, Lucie, Oost, Zuid and Saramacca Rivers and important eastern tributaries of the Suriname River and the Tapanahony River. Established on July 31, 1998 (Staatsblad 1998 no.65), the CSNR encompasses three previously existing reserves: the Eilerts de Haan Gebergte Nature Reserve (220,000 ha), Raleighvallen Nature Reserve (78,200 ha) and Tafelberg Nature Reserve (140,000 ha). The CSNR is one of the largest strictly protected areas in South America.

Many organizations, including the Ministry of Natural Resources, the Forest Service, United Nations Development Program (UNDP), Global Environmental Facility (GEF), United Nations Office for Project services (UNOPS), Conservation International Suriname, international donors, as well as the Kwinti, Matawai, Tareno and Samaaka communities living near the Nature Reserve, have contributed significantly to the establishment of the CSNR. The CSNR has been proposed as a World Heritage Site (United Nations Educational Scientific and Cultural Organization 1999) and meets two criteria: (ii) "ecological processes" and (iv) "biodiversity and threatened species." Criterion (ii) is based on the fact that the CSNR conserves a large portion of the eastern part of the Guayana Shield, which stretches over eastern Venezuela, Guyana, Suriname and northern Brazil. The CSNR contains a variety of ecosystems across environmental gradients that allow for gene flow between populations, adaptation to changes, and movement of organisms in response to adaptation. Criterion (iv) indicates that the Reserve is a major reservoir for biota of the region, including many endemic species.

IMPORTANCE

The CSNR has a special value as a very large protected area, providing a hedge against human induced global scale climatic changes. Global warming may well have a significant impact on vegetation and biodiversity in general in the future, but because the CSNR is so large and protects such a seamless expanse of natural ecosystems (from close to sea level to the very highest elevation in Suriname), it can act as an important refuge for species and communities if and when climatic conditions change.

The size and diversity of the CSNR are also important because tropical rainforests in general and the Guianan Bioregion in particular are so poorly understood. Aside from a few notable exceptions, particularly research conducted around Raleighvallen, the CSNR is unstudied. Our knowledge of rainforest ecosystems and species interactions in the Guianas remains minimal. Long-term protection provides us time to learn from nature. Such an opportunity is not available in many regions of the world - where protected areas large enough to contain viable populations of widely dispersed species and ecological processes are not a viable option.

Finally and immeasurably important are the free goods and services that the ecosystems of the CSNR provide to society including clean water, pure air, and soil formation and protection. The CSNR is an enormously important protected area both to Suriname and to the global community, as a rare living example of the way natural processes function in a place where human impacts have been minimal.

Geological Features

The Guayana Shield consists of Precambrian igneous and metamorphic rocks, which originated during the period of Trans-Amazonian Orogenesis about 1.9 billion years ago. Since that time, it has been a stable area with respect to volcanic activities, earthquakes, and orogenesis. There are two very distinct geological features within the area of the reserve, Roraima sandstone and exposed Precambrian crystalline granitic rocks.

Roraima sandstone is only found in the Tafelberg area: Tafelberg, Kappel Savanna, and the southern Hendrik top of the Emma Range.

The Precambrian crystalline basement rock of the Guayana Shield comes to the surface as inselbergs (granitic outcroppings) and granite plateaus; as *sulas*, river rapids and falls; and as bare granitic slopes and/or summits of mountain ranges. Within the CSNR, inselbergs and granite plateaus are found in the Voltzberg area, Van Stockumberg, Van der Wijcktop; *sulas* on all the rivers – the largest complex being at Raleighvallen on the Coppename; bare slopes and/or summits are found on the Wilhelmina Mountains and Emma Range.

Granite inselbergs and granitic outcroppings have the shape of a dome, with steep sides and little or no vegetation on their summits and were formed during the Tertiary and Pleistocene periods. The Voltzberg dome, which is 240 m above sea level, is the most famous inselberg in the CSNR and is characterized by unique vegetation. The Devil's Egg is a giant boulder on top of a granite spire that is several hundred meters high and can be defined as a unique geological feature within the CSNR. In the Tafelberg Nature Reserve and other sites of the CSNR, flat topped mountains, called *tepuis*, are present. The Wilhelmina mountain range, with the Juliana Top (1,230 m), the highest peak of Suriname, is located in the southern portion of the CSNR.

Ecosystems

Pristine primary lowland and montane tropical rain forest are dominant in the CSNR. Isolated savannas occur within the Reserve with their specific vegetation and along the rivers and creeks marsh forest exist. The Roraima sandstone savanna, known as Rudi Kappel savanna, is a unique ecosystem within the Reserve and is the only one occurring in Suriname. It extends over 1,000 ha at an elevation of 300 m. The majority of forest vegetation types of the CSNR are moist mesophytic forest, swamp forest, liana forest, savanna forest and mountain savanna forest.

The reserve contains a number of more or less isolated ecosystems. These include:

- An unbroken blanket of pristine lowland rain forest ranging from hydrophytic to mesophytic lowland (less than 500 meters elevation).
- Isolated areas of super humid or xeric submontane tropical forest (generally occurring at elevations higher than 500 meters), including the unique Tafelberg *tepui* (1090 M and the easternmost outpost of this Roraima sandstone formation), and the Wilhelmina Mountain range with the highest peak in Suriname, the Juliana Top (1230 M).
- Isolated xeric inselbergs (granite outcroppings) and strongly seasonal lowland rain forest, such as the Voltzberg and the forest surrounding it.
- Isolated open lowland savannas on poor sandy soils, such as the Kappel Savanna, surrounded by lowland xerophytic woodlands and forests.
- Clear-water as well as black-water rivers and creeks with rapids and waterfalls, such as the Coppename, the Lucie and the Zuid Rivers.
- Floodable low forest and forest swamps that harbor species that migrate from rivers during the dry season into the flooded forest. Many fish species spawn during the wet season in these flooded areas, attracting predators such as otters, caimans and birds.

Biodiversity

Suriname is rich in biodiversity, with 200 species of mammals, 674 species of birds, 152 species of reptiles, 99 species of amphibians, and 790 species of fishes (Mittermeier et al., 1990). As the most significant single reserve for the biota and unique geological and geomorphological features of the Guayana Shield, the CSNR includes a high proportion of this biodiversity: 4,500 vascular plant species and 81 mammal species occur in the CSNR; 447 species of birds are known from Raleighvallen alone. Since the CSNR has been so little studied, the number of species is most likely significantly higher.

A review of the floristic inventories carried out in the Guianas is given in Lindeman and Mori (1989) and Pulle et al. (1932 -1986), and Lindeman and Mennega (1963) deal specifically with the flora of Suriname. Many species of plants are endemic to the nature reserve. Five endemic species occur in the Voltzberg area and two are listed for the forest of the Raleighvallen/Voltzberg area; 29 endemics are known for the Tafelberg and 11 for the Wilhelmina Mountains.

Early botanical and zoological research in the CSNR included specimen collecting by Dutch and American museums and species mapping. One of the first zoologists to explore the CSNR area systematically was Harry Beatty of the Chicago Field Museum who collected over 268 species of birds from the Kayser and Wilhemina Mountains in the early 1960s, of which 27 were new to Suriname. In the same period, one of the first studies of the Raleighvallen/Voltzberg was Donselaar and Schulz's study (1973a, 1973b) of rocky outcrops.

The birds of Suriname have been well documented (Haverschmidt & Mees 1994) and a species list is available for the Raleighvallen/Voltzberg area. Hoogmoed (1968, 1973), Goin (1971) and Ouboter (1996) have studied the herpetofauna of the region. Based on his primatological research at Raleighvallen, Van Roosmalen published a comprehensive guide to the fruits of the Guianas in 1979 (Van Roosmalen, 1979, 1985b).

The fish fauna of Suriname has been studied by many researchers (see Chapter 5 this volume). Ouboter and Mol (1993) listed 318 freshwater fish species known to occur in Suriname and this number has recently increased dramatically to approximately 450 (J.H. Mol and P.E. Ouboter unpublished results) mainly due to the inventory of the Marowijne River fish fauna by Planquette et al. (Planquette et al. 1996, Keith et al. 2000, Le Bail et al. 2000). However, new species are still discovered (e.g., Vari et al. 2003).

Fauna endemic to Suriname and known to occur in the CSNR include: two bats (*Tonatia schulzi*, and *Molossops neglectus*), a reptile (*Amphisbaena myersi*), and five amphibians (*Centrolenella geijski*, *Hyla fuenti*, *Eleutherodactylus grandoculis*, *Caecilia albiventris*, and *Micocaecilia taylori*) (Goin 1971, Hoogmoed 1973).

More recent research has focused on ecology and behavior. A number of studies in the Raleighvallen/Voltzberg area attracted attention and promoted similar efforts elsewhere in South America. Examples are the primatological research of Russell A. Mittermeier (synecology), Marc G. M. van Roosmalen (ecology and behavior of spider monkeys, *Ateles paniscus*), and John G. Fleagle (locomotion and posture) (Mittermeier 1977, Fleagle et al. 1981; Mittermeier and Fleagle 1981, Mittermeier and Van Roosmalen 1981, Van Roosmalen 1985a). The primatological research carried out at Raleighvallen has formed the basis for a field guide to the primates of the Guianas (Van Roosmalen et al. 2003). Duplaix (1980) has studied the giant river otter, *Pteronura brasiliensis*, Trail (1985a, 1985b) studied the Cock-of-the-Rock (*Rupicola rupicola*). Ouboter (1996) has studied the caiman, *Caiman crocodilus* and *Paleosuchus trigonatus*.

The geologically stable Guianan Bioregion has long supported tropical ecosystems. During glacial periods, a drier climate in the Guayana Shield favored the expansion of savannas; forests shrank to higher elevation islands. Forested areas above 500 meters probably remained intact, allowing for isolated and undisturbed evolution over long periods of time. Isolation, followed by speciation, also accounts for the many endemic plant species found on inselbergs (e.g. Voltzberg) today. Likewise for the Tafelberg, where speciation is known to have occurred in plants and is expected in other taxa. It is considered likely that endemic aquatic fauna (fish and invertebrates) occur in the upper reaches of the numerous isolated river systems.

Cultural Aspects

Cultural artifacts and petroglyphs have been found at Raleighvallen and in the Coppename River and its tributaries, the Linker and Midden Coppename and the Adampada creek. This indicates that ancestors of the Carib Indians inhabited the site during Pre-Columbian time. The Kwinti tribe outside the Reserve is believed to have settled there during the 17th century.

THE COPPENAME RIVER BASIN

The Coppename River Basin is the third largest watershed in Suriname. Together with its tributaries, the Rechter Coppename, Linker Coppename, Midden Coppename, Adampada, Tibiti, Coesewijne and Wayambo, it is one of the seven river systems that drain the land surface of Suriname (see Map). The Coppename River watershed flows through the CSNR and empties into the Atlantic Ocean in the northern part of the country. The Coppename River watershed is not part of the Amazon or Orinoco drainages, thus the aquatic biota does not pertain to that of other watersheds in South America, indicating the uniqueness of this river.

The Coppename River Basin is characterized by six habitat types: the main – channel habitat, rapids, creeks, rocky shores, backwaters and sandy beaches. The bottom of the main channel and streams is usually covered with rocks and sand. High, steep banks keep the water in narrow channels and water levels may rise up to 5 meters or more during the rainy season.

The main channel of the Coppename River is highly variable. The water is brown and clear and the riverbed is mainly covered with rock formations, making it difficult to navigate at certain sites, especially in the dry season. The river is wide at certain points and narrow at other points. At low water levels, which occur from February through April and from September through December, it is extremely difficult to travel by boat on the Coppename River. Many rocks are displayed and mounds (as at Sidonkroetoe sula) become more visible. Near Foengoe island at Ralleighvallen there is a series of sulas (rapids) that stretch over 1.5 to 2 km. This site is extremely difficult to navigate.

The Rechter Coppename River is unique, for it is the only part with black water. Shallow sandy and rocky habitats were encountered in this tributary of the Coppename River. Many rapids are present here, the largest is the Bolletrie Falls, an enormous granite rock, which extends over the entire river width and never completely dries up in the dry season. Because of its height, which becomes more visible in the dry season, it is not easy to cross. On the rock vegetation, isolated water pools and forest islands are visible. Terra firme forest is found along the Rechter Coppename.

The Linker Coppename is a densely forested river with terra firme forest in some parts and seasonally inundated forest, giving the impression of swampy areas. Many rapids, islands and rock complexes occur in the Linker Coppename. Tributaries of this river are shallow with a sandy or muddy bottom and backwaters are also present. At Kaaiman sula or Kankantrie sula the water is very clear. This is an area of rocky pools, rapids and several Podostemaceae beds and guave plants (2 m). The water flows via several routes between the rocks over the rocky and sandy bottom down streams of the river.

The Midden Coppename is narrow compared to the Linker Coppename. The upper part doesn't have that many visible rocks possibly because the river is deeper and rocks are submerged. Down streams, rapids become abundant and visible.

Adampada creek, one of the tributaries of the Coppename River, which originates in the Bakhuys Gebergte (Bakhuis Mountain) with a major bauxite deposit, has a thick rocky bottom. The rocks seem to be layered more flat compared to the other rivers where the rocks point out of the water. Sandy spots are quite sparsely distributed in the Adampada creek. There are rocks, islands and rapids in the Adampada creek. The Adampada creek is forested with terra firme forest, the water is shallow and very clear (Secchi disk depth >2 m) and slopes are very high at certain sites. Compared to the Linker Coppename and the Coppename River, conductivity, alkalinity and hardness are relatively high in the Adampada creek. This may be caused by the fact that the water originates from another geological formation (see Chapter 2 this volume).

The Adampada creek is very important in terms of the intended mining operations that may take place outside of the Central Suriname Nature Reserve, and may negatively influence the Adampada creek and the entire lower section of the Coppename River watershed with its unique biota.

LITERATURE CITED

Duplaix, N. 1980. Observations on the ecology and behavior of the giant river otter *Pteronura brasiliensis* in Suriname. Rev. Ecol. (Terre Vie) 34: 496-617.

Fleagle, J. G., R.A. Mittermeier, and A.L. Skopen. 1981. Differential habitat use by *Cebus apella* and *Saimiri sciureus* in central Surinam. Primates 22(3): 361-367.

Goin, C.J., 1971. A synopsis of the tree frogs of Suriname. Ann. Carnegie Mus. 43 (1): 1-23.

Haversmidt, F. and G.F. Mees. 1994. Birds of Suriname. Vaco, Paramaribo, 578 pp.

Hoogmoed, M.S. 1968. Enige opmerkingen over herpetologische fauna van het Raleighvallen Voltzberg natuurreservaat. Report to STINASU, Paramaribo. 4 pp.

Hoogmoed, M.S. 1973. The lizards and amphisbaenians of Surinam. Notes on the herpetofauna of Surinam IV. Dr. W. Junk, The Hague, 419pp.

Lindeman, J.C. and A.M. Mennega. 1963. Bomenboek voor Suriname. Met tekeningen van W. H. hekking. Dienst Lands Bosbeheer Suriname. 312 pp.

Lindeman J.C. and S.A. Mori. 1989. Botanical Inventory. *In:* D.G. Campbell and H.D. Hammond (eds), Floristic inventory of tropical countries: The status of plant systematics, collection, and vegetation, plus recommendations for the future. The New York Botanical Garden. pp. 380-388.

Mittermeier, R.A. 1977. Distribution, synecology and conservation of Surinam monkeys. Unpublished Ph.D. thesis. Harvard University, Cambridge, MA.

Mittermeier, R.A. and J.G. Fleagle. 1981. Locomotor behavior, body size and comparative ecology of seven Surinam monkeys. Am. J. Phys. Anthropol. 52: 301-314.

Mittermeier, R.A. and Van Roosmalen, M.G.M. 1981. Preliminary observations on habitat utilization and diet in eight Surinam monkeys. Folia Primatol. 36: 139.

Mittermeier R.A., S.A. Malone, M.J. Plotkin, F.Baal, K. Mohadin, J. Mac Knight, M.M. Werkhoven, and T.H. Werner. 1990. Conservation Action Plan for Suriname. Conservation International, Suriname Forest Service, World Wildlife Fund – USA, STINASU, University of Suriname. 45 pp.

Ouboter, P.E. 1996. Ecological studies on crocodilians in Suriname. Niche segregation and competition in three predators. SPB Academic Publ., Amsterdam. 139 pp.

Pulle, A.A. 1906. An Enumeration of the Vascular Plants known from Surinam together with their Distribution and Synonymy. E.J. Brill. Leiden. Pp. 1-155.

Pulle A.A., J. Lanjouw, A.L. Stoffers, J.C. Lindeman (Eds.). 1932 – 1986. Flora of Suriname 1-6. J.H. de Bussy, Amsterdam/ E.J.Brill, Leiden.

Trail, P.W., 1985a. Territoriality and dominance in the lekbreeding Cock of the Rock. Nat. Geogr. Research 1: 112-123.

Trail, P.W., 1985b. Courtship disruption modifies mate choice in a lekbreeding bird. Science 227: 778-780.

United Nations Educational Scientific and Cultural Organization. 1999. Convention Concerning the Protection of the World Cultural and Natural Heritage. The Central Suriname Nature Reserve. Nomination of Properties for Inclusion on the World Heritage List as Natural Heritage. Suriname.

Van Roosmalen, M.G.M. 1979. Surinaams vruchtenboek. Instituut voor Systematische plantkunde Transitorium II. Deel I. (Beschrijvingen) 326 pp. Deel II. Platen. 230 pp.

Van Roosmalen, M.G.M. 1985a. Habitat preferences, diet, feeding strategy, and social organization of the black spider monkey (Ateles paniscus paniscus Linnaeus 1758) in Surinam. Acta Amazonica 15(3/4) Supl. 238pp.

Van Roosmalen, M.G.M. 1985b. Fruits of the Guianan Flora. Institute of Systematic Botany, Utrecht.

Van Roosmalen, M.G.M., A.B. Rylands, R.A. Mittermeier, and W.R. Kontant. 2003. The Primates of the Guianas. Conservation International Tropical Field Guide Series, Conservation International, Washington, D.C.

Van Donselaar, J. and J.P. Schulz. 1973a. On the flora and vegetation of granite exposures in the Voltzberg region (Surinam). With notes on some similar areas in Surinam (unpublished). Typescript.

Van Donselaar, J. and J.P. Schulz. 1973b. Lijst van rotsplanten aangetroffen in Suriname. (unpublished). Typescript with handwritten annotations.

Chapter 2

Water Quality of the Coppename River Basin, with notes on aquatic fauna distribution

Paul Ouboter and Gwen Landburg

INTRODUCTION

The water quality of the interior rivers and creeks of Suriname is usually characterized by a low amount of nutrients, pH slightly below 7, dissolved oxygen almost saturated, and water almost clear (Haripersad-Makhanlal and Ouboter 1993). This generalization is mainly based on surveys done in the Corantijn, Nickerie, Saramacca, Suriname and Marowijne basins. Hardly any water quality data are available for the Coppename basin. Based on the geology of the area and reconnaissance flights carried out some years ago, it was expected that the general water quality of the upper Coppename basin would not be very different from other interior rivers. However, it is known that the Rechter Coppename River has slightly black water originating from an area of sandstone at the Tafelberg Mountain. This AquaRAP survey will be the first research to compare the actual data with the expectations.

METHODOLOGY WATER QUALITY

Parameter selection

Parameters were selected on the basis of common limnological practices, differences known between river sections and possible future pollution. Basic water quality parameters measured were:

- Temperature (°C)
- pH
- Conductivity (μS/cm)
- Dissolved oxygen (% saturation)
- Alkalinity (ml/l as $CaCO_3$)
- Hardness (mg/l as $CaCO_3$)
- Chloride (mg/l)

The following parameters measured nutrients:

- Phosphate (mg/l)
- Nitrate (mg/l)
- Ammonia (mg/l)

Analyses

The Rechter Coppename River was known to have slightly blackish water, with much humic acids. This could not be measured directly, but the following parameters are indicators of high humic acid contents:

- High COD (Chemical Oxygen Demand [mg/l] = the oxygen required for the oxidation of all the substances of the water, included those not biologically decomposable)
- Low pH
- Low Secchi depth (cm)

- Usually blackish waters are also relatively low in dissolved oxygen, alkalinity and nutrients

Unfortunately, the program was so busy that COD, which needs a 2 hour-destruction time, could only be measured sporadically.

Indicators of pollution are the following:

- Low Secchi depth (turbidity)
- High conductivity (dissolved solids)
- Low dissolved oxygen (organic waste)
- High alkalinity (various pollutants)
- High chloride (various pollutants)
- High nutrients (organic waste and fertilizers)
- High COD
- High metals

Of the metals only aluminum was measured. This metal was chosen in relation to the high aluminum contents of the soils of the Bakhuis Mountains.

METHODS

The following methods were used:

- Electro-chemical/physical (temperature, pH, conductivity, dissolved oxygen, secchi depth)
- Titrimetric (alkalinity, hardness, chloride)
- Colorimetric (phosphate, nitrate, ammonia, aluminum, COD)

Chemicals and most electro-chemical meters were manufactured by HACH Company, the dissolved oxygen meter by Yellow Springs Instruments. Most parameters were measured at the sampling localities within a two-hour period.

Sample localities

Measurements were taken at 28 localities; most of them in duplicate. Measurements were taken at:

- Rechter Coppename River: 8 localities.
- Linker Coppename River: 5 localities.
- Midden Coppename River: 2 localities.
- Main Coppename River: 8 localities.
- Adampada Creek: 5 localities.

Most sample localities were near rapids or in tributaries. The selection was mainly based on habitat availability for fishes and aquatic invertebrates.

RESULTS

All results are listed in Table 2.1 and illustrated in Figures 2.1-2.12. It should be noted that results were sometimes influenced by the weather conditions before and during measurement. For instance during the period that most localities of the Linker Coppename and Midden Coppename were measured, it rained quite often while during the remainder of the period it was rather dry. This is reflected in a lower temperature and secchi depth (Figures 2.1 and 2.5) and probably also a higher phosphate and ammonia level (Figures 2.9 and 2.11) in the Linker Coppename.

Water quality of specific river sections

Rechter Coppename

The Rechter Coppename is a river with different habitats of shallow, sandy and rocky parts. There were also some deeper stretches. The shores are vegetated with terra firme forest. The river contains a few rapids with the Bolletrieval as the largest. The water is slightly acidic and blackish and also relatively warm.

The nutrient content is relatively low except for phosphate (0.04-0.09 mg/l). Nitrate is between 0.01-0.05 mg/l; ammonium is not above 0.005mg/l. Dissolved oxygen does not reach saturation, even in rapids. The tributaries of the Rechter Coppename are shallow with sandy and muddy bottom. The water temperature in the tributaries is lower than in the river (24.9-25.7 °C) and the pH is higher (around 6.3).

The river is habitat to two species of caiman, *Caiman crocodilus* and *Paleosuchus trigonatus* and a number of fish eating birds. Also observed was the giant otter, *Pteronura brasiliensis*.

Linker Coppename

The Linker Coppename is a forested river. The shore has terra firme and seasonally inundated forest. There are many rapids, including islands and rock complexes. The water is hardly colored and slightly turbid (much rain during surveys). The pH is 6.0-6.3.

The Linker Coppename has more phosphate and ammonium than the Rechter Coppename. Nitrate is between 0.01-0.03 mg/l. The water has more oxygen than the Rechter Coppename.

The tributaries of the Linker Coppename are shallow with sandy and muddy bottom. Dissolved oxygen and temperature are much lower than in the river.

The caiman *Paleosuchus trigonatus* was observed, not *Caiman crocodilus*. There were less aquatic fishing birds than in the Rechter Coppename.

Midden Coppename

The Midden Coppename is narrower than the Linker Coppename. Downstream there are rapids. The river is more upstream quiet without any visible rocks. The river was turbid at time of measurement (it was also raining during sample measurements). The nutrients were relatively low (only one locality was sampled).

One tributary of the Midden Coppename was assessed. The pH, dissolved oxygen and the temperature are much lower than in the river, but the conductivity (around 29 µS/cm) and the nutrients were relatively high

Observation time in this river section was limited to one day. Only one species of fish eating bird, a tiger heron, was observed.

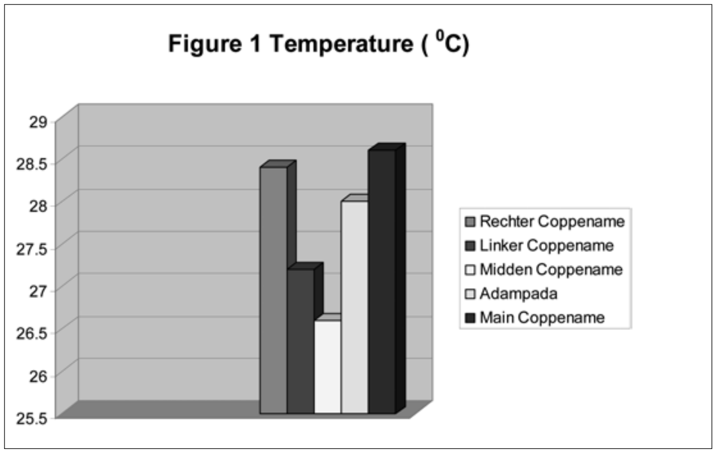


Figure 2.1. Mean water temperatures recorded in the Coppename Basin during the AquaRAP survey.

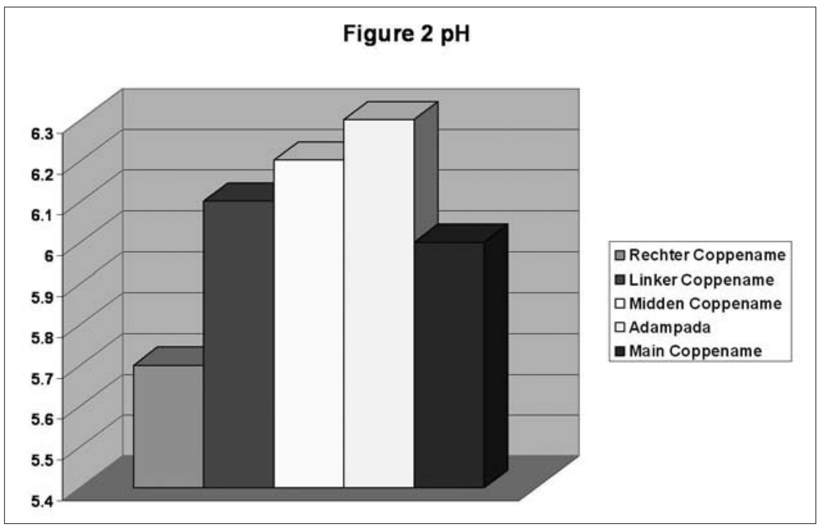


Figure 2.2. Mean pH of the water recorded in the Coppename Basin during the AquaRAP survey.

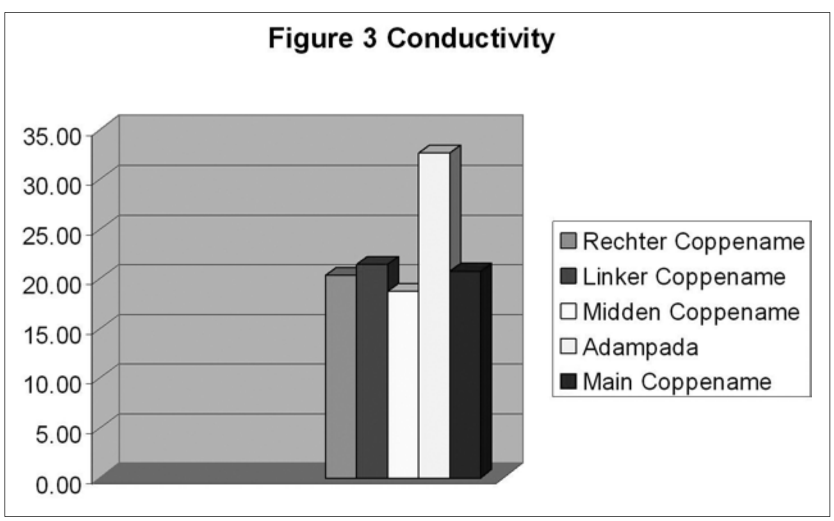


Figure 2.3. Mean water conductivity (µS/cm) recorded in the Coppename Basin during the AquaRAP survey.

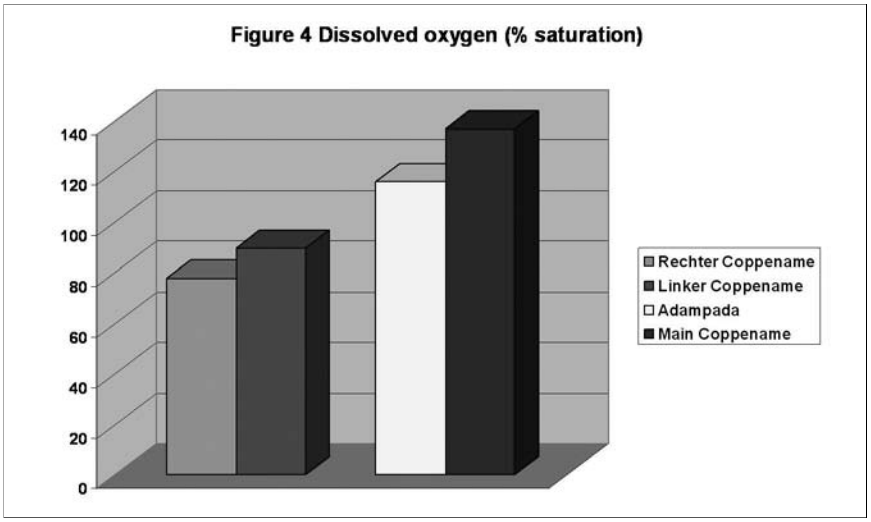


Figure 2.4. Mean levels of dissolved oxygen (% saturation) recorded in the Coppename Basin during the AquaRAP survey.

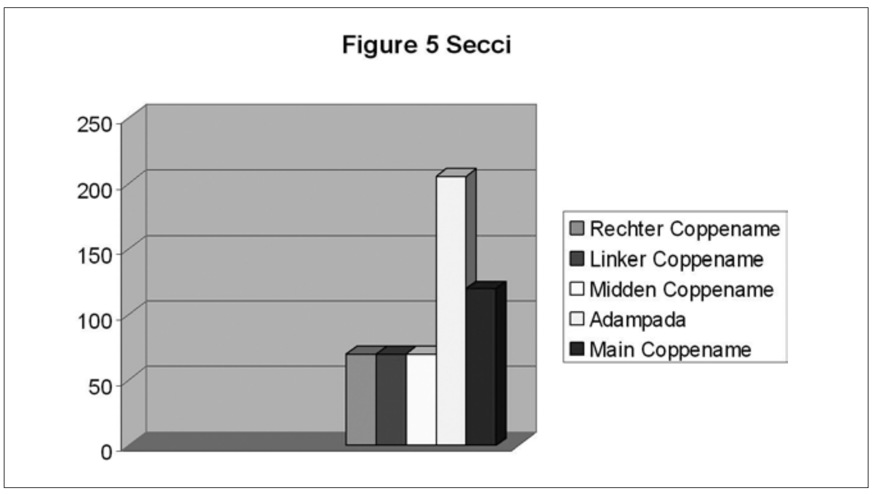


Figure 2.5. Mean water clarity values (cm) as measured by secchi dish in the Coppename Basin during the AquaRAP survey.

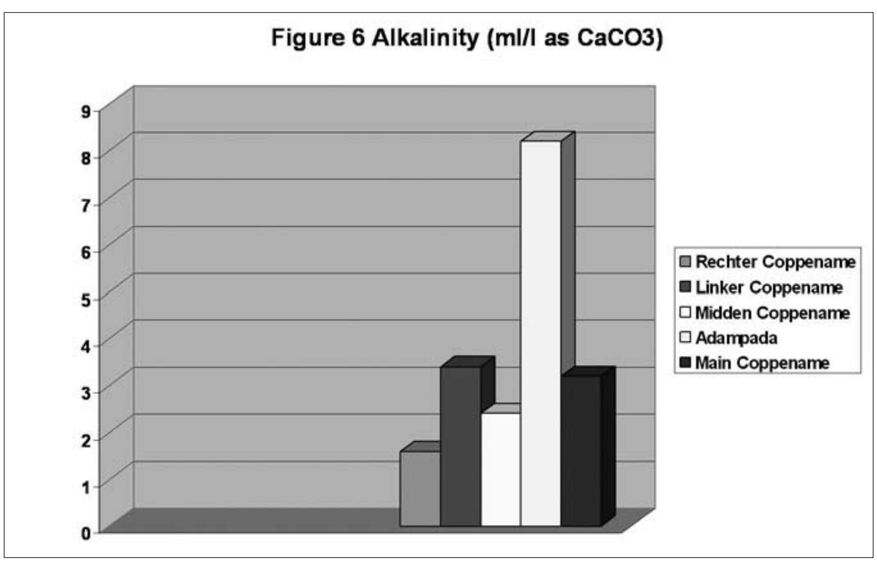


Figure 2.6. Mean alkalinity (ml/l as $CaCO_3$) recorded in the Coppename Basin during the AquaRAP survey.

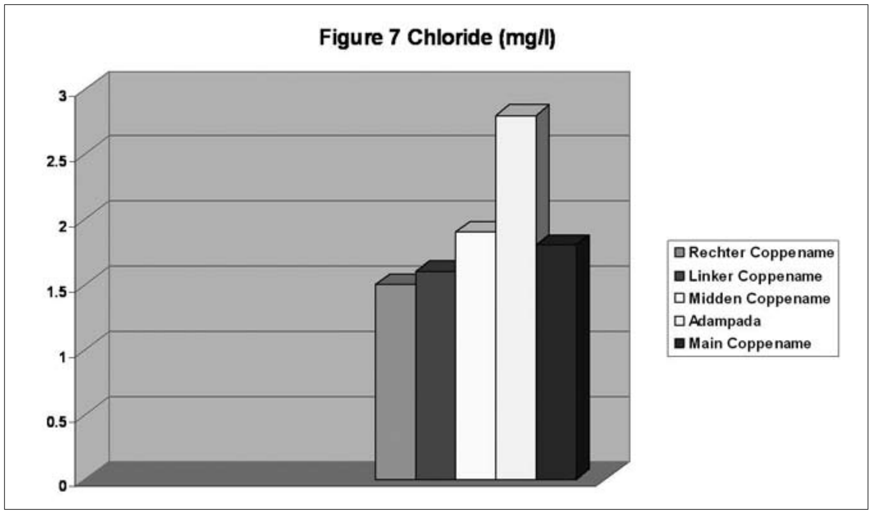


Figure 2.7. Mean chloride levels (mg/l) recorded in the Coppename Basin during the AquaRAP survey.

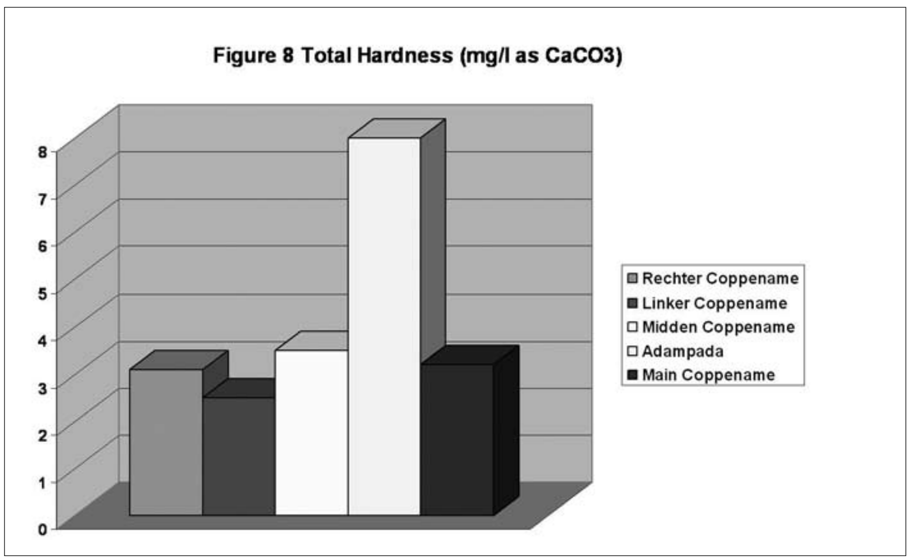


Figure 2.8. Mean total hardness (mg/l as $CaCO_3$) of the water recorded in the Coppename Basin during the AquaRAP survey.

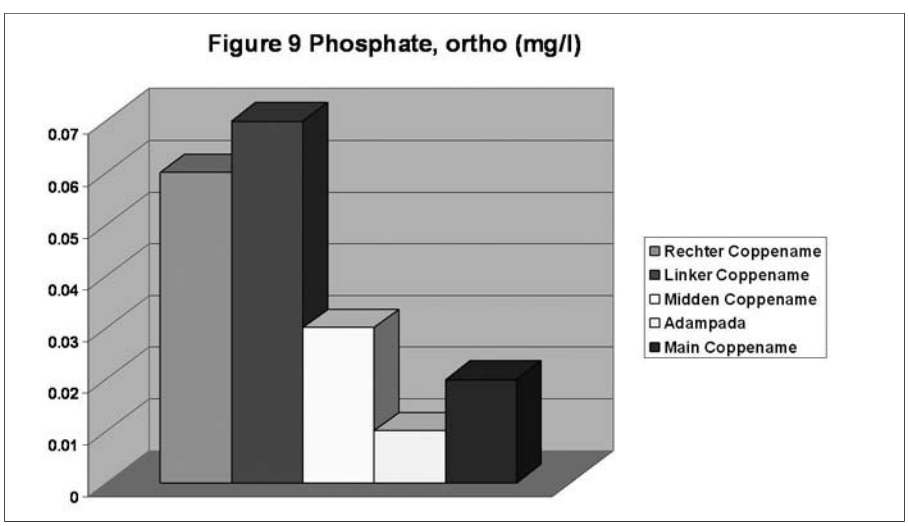


Figure 2.9. Mean phosphate levels (mg/l) recorded in the Coppename Basin during the AquaRAP survey.

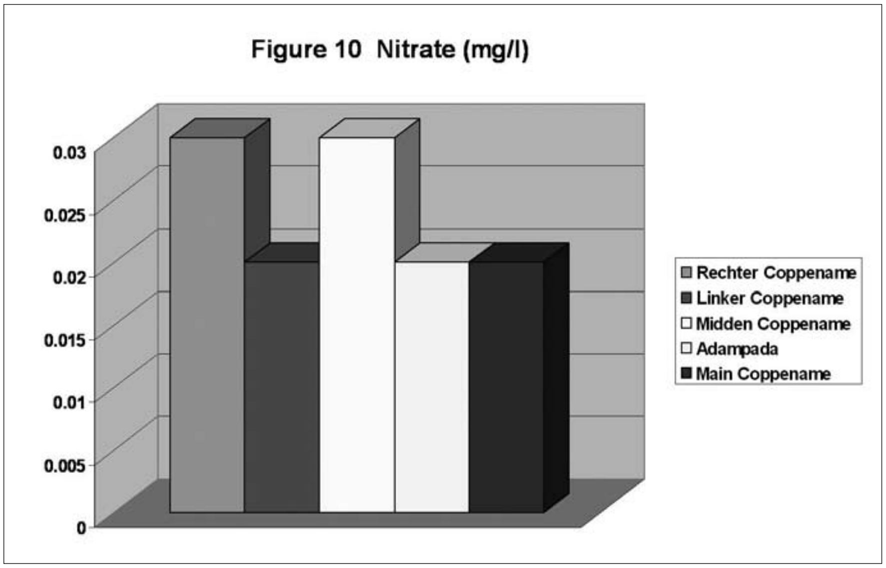


Figure 2.10. Mean nitrate levels (mg/l) recorded in the Coppename Basin during the AquaRAP survey.

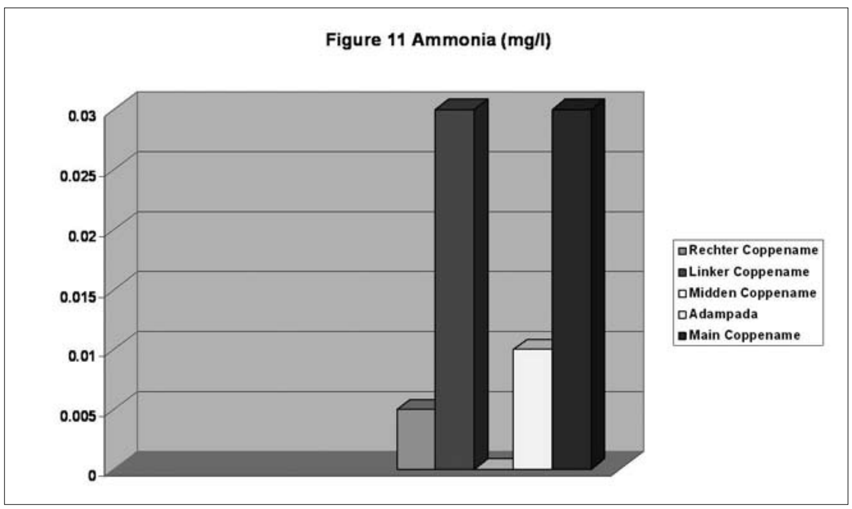


Figure 2.11. Mean ammonia levels (mg/l) recorded in the Coppename Basin during the AquaRAP survey.

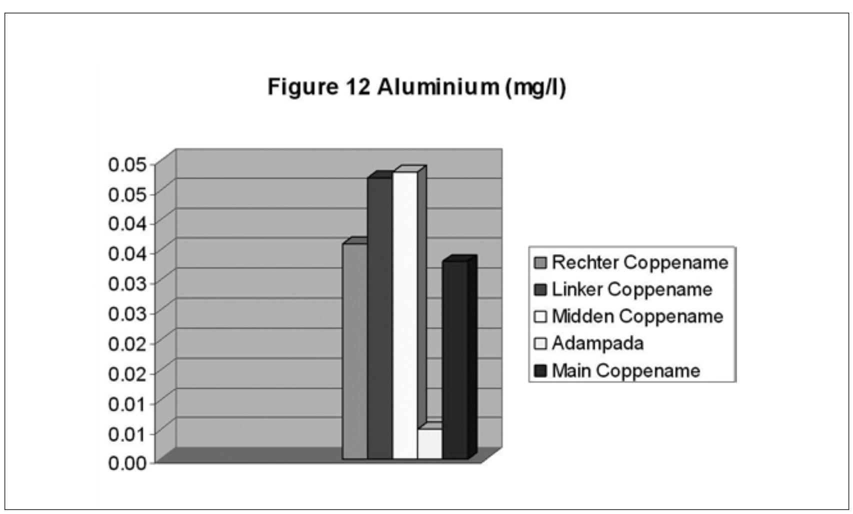


Figure 2.12. Mean aluminium (mg/l) recorded in the Coppename Basin during the AquaRAP survey.

Table 2.1. Water Quality measurements taken during the AquaRAP survey. All parameters were measured as mg/l unless otherwise noted.

Georeference Site	Sampling Point	Habitat Description	Notes	Temperature (°C)	pH	Conductivity µS/cm	DO mg/l	O %sat	Secchi cm	Alkalinity ml/l	Chloride mg/l	Hardness mg/l	Phosphate mg/l	Nitrate mg/l	Ammonia mg/l	Aluminum mg/l	COD mg/l
S2004-1	WQ-1A	BWKW camp Copp riv		28.9	6.0	21.10	5.80										27
S2004-1	WQ-1B		Duplicate of A	28.8	5.8	21.20	5.86										
S2004-2	WQ-2A	Tonckensval		28.2	6.3	21.00	6.46			2.3	1.7	3.1	0.01	0.03	0.04	0.000	
S2004-2	WQ-2B		Duplicate of A	29.3	5.3	21.10	6.66	87		2.8	1.6	3.4	0.00	0.02	0.00		22
S2004-2	WQ-2C	Main fall Tonckens		28.2	6.0	21.20	6.64		1								
S2004-3	WQ-3A	tributary Rechter Cop		25.7	6.3	30.20											
S2004-3	WQ-3B		Duplicate of A	25.6	6.2	29.90											
S2004-4	WQ-4A	Rechter Copp dwnstr		29.1	5.5	20.30	6.24			1.3	2.3	3.1	0.07	0.02	0.05		30
S2004-4	WQ-4B		Duplicate of A	29.0	5.7	20.40	6.02			1.3	2.5	3.3	0.05	0.02	0.02	0.065	33
S2004-5	WQ-5A	Rechter Copp upstr		24.3	6.0	19.30	5.10										
S2004-5	WQ-5B		Duplicate of A	24.3	5.7	19.42	5.38										
S2004-6	WQ-6A	Rechter Copp upstr		28.2	6.0	18.31	6.07		70	1.4	1.4	3.4	0.06	0.01			
S2004-6	WQ-6B		Duplicate of A	28.1	5.7	18.45	6.04		70	1.7	1.8	4.5	0.09	0.01			
S2004-6	WQ-7A	Bolletrieval		28.2	5.4	18.45	5.97	76		1.3	1.3	2.4	0.05	0.05	0.00	0.000	
S2004-7	WQ-7B		Duplicate of A	27.9	5.4	18.63	6.05			1.8	1.4	2.1	0.04	0.04	0.01	0.071	
S2004-7	WQ-7C	Pool		31.7	5.9	31.80	5.66	76									
S2004-7	WQ-7D	Rapid		27.9	5.6	18.59	6.46	83									
S2004-8	WQ-8A	tributary Rechter Cop		25.0	6.1	27.90	5.73										
S2004-8	WQ-8B		Duplicate of A	24.9	5.9	27.50	2.7-4.7										
S2004-9	WQ-9A	Confl Midden & Recht		28.1	6.3	19.12	6.93		75	4.7	1.0	2.6	0.09	0.01	0.11	0.045	
S2004-9	WQ-9B		Duplicate of A	28.6	6.2	23.20	6.51	84		4.2	1.7	2.6	0.11	0.02	0.03	0.043	
S2004-10	WQ-10A	tributary upstream 1		24.3	6.1	19.21	7.15										
S2004-10	WQ-10B		Duplicate of A	24.3	5.9	19.25	6.99		>120								
S2004-10	WQ-10C	tributary upstream 2		24.9			5.32	64									
S2004-10	WQ-10D		Duplicate of A	24.9			5.40	65									
S2004-11	WQ-11A	rapid Linker Copp		26.1	6.0	21.80	7.74	96	65	3.1	1.3	2.3	0.03	0.02	0.01	0.060	

Georeference Site	Sampling Point	Habitat Description	Notes	Temperature (°C)	pH	Conductivity µS/cm	DO mg/l	O %sat	Secchi cm	Alkalinity ml/l	Chloride mg/l	Hardness mg/l	Phosphate mg/l	Nitrate mg/l	Ammonia mg/l	Aluminum mg/l	COD mg/l
S2004-11	WQ-11B		Duplicate of A	26.1	6.0	21.80	7.40	91		2.9	2.2	2.3	0.06	0.01	0.04	0.041	
S2004-12	WQ-12A	Rapid dwnstr Linker		27.2			7.02	89	70	3.0	1.3	2.7	0.07	0.03	0.00	0.046	
S2004-12	WQ-12B		Duplicate of A	27.3			7.08	89		2.7	2.3	2.7	0.03	0.02	0.00		
S2004-13	WQ-13A	midden Copp dwnstr		26.6	6.2	18.66	7.29		70	2.2	2.1	3.3	0.04	0.03	0.00	0.052	
S2004-13	WQ-13B		Duplicate of A	26.6	6.2	18.79	7.21			2.5	1.6	3.6	0.02	0.03	0.00	0.043	
S2004-14	WQ-14A	dwnstr linker Copp		27.1	6.1	20.60	7.09										
S2004-14	WQ-14B		Duplicate of A	27.1	6.2	20.60	7.05										
S2004-15	WQ-15A	tributary Midden Copp		24.2	5.5	28.80	4.91		35-40	2.5	1.5	4.7	0.08	0.04	0.05	0.032	
S2004-15	WQ-15B		Duplicate of A	24.2	5.4	29.10	4.78			2.7	2.2	4.0	0.12	0.04	0.04		
S2004-16	WQ-16A	tributary linker Copp		27.2	5.6	21.50	5.55		60	3.4	1.4	3.2	0.05	0.03	>2.50	0.041	
S2004-16	WQ-16B		Duplicate of A	27.3	5.7	21.50	5.82			2.9	1.0	3.3	0.07	0.04	>2.50	0.036	
S2004-17	WQ-17A	Kaimansoela, Adamp		27.9	6.3	32.40	9.40	122	210	8.3	3.1	7.9	0.02	0.02	0.00	0.005	
S2004-17	WQ-17B		Duplicate of A	27.9	6.3	32.50	9.30	120		8.0	2.5	8.0	0.00	0.02	0.02	0.004	
S2004-17	WQ-17C	Pool		27.4	6.5	32.40	7.90	100									
S2004-17	WQ-17D		Duplicate of A	26.6	6.3	33.30	6.80	87									
S2004-18	WQ-18A	tributary Adampada		27.2	6.3	32.30	5.87										
S2004-18	WQ-18B		Duplicate of A	27.9	6.4	32.70	5.53										
S2004-19	WQ-19A	Sidunkrutu soela		28.1	6.4	19.40	13.10	169	110	2.9	1.9	2.9	0.04	0.00	0.08	0.058	
S2004-19	WQ-19B		Duplicate of A	28.1	6.2	20.00	12.40	157		2.8	2.3	3.0	0.01	0.04	0.04	0.031	
S2004-20	WQ-20A	Moroco soela Adamp		28.1	6.4	33.40	10.30	133	200								
S2004-20	WQ-20B		Duplicate of A	28.1	6.3	33.40	10.40	134									
S2004-21	WQ-21A	tributary Adampada		27.3	6.4	33.00	5.40	68									
S2004-21	WQ-21B		Duplicate of A	27.4	6.5	33.00	5.90	75									
S2004-22	WQ-22A	side channel Copp		28.3	6.2	19.97	6.73										
S2004-22	WQ-22B		Duplicate of A	28.3	6.2	19.91	6.55										
S2004-23	WQ-23A	driefutu soela		28.6	6.0	20.80	10.20	132	130	3.4	1.4	2.9	0.03	0.02	0.00	0.047	
S2004-23	WQ-23B		Duplicate of A	29.2	6.1	20.90	10.80	138		3.7	1.5	4.0	0.04	0.02	0.00	0.031	
S2004-24	WQ-24A	tributary driefutu soela		29.7	6.1	20.70	6.80	78									
S2004-24	WQ-24B		Duplicate of A	29.6	6.1	20.70	5.78	72									

Adampada creek
The Adampada creek is forested with terra firme forest. In many stretches the water is very shallow, about one meter. The creek has also a rocky and or sandy bottom. The water is very clear (secchi depth two meters or more). The creek has parts with rocks, islands and rapids. In swift parts there is aquatic vegetation of Podostemaceae.

The pH is between 6.3-6.4. Conductivity, alkalinity and hardness are relatively high. It seems that the water comes from another geological formation than the Linker and Main Coppename River. Nutrients are low, probably because of Podostemaceae. Oxygen saturation is above 100%.

The Adampada creek, which originates in the Bakhuisgebergte, where the soil has high aluminum content, showed surprisingly the lowest aluminum contents in water. The tributaries of the Adampada creek are shallow with some deeper stretches.

Animals observed included the giant otter, *Paleosuchus trigonatus*, and a few fish eating birds.

MAIN COPPENAME RIVER

The Main Coppename is a forested river. Widening in many places where rapids, islands and rocks are present. The water is clear, slightly turbid with an abundance of *Podostemaceae*. Oxygen content is usually above 100%. The water is low in nutrients and conductivity. The pH is around 6. Temperature of the water is high, around 28-29 °C.

The river has abundant fish and many fish eating animals are present in the area, including spectacled caiman, *Caiman crocodilus*, smoothed fronted caiman, *Paleosuchus trigonatus,* ospreys, cormorants, white-neck herons.

Impact of water quality on fauna distribution
The fauna most intensively sampled were fishes and crustaceans. The results for fishes were compared with the water quality data, focusing on the effect of blackish water in the Rechter Coppename River on fish species composition. The black water rivers draining the Savanna Belt of northern Suriname have special fish communities with several species that do not occur in the interior (Ouboter and Mol 1993). It could be expected that some of these species also occur in the black water of the Rechter Coppename River.

Of the 81 fish species collected in the Rechter Coppename River, only one is characteristic of black water, but is occasionally found in the interior: *Nannacara anomala*. So, in general, the fish fauna of the Rechter Coppename River is an interior fauna, quite similar to other parts of the river with clear water. The difference in water quality of the Rechter Coppename River does not seem to have much impact on fish fauna.

Fish-eating birds were most abundant in wide river sections with rapids. Their abundance is probably related to fish abundance. It is well-known that rapids are rich in fish, which may be related to a high oxygen concentration of the water or the occurrence of many invertebrates on the Podostemaceae that grow in the rapids.

Caiman distribution and habitat selection was studied by Ouboter (1996). Spectacled caimans (*Caiman crocodilus*) are thermophilic, preferring wide rivers, or rivers with rather open shore vegetation. Smooth-fronted caimans (*Paleosuchus trigonatus*) can tolerate much cooler conditions, even occurring at relatively high altitudes in completely shaded creeks. Both species were found in the wide and warm main Coppename River and in the Rechter Coppename River. Spectacled caimans were not seen in the Linker and Midden Coppename Rivers and the Adampada Creek. Our temperature measurements show lower water temperatures for these river sections compared to the main and Rechter Coppename River sections, probably partly an artifact of rainy conditions. However, notwithstanding weather conditions, black water is known to absorb heat in the surface layers quite well, this way providing a better habitat for thermophilic species like the spectacled caiman.

CONCLUSIONS

- Water quality is good in all river sections.
- Abundance of aquatic vegetation leads to lower phosphate levels, because phosphate is easily taken up by plants.
- In creeks in which few organisms were found, oxygen content was usually lower than in the main river.
- Differences in microhabitats between river sections can lead to differences in physical and chemical water quality, consequently influencing the distribution of certain organisms such as caiman.
- Differences in water quality between river sections can be attributed to the geological formations of the drainages of the respective river sections and on some occasions to weather conditions.
- Despite the highest concentration of dissolved solids, the Adampada creek had the clearest water. Mining in the upper reaches of the Adampada creek will almost certainly lead to deterioration of the water quality of this creek and the lower reaches of the Coppename River.

REFERENCES

Haripersad-Makhanlal, A. and P.E. Ouboter. 1993. Limnology: physics-chemical parameters and phytoplankton composition. *In:* P.E. Ouboter (Ed.), Freshwater Ecosystems of Suriname, pp. 53-75. Kluwer Academic Publishers, Dordrecht.

Ouboter, P.E. 1996. Ecological studies on crocodilians in Suriname. Niche segregation and competition in three predators. SPB Academic Publ., Amsterdam, pp. 139.
Ouboter, P.E. and J.H Mol. 1993. The fish fauna of Suriname. *In:* P.E. Ouboter (ed.), The Freshwater Ecosystems of Suriname, pp. 133-154. Kluwer Academic Publishers, Dordrecht.

Chapter 3

Plant Diversity of the Central Suriname Nature Reserve: Implications for Conservation and Biogeography

David Clarke and Jayne H. Rhodes

ABSTRACT

The biological significance and resulting implications for conservation of the plant diversity of the Central Suriname Nature Reserve (CSNR) were evaluated both analytically and descriptively. Analytically, the 349 collections made in the CSNR were compared with florulas of five well-collected locations in northeastern South America. Checklists of Kaieteur Falls National Park, Mabura Hill, and Iwokrama (Guyana); Reserva Ducke (Brazil); and Saül (Central French Guiana) were synonymized with the checklist from the CSNR and their biogeographic patterns and floristic similarities were then examined using the Mantel test and UPGMA clustering methods at the species and genus level. The Mantel test reveals that the distributions of species across the sites were influenced by the distances between sites. However, there was no evidence that the distributions of genera between sites were influenced by the distances between sites, in fact there seemed to be a negative correlation between the two variables.

At the species level, the UPGMA cluster analysis indicates a relatively close affinity of the CSNR with the three Guyana florulas and much less affinity to the florula of Central French Guiana, although the distances from the CSNR to the Guyana and French Guiana sites are comparable. At the genus level, the UPGMA cluster analysis shows the CSNR to be dissimilar to all other florulas, but this may be an artifact of limited collecting within the CSNR, preventing sufficient sampling of plant genera compared to the other sites. Qualitatively, field observations and an examination of plants documented at each georeference site indicate that there is significant floristic heterogeneity within the CSNR. Substantially more field work will be needed to document the different plant communities within the reserve in the interest of developing a more refined conservation strategy.

INTRODUCTION

The Central Suriname Nature Reserve (CSNR) encompasses 1.6 million hectares of primary Neotropical lowland forest of west-central Suriname (Conservation International 2002). Established in 1998, and added to the UNESCO World Heritage List of Natural Sites in 2000, the reserve's size and undisturbed state make it one of the most pristine nature reserves on the world heritage list. Its size and pristine condition alone give the CSNR an obvious conservation value that can be established prior to any actual investigation within the reserve. Further insight into the significance of the plant diversity of the CSNR must be approached both practically and theoretically. The complete lack of plant collections made within the reserve prior to the AquaRAP expedition makes the practical approach straightforward: Documenting the plants of the CSNR via collecting expeditions such as that of the AquaRAP is a necessary first step. The theoretical approach begins with an understanding of the CSNR's unique geological, ecological, and historical context.

Situated near the northern terminus of the world's largest continuous area of tropical moist, wet, and rainforest, one must consider the CSNR, although quite large, as but a small portion of the vast Hylaea—the Amazonian and extra-Amazonian (principally Guianan) forests that extend from central Mato Grosso and Rondonia in Brazil and the eastern slopes of the Andes north and east to the Atlantic Ocean. Although these low elevation forests of tropical South America span geographic distances measured in thousands of kilometers, ecological gradients across the Hylaea are for the most part diminished: 1) Rainfall amounts are in the range of 2-3 m per year with no prolonged dry seasons. 2) Elevations are uniformly low with few localities exceeding 1000 m asl and most below 200 m asl. 3) Soils are highly weathered and nutrient poor. And 4) Temperatures are uniformly warm as this area is centered on the equator. This uniformity has invited theories that attribute floristic heterogeneity across lowland tropical South America to dispersal limitations of species and sympatric or parapatric speciation rather than niche partitioning and ecological differentiation (Condit et al. 2002, Hubbell 2001). The unified neutral theory of biodiversity and biogeography (Hubbell 2001) proposes a non-equilibrium model that relies on dispersal limited sympatric speciation. According to this model, distribution in the lowland rainforests of northern South America is not limited by environmental gradients, but rather by dispersal. Presence or absence of plant species within a given area is a function of species differentiating at a certain place and time, dispersing from a point of origin and increasing in population size or decreasing to a point of extinction all as part of a stochastic process. This theory draws heavily on the theory of island biogeography (MacArthur and Wilson 1967) that explains the number of species on an island or otherwise delimited area as a dynamic equilibrium between the rates of immigration and extinction of species, rather than niche partitioning, and the logistic equation which models population size over time as a function of finite rates of increase or decrease (Townsend et al. 2000). Although obviously unrealistic in its assumptions, the neutral theory is useful in that it may describe processes that operate in the absence of other limiting variables. Further, floras such as those of the CSNR may be more likely to conform to a neutral model than other habitats where both diversity and biomass are not dominated by canopy tree species and where recruitment of juveniles to reproductive phases in the canopy is a stochastic function of canopy gap formation rather than competitive exclusion.

In addition to this neutral model, there are two competing hypotheses governing floral species distribution in the lowland tropical forests of northern South America that take into account either historical or geological factors. This study attempts to test two of the most prominent models: the Pleistocene refugia theory and the theory of edaphic endemism. The refugia theory is a non-dispersal-limited equilibrium model. It holds that climatic fluctuations over a geologic time scale associated with glacial maxima at high latitudes led to contractions and expansions of forests and savannas throughout tropical South America. Allopatric speciation occurred between separated forest islands that were eventually rejoined to form the vast Neotropical forest that now comprises all of northern lowland South America (Behrensmyer 1992; Willis, 2000). Support for this theory resulted in the assignment of various refugia throughout northern South America based on species diversity and endemism (Prance 1982, Haffer 1969). Although the proposed number and area of refugia vary among authors, a refuge that is partially situated in Suriname is consistently identified in each case (Figures 3.1 and 3.2). Within this refugium, both white sand and granite-derived soils are encountered, indicating that a shared history of persistence of forested areas rather than soil composition is the primary factor affecting species distribution according to this theory.

In contrast, the theory of edaphic endemism accredits the spatial organization of tropical forest plant communities to the influence of soil substrates (Kubitzki 1989, 1990; Sabatier et al. 1997). Tropical lowlands are characterized by red clay soils of moderate acidity (latosols) that contrast with the upland white sands of high acidity (podzols and areno-

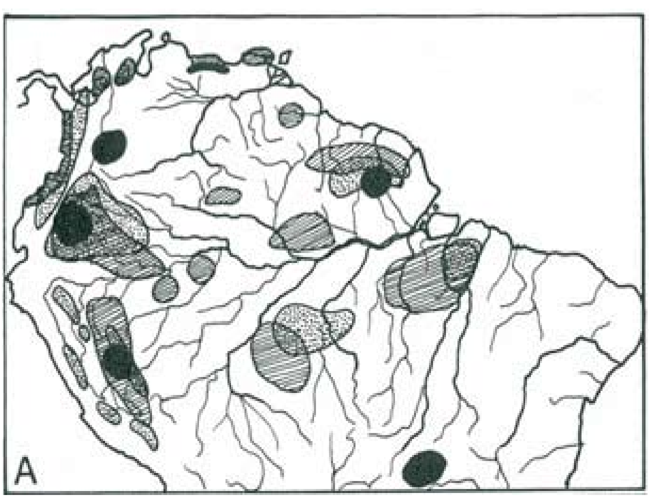
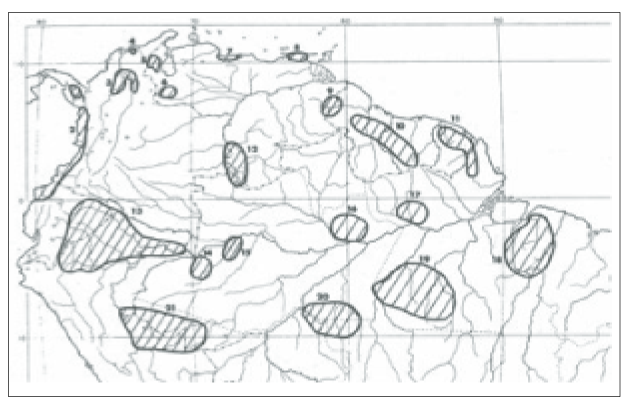


Figure 3.1. Rain forest refuges in tropical America during the late Pleistocene (22,000-13,000 B.P.). Adapted from Granville (1982).



1. Panama-Darién; 2. Chocó; 3. Río Magdalena; 4. Santa Marta; 5. Catatumbo; 6. Apure; 7. Rancho Grande; 8. Paria; 9. Imataca; 10. W. Guiana; 11. E. Guiana; 12. Imerí; 13. Napo; 14. São Paulo de Olivenca; 15. Tefé; 16. Manaus; 17. Trombetas; 18. Belém; 19. Tapajós; 20. Aripuanã; 21. E. Peru-Acre; 22. Beni; 23. Pernambuco; 24. Bahia; 25. Rio Espírito Santo; 26. Araguaia.

Figure 3.2. Proposed forest refuges, based on distribution of woody Angiosperm families. Adapted from Prance (1982).

sols) that have developed from the uplift and erosion of the Roraima sandstone complex covering the core of the Guayana Shield. Nutrient cycling occurs differently in these two soil types (Jordan 1985). Sandy podzol soils drain rapidly, depositing plant compounds such as tannins leached from leaf litter into the rivers (hence the term 'blackwater'). Clay latosol soils absorb and decompose the compounds leached from litter and are associated with clear rivers. These differences and others have led to the evolution of a distinctively psammophilous ('sand-loving') flora in parts of northern South America (Kubitzki 1990) which, owing to their ability to thrive on nutrient-poor soils, are able to competitively exclude species adapted to clay soils. Under this theory, plant distribution in regions characterized by latosol soils, such as the CSNR, should differ from distribution in regions with podzol soils.

The CSNR is located on the Guayana Shield, a massive granitic formation of the Pre-Cambrian era. The Guayana Shield includes all of Guyana, Suriname and French Guiana, as well as parts of Colombia, Venezuela, and Brazil, and is the largest expanse of relatively undisturbed tropical rain forest in the world. The 349 collections made in the CSNR between 22 February-11 March, 2004 by David Clarke and Jaye Rhodes are the basis of this study and will be treated as a checklist for the plants of the reserve. Collections are made from a region along the Coppename River from which very few other collections are known, providing valuable new data for comparison with checklists of other sites on and adjacent to the Guayana Shield.

Botanical inventory, documented by collections in herbaria, provides data for defining floristic patterns, and is useful for addressing conservation issues concerning the diversity and distribution of plant species in a given region. A regional flora cannot be compiled until all of the species in the region are documented, and information is gathered on the developmental processes and appearances, morphological variation, distribution, and uses of the plants (Lindeman & Mori 1989). Considering the diversity of the tropics, it is difficult to know when all of the present species have been documented. As a result, well-collected areas often coincide with areas said to have high species diversity (Steege et al. 2000), so it is important to consider the level of collecting intensity when assessing the true diversity of a given region. It is estimated that Flora Neotropica will require another 300 years to reach completion (Mori 1992) and the Flora of the Guianas may require a similar amount of time; however, five checklists of floras of restricted areas on or adjacent to the Guayana Shield are available. These checklists will be substituted for regional floras to answer questions concerning the distribution of plants and the biogeography of the Guayana Shield. Three of these five areas are in Guyana: the Iwokrama International Centre for Rain Forest Conservation and Development (hereafter Iwokrama Forest; Clarke and Funk 1998, Clarke et al. 2001), Mabura Hill (Ek and ter Steege 1997), and Kaieteur Falls National Park (Kelloff and Funk 1998). A comprehensive checklist is also available for Saül in Central French Guiana (Mori et al. 1997, 2002) and a checklist has been produced for Reserva Ducke near Manaus, Brazil (Ribeiro and Hopkins 1999). A complete, synonymized checklist is found in Clarke et al. (2001). The five checklists are appropriate for floristic comparisons on a regional scale for several reasons. First, human disturbance is low or absent in each area, allowing hypotheses to be made regarding an essentially pristine flora. Environmental variables such as rainfall, climate, soils, and topography are relatively well known for each area (Kelloff and Funk 2004, Clarke and Funk 2005) and are fairly uniform except for soils and topography. Collecting methodology and intensity is documented for each area and can be considered when evaluating the relative completeness of the checklists. Finally, the area covered by each flora is clearly defined, ranging from 10,000 to 360,000 hectares (ha), and contains significant geographic and ecological gradients of the Guayana Shield and immediate environs. These factors facilitate comparisons between checklists and provide a foundation for interpretation of observed differences.

The goal of this study is to test two of the most prominent models: the refugia theory and the theory of edaphic endemism. In particular, we examined whether the proposed Guyana refuge represents a center of endemism of the neotropical flora, or whether the endemic elements of the flora of the Guayana Shield should more properly be considered to be those associated with sand and sandstone substrates ("psammophilous"). If the Guyana refuge represents a center of endemism, the florulas of Reserva Ducke and Saül would be expected to share few species with the other four florulas. Conversely, if endemism is associated with sand and sandstone substrates, the florula of the CSNR should be most similar to Saül since both lack sandstone-derived substrates. High species overlap would be expected among the three areas that have extensive white sand and sandstone substrates (Kaieteur at mid-elevation and Mabura and Iwokrama at low elevation).

In addition to answering questions concerning floristic distribution, we also attempt to make qualitative conclusions about the botanical diversity within the CSNR. The sites visited on the Coppename River can be divided into four regions: 1) the Rechter Coppename, a tributary of the Coppename with headwaters originating on the Tafelberg, the easternmost sandstone tepui on the Guayana Shield; 2) the Midden and Linker Coppename, which drain the highest elevations in Suriname, the Wilhelmina Mountains; 3) Adampada Creek, a comparatively small tributary with steep environmental gradients that drains the Bakhuis Gebergte, and 4) the main Coppename River (below the confluence of the Rechter, Midden, and Linker River). Qualitative analysis is used to designate the 10 most diverse families in each region and comparisons are made between regions. Comparisons of the 10 most prominent families are also made between the six florulas.

METHODS

Plant Collecting Only fertile (flowering or fruiting) plants were collected due to the difficulty of identifying sterile material from neotropical forests. Plants were pressed in the field and were tied in bundles (about 30 cm thickness) and brought back to camp. Once several bundles were made (nearly every day), they were preserved with 60% ethanol in heavy plastic bags until they could be dried in plant dryers at the University of Suriname at the end of the expedition. Specimens were shipped to the Smithsonian Institution for identification in the United States National Herbarium. Plants were generally collected in multiples of up to six specimens per collection (when possible) in order to provide pressed collections to the National Herbarium of the University of Suriname, the United States National Herbarium, and various other herbaria involved in the Flora of the Guianas Program. This type of distribution ensures the accuracy and repeatability of determinations (because collections are sent to botanists specializing in certain families or genera) and also increases the knowledge of Suriname's considerable botanical diversity in the world's scientific community. Collections were made at geo-referenced localities chosen by the AquaRAP expedition members. In each locality, the goal was to document the diversity of plants from the riparian zone to the terra firme forest behind the river. Vegetative habits that were encountered included submerged aquatic vegetation, emergent aquatics and rheophytic vegetation, seasonally flooded forest, herbs, vines, lianas, and herbaceous plants growing at the river's edge. In terra firme forest, understory herbs and shrubs, mid-story trees and palms, epiphytes, lianas, and emergent canopy trees were collected. Tree climbing spikes (grimpettes from La Coste Pere et Fils, Bordeaux, France) and extendible aluminum clipper poles facilitated collections above ground level. Canopy collections of this type are of particular importance because canopy trees, lianas, and epiphytes tend to be underrepresented in herbaria and are often misidentified when the transect method of collection is used. Small leaf samples were dried in silica gel to extract and sequence DNA of taxa under active molecular phylogenetic research, e.g. Lecythidaceae, Sapindaceae, Fabaceae, and Solanaceae.

Quantitative Data Analysis The six checklists were entered into a Microsoft Access© database in a presence/absence binary format. Similarity coefficients comparing each checklist pair were computed using NTSYSpc2.01© (Rohlf 1997). Dissimilarity was found by subtracting each of the calculated similarity coefficients from 1. Distances between areas were calculated using the great circle distance method from the latitude and longitude coordinates at the center of each area (Swartz 2004). The dissimilarity coefficients and distance coefficients were entered into separate 6 x 6 matrices, and a Mantel test was performed using NTSYS (Sokal and Rohlf 1995). The Mantel statistic (Z) is the sum across all of the products of corresponding elements between the two matrices (ignoring diagonal values). Multiple random permutations (500) of the matrices yield a normalized distribution that can be compared with the experimental Z value to determine if a significant difference exists. The t-test approximation was used for the comparison. Results are presented in scatter diagram format, and Mantel statistics are given as well. Analysis was preformed at the species and genus level. Dissimilarity coefficients for each taxon are presented in table format. A UPGMA dendogram was computed for similarity coefficients at the species and genus level using NTSYS.

Table 3.1. Dissimilarity Coefficients among Florulas at the species (A) and genus (B) level. Geographic distances between sites are given in parentheses (km). See text for site descriptions.

(A) Species						
	Kaieteur	**Iwokrama**	**Mabura**	**Saül**	**Ducke**	**CSNR**
Kaieteur	——					
Iwokrama	0.35 (103)	——				
Mabura	0.34 (76)	0.30 (79)	——			
Saül	0.51 (718)	0.46 (633)	0.44 (646)	——		
Ducke	0.54 (892)	0.52 (826)	0.50 (905)	0.57 (1041)	——	
CSNR	<u>0.25</u> (343)	<u>0.26</u> (259)	<u>0.27</u> (272)	0.44 (376)	0.42 (889)	——
(B) Genera						
	Kaieteur	**Iwokrama**	**Mabura**	**Saül**	**Ducke**	**CSNR**
Kaieteur	——					
Iwokrama	0.37	——				
Mabura	0.35	0.30	——			
Saül	0.50	0.42	0.39	——		
Ducke	0.45	0.40	0.33	0.40	——	
CSNR	0.41	0.43	0.43	0.61	0.52	——

Family Composition Analysis The comprehensive list of determined collections from the CSNR expedition was divided into four localities according to the four river regions: 1) the Rechter Coppename River; 2) the Midden and Linker Coppename River; 3) Adampada Creek; and 4) the main Coppename River (below the confluence of the Rechter and Linker). Within each locality, families were ranked according to species richness. Data for Iwokrama, Mabura Hill, Saül, and Reserva Ducke (Clarke et al. 2001) were entered into a Microsoft Excel© database for qualitative comparison with the CSNR results.

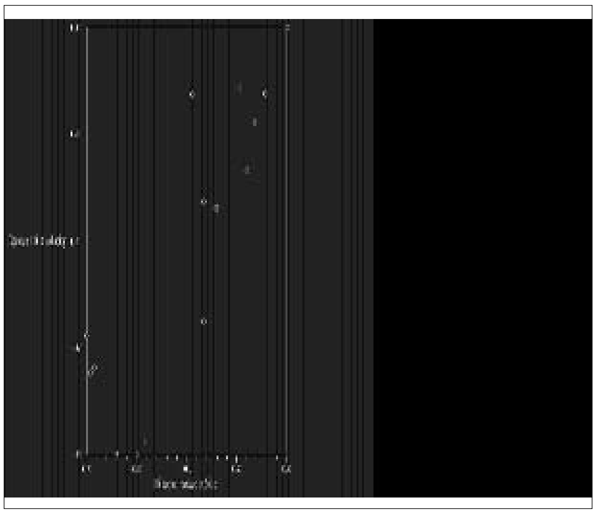


Figure 3.3. Plot of distance vs. species dissimilarity.

RESULTS

Quantitative Results A total of 349 specimens from 24 georeference sites within the CSNR were collected (Appendix 1). The combined checklist contained 4682 species: 1256 at Iwokrama, 1140 at Kaituer, 1240 at Mabura Hill, 2073 at Saül, 1926 at Reserva Ducke, and 150 at CSNR(Appendix 2). At the species level, low dissimilarity coefficients (Table 3.1) indicate a strong relationship

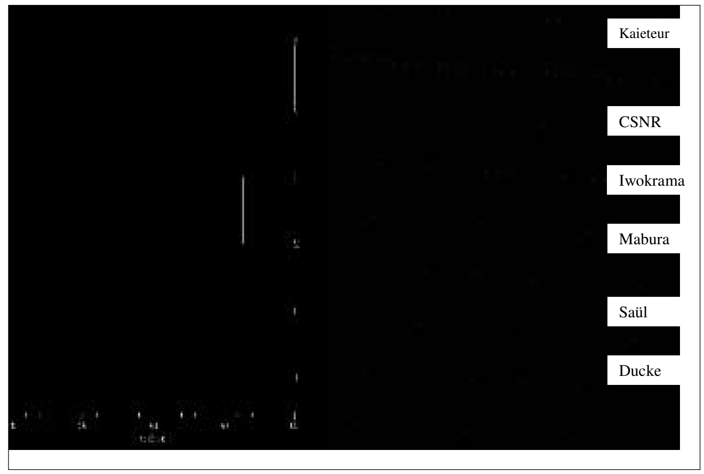


Figure 3.4. UPGMA dendrogram showing relative species similarity of the six florulas.

Table 3.2. The 20 most abundant plant families at each study site with number of species listed.

Rechter Coppename	Midden/Linker Coppename	Adampada Creek	Main Coppename
Rubiaceae 8	Cyperaceae 8	Rubiaceae 7	Rubiaceae 11
Orchidaceae 5	Rubiaceae 6	Cyperaceae 5	Bromeliaceae 5
Cyperaceae 4	Poaceae 5	Fabaceae 4	Cyperaceae 5
Fabaceae 4	Violaceae 5	Onagraceae 4	Annonaceae 4
Adiantaceae 3	Euphorbiaceae 4	Apocynaceae 3	Fabaceae 4
Bignoniaceae 3	Fabaceae 4	Araceae 3	Orchidaceae 4
Flacortuaceae 3	Flacourtaceae 4	Euphorbiaceae 3	Aquifoliaceae 3
Melastomaceae 3	Ochnaceae 4	Melastomaceae 3	Araceae 3
Piperaceae 3	Olacaceae 4	Bignoniaceae 2	Melastomaceae 3
Aspleniaceae 2	Orchidaceae 4	Gentianaceae 2	Meliaceae 3
Euphorbiaceae 2	Polypodiaceae 4	Myrtaceae 2	Ochnaceae 3
Liliaceae 2	Bromeliaceae 3	Poaceae 2	Polypodiaceae 3
Myrtaceae 2	Lecythidaceae 3	Podostemaceae 2	Verbenaceae 3
Sapindaceae 2	Marantaceae 3	Turneraceae 2	Bignoniaceae 2
Selaginellaceae 2	Meliaceae 3	Annonaceae 1	Boraginaceae 2
Violaceae 2	Myrtaceae 3	Asteraceae 1	Heliconiaceae 2
Arecacea 1	Piperaceae 3	Bromeliaceae 1	Lecythidaceae 2
Bombacaceae 1	Arecaceae 2	Chrysobalanaceae 1	Marantaceae 2
Bromeliaceae 1	Gesneriaceae 2	Combretaceae 1	Moraceae 2
Chrysobalanaceae 1	Heliconiaceae 2	Convolvulaceae 1	Myrtaceae 2

between the Guyana locations (Kaieteur, Iwokrama, and Mabura Hill) and the CSNR. The Amazonian site (Reserva Ducke) and the site in French Guiana (Saül) are quite dissimilar from the other areas and each other. The scatter plot of distance vs. species dissimilarity exhibits a positive correlation between increasing species dissimilarity and distance between sites (r = 0.85) (Figure 3.3). Results of the Mantel test were significant (approximate Mantel t-test; t = 2.06; p = 0.02). The UPGMA dendrogram (Figure 3.4) shows that, in relative terms, the CSNR and Kaieteur are most similar floristically, Iwokrama and Mabura Hill are next most similar, and that these four florulas are more similar to each other than they are to the florulas of Saül and Reserva Ducke.
At the genus level, patterns among genus dissimilarity coefficients become less distinct, although a discernable relationship remains between the Guyana locations and the CSNR. Saül and Ducke continue to be the most dissimilar to the CSNR (Table 3.1). The scatter plot of distance vs. genus dissimilarity does not show a significant trend (r = 0.24; Figure 3.5). Results of the Mantel test were not significant (approximate Mantel t-test; t = 0.64; p = 0.26). The UPGMA dendrogram (Figure 3.6) shows that Iwokrama and Mabura Hill are most similar floristically, and are next most similar to Kaieteur. These three florulas are decreasingly similar to Reserva Ducke, Saül, and the CSNR, in that order.

Family Composition Results The 20 most abundant families within the four regions of the Coppename River in the CSNR are listed in Table 3.2. Within each region, Rubiaceae and Cyperaceae are consistently among the top three most abundant families. Fabaceae also exhibits high species richness and collection frequency.

The ten most abundant families within the six florulas are listed in Table 3.3. The Fabaceae, Rubiaceae, and Orchidaceae comprise the top three families within Kaieteur, Iwokrama, Mabura Hill, and Saül. Similarly, Fabaceae, Orchidaceae, and Lauraceae comprise the top three families within Reserva Ducke. The top three families within the CSNR differ from the other five florulas, consisting of the Rubiaceae, Cyperaceae, and Araceae (mainly herbaceous species). Fabaceae and Orchidaceae are ranked relatively low on the list, while Araceae and Bromeliaceae are ranked relatively high. The CSNR lacks several prominent woody families found within the other five sites, namely the Myrtaceae, Chrysobalanaceae, Annonaceae, and Sapotaceae. These families were collected within the CSNR, but in too few numbers to exhibit prominence.

DISCUSSION

Soil types differ among the six florulas and were considered when interpreting the data. The sampled region in the CSNR is characterized by low elevation (≤ 100 meters above sea level (msl) and has both dolerite- and granite-derived latosol soils. Kaieteur Falls National Park is located at mid-elevation (500 m asl) on the edge of the Pakaraima escarpment and is dominated by sandy podzol soils associated with the Roraima sandstone formation. Iwokrama Forest and Mabura Hill are at low elevations (except for an isolated

Table 3.3. The 10 most abundant plant families at each study site with number of species and rank of family.

Kaieteur	Iwokrama	Mabura	Saül	Ducke	CSNR
Orchidaceae 111 (1)	Fabaceae 103 (1)	Fabaceae 114 (1)	Orchidaceae 150 (1)	Fabaceae 192 (1)	Rubiaceae 13 (1)
Rubiaceae 72 (2)	Rubiaceae 81 (2)	Orchidaceae 110 (2)	Fabaceae 136 (2)	Lauraceae 96 (2)	Cyperaceae 9 (2)
Fabaceae 66 (3.5)	Orchidaceae 51 (3)	Rubiaceae 60 (3)	Rubiaceae 127 (3)	Orchidaceae 92 (3)	Araceae 6 (3.25)
Myrtaceae 66 (3.5)	Cyperaceae 42 (4)	Bignoniaceae 37 (4)	Myrtaceae 76 (4)	Sapotaceae 87 (4)	Bromeliaceae 6 (3.25)
Poaceae 52 (5)	Myrtaceae 36 (5)	Myrtaceae 35 (5.5)	Araceae 57 (5)	Rubiaceae 85 (5)	Euphorbiaceae 6 (3.25)
Cyperaceae 43 (6)	Poaceae 34 (7)	Chrysobalanaceae 35(5.5)	Sapotaceae 55 (6)	Myrtaceae 80 (6)	Polypodiaceae 6 (3.25)
Bromeliaceae 33 (7)	Araceae 32 (7.5)	Annonaceae 30 (7)	Lauraceae 51 (7)	Annonaceae 62 (7)	Lecythidaceae 5 (7.33)
Clusiaceae 25 (8)	Lauraceae 32 (7.5)	Apocynaceae 29 (8)	Euphorbiaceae 46 (8.5)	Clusiaceae 53 (8)	Orchidaceae 5 (7.33)
Apocynaceae 23 (9)	Annonaceae 30 (9)	Lauraceae 28 (9.5)	Piperaceae 46 (8.5)	Araceae 50 (9)	Poaceae 5 (7.33)
Chrysobalanaceae 20 (10)	Chrysobalanaceae 29 (10)	Sapotaceae 28 (9.5)	Bignoniaceae 43 (10)	Chrysobalanaceae 50 (10)	Fabaceae 4 (10)

mountain range rising to 1000 msl in Iwokrama Forest) and have sandstone- and granite-derived soils. Saül in Central French Guiana is characterized by low elevation but lacks the sandstone and white sands that characterize Iwokrama Forest and Mabura Hill. Reserva Ducke is also characterized by low elevation but is in Amazonia proper and is not part of the Guayana Shield formation.

A strong relationship between the species of the Guyana locations (Kaieteur, Iwokrama, and Mabura Hill) and the CSNR indicates a center of endemism centered between Guyana and Suriname (Table 3.1). Within these four locations both sandy podzol and clay latosol soils are encountered, indicating that species distribution is largely independent of soil substrate. The fact that Reserva Ducke and Saül share few species with the other four florulas indicates that they belong to separate refugia, one centered in French Guiana, and one centered in Brazil. This conclusion is supported by the refugia outlined in Figure 3.2. The positive correlation between increasing distance and species dissimilarity fits this model, and can be explained in part by the considerable distance between the five florulas on the Guayana Shield and Reserva Ducke in Brazil (r = 0.85; Figure 3.3). The UPGMA dendrogram (Figure 3.4) indicates that the CSNR and Kaieteur are most similar floristically despite the differences in topography and elevation between the sites. This could be the result of a collecting artifact (such as under-collection of canopy species). Iwokrama and Mabura Hill are the next most similar florulas to the CSNR and Kaieteur, in support of the refugia theory. Accordingly, Saül and Reserva Ducke are the least similar to the CSNR, despite having similar soil types. It should be noted that the collecting intensity is drastically lower for the CSNR (150 species) in comparison to the other five sites (average = 1527 species). An increase in the number of CSNR species would likely affect similarity between sites and could affect the relationships between them.

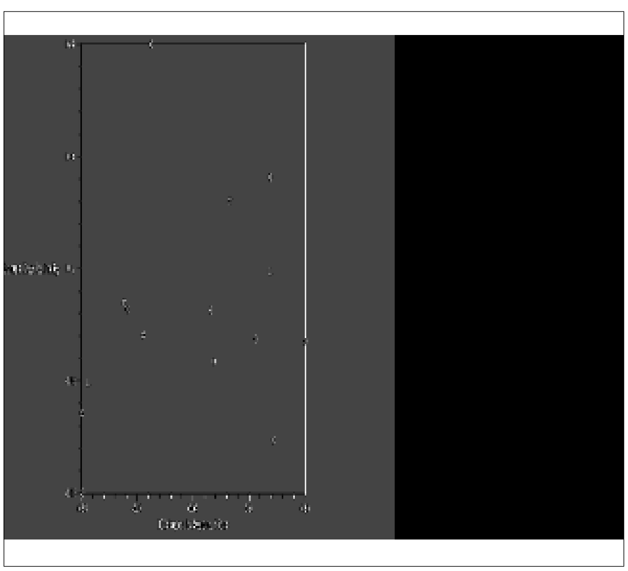


Figure 3.5. Plot of distance vs. genus dissimilarity.

According to the refugia theory, genera and families have remained more or less constant since the Tertiary, whereas species show more recent effects of allopatric speciation in refugia during the Pleistocene. Data at the genus level support this model, which explains the lack of a clear correlation between increasing distance and genus dissimilarity (r = 0.24, Figure 3.5). A discernible relationship remains (though less distinct) between the dissimilarity coefficients of the Guyana locations and the CSNR, and Saül and Ducke continue to exhibit the most dissimilarity to the CSNR. The UPGMA dendrogram shows that Iwokrama and Mabura Hill are most similar floristically, and are next most similar to Kaieteur (Figure 3.6). These relationships are concurrent with soil and topography data. The Guyana locations are next most similar to Ducke, then Saül, and lastly to the CSNR, though these relationships are speculative due to less intense collecting activity and fewer genera recorded for the CSNR.

The 20 most abundant families within each of the four regions of the Coppename River in the CSNR largely consist of woody shrubs and herbaceous families. More thorough collection of species at ground level species and under-collection of canopy species in the CSNR is a likely source of bias. It is estimated that approximately 80% of rainforest species diversity is found in the forest canopy; however, most of our collections were made within the first 6 m above ground level due to the time constraints associated with an AquaRAP expedition. This type of collecting yields a greater ratio of herbaceous to woody plants, explaining the absence of several prominent woody families from Table 3.3. Increased canopy collection of the CSNR would increase the numbers of Orchidaceae species and would add several prominent families to the list such as the Myrtaceae, Chrysobalanaceae, Annonaceae, and Sapotaceae. The Rubiaceae and Cyperaceae are consistently among the top three most abundant families between regions, due mostly to their accessibility at ground level. The Fabaceae exhibit high species richness and collection frequency between regions. Only four species of Fabaceae were collected within the CSNR, but all four were

Figure 3.6. UPGMA dendrogram showing relative genera similarity of the six florulas.

encountered in each region of the Coppename River.

Of the ten most abundant families within the five published florulas, the Fabaceae, Rubiaceae, and Orchidaceae are consistently among the top three (with the exception of Reserva Ducke where Lauraceae substitutes for Orchidaceae). These numbers point to extensive canopy collections within localities, as the Fabaceae is mainly a canopy family, and Orchids are generally epiphytic. The top three families within the CSNR differ from the other five florulas, consisting of the Rubiaceae, Cyperaceae, and Araceae. The Fabaceae and Orchidaceae are ranked relatively low on the list, while Araceae and Bromeliaceae are ranked relatively high, due to their accessibility at or near ground level.

CONCLUSIONS

The size and pristine nature of the Central Suriname Nature Reserve present a tremendous opportunity for continued research. The plant communities sampled were composed of a unique assemblage of species, and results presented here support the refugia theory. However, it is clear that more thorough collecting is needed before the CSNR checklist can be considered fully appropriate for floristic comparisons on a regional scale**.** Although the reserve is expected to receive continued protection, Adampada Creek is threatened by large scale bauxite extraction outside of the reserve boundaries. If such mining occurs, it will have a profound effect on the ecology of the region, and the pristine nature of the CSNR will be compromised. A high priority should be placed on sampling the region surrounding Adampada Creek in order to document the diversity as well as to further assess the threat of mining.

LITERATURE CITED

Behrensmeyer, A. K. 1992. Terrestrial ecosystems through time: evolutionary paleocology of terrestrial plants and animals. University of Chicago Press, Chicago, IL.

Berry, P. E., O. Huber, and B. K. Holst. 1995. Floristic analysis and phytogeography. In: P. E. Berry, B. K. Holst, and K Yatskievych (eds), Flora of the Venezuelan Guayana. Vol. 1: Introduction, pp. 161-191. Missouri Botanical Garden, St. Louis and Timber Press, Portland, Oregon.

Clarke, H. D. and V. A. Funk. 1998. A preliminary analysis of the plant diversity of the Iwokrama Forest, Guyana. Biological Diversity of the Guianas Program, Smithsonian Institution, Washington, D.C.

Clarke, H. D., V. A. Funk, and T. Hollowell. 2001. Using checklists and collections data to investigate plant diversity: A comparative checklist of the plant diversity of the Iwokrama Forest, Guyana. Sida, Botanical Miscellancy 21:1-86.

Clarke, H. D. and V. A. Funk. 2005. Using checklists and collections data to investigate plant diversity: II. An analysis of five florulas from northeastern South America. Academy of Natural Sciences of Philidelphia 154: 29-37.

Condit, R., N. Pitman, E. G. Leigh, Jr., J. Chave, J. Terborgh, R. B. Foster, P. Núñez V., S. Aguilar, R. Valencia, G. Villa, H. C. Muller-Landau, E. Losos, and S. P. Hubbell. 2002. Beta-diversity in tropical forest trees. Science 295: 666-669.

Conservation International. 2002. The Central Suriname Nature Reserve: Republic of Suriname. Quick-O-Print, Paramaribo, Suriname.

Ek, R. C. and H. Ter Steege. 1997. The flora of the Mabura Hill area, Guyana. In: R. C.

Ek (ed.). Botanical diversity in the tropical rainforest of Guyana. Tropenbos-Guyana Series 4, pp. 27-64. Tropenbos-Guyana Programme, Georgetown, Guyana.

Granville, J.-J. D. 1982. Rainforest and xeric flora refuges in French Guiana. In: G. T.

Prance (ed.). Biological diversification in the tropics. Columbia University Press, New York, NY. pp 164-165.

Haffer, J. 1969. Speciation in Amazonian forest birds. Science 165: 131-136.

Hubbell, S. P. 2001. The unified neutral theory of biodiversity and biogeography. Princeton University Press, Princeton, New Jersey.

Jordan, C. F. 1985. Soils of the Amazon rainforest. In: G. T. Prance and T. E. Lovejoy (eds), Amazonia. pp 83-94. Pergamon Press, New York.

Kelloff, C. L. and V. A. Funk. 1998. Preliminary checklist of the plants of Kaieteur Falls National Park, Guyana. Biological Diversity of the Guianas Program, Smithsonian Institution, Washington, D.C.

Kelloff, C. L. and V. A. Funk. 2004. Phytogeography of the Kaieteur Falls, Potaro Plateau, Guyana: floral distributions and affinities. Journal of Biogeography 31:501-513.

Kubitzki, K. 1989. Amazon lowland and Guayana highland. Historical and ecological aspects of the floristic development. Revista de la Academia Volombiana de Ciencias Exactas 17:271-276.

Kubitzki, K.1990. The psammophilous flora of northern South America. Memoirs of the New York Botanical Garden 64:248-253.

Lindeman J. C. and S. A. Mori. 1989. Botanical Inventory. In: D.G. Campbell and H. D.

Hammond (eds), Floristic inventory of tropical countries: The status of plant systematics, collection, and vegetation, plus recommendations for the future, pp. 380-388. The New York Botanical Garden.

MacArthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography. Monographs in Population Biology. Princeton University Press, Princeton, NJ.

Mori, S. 1991. The Guyana lowland floristic province. Compte Rendu des Séances de la Societé de Biogéographie 67(2)67-75.

Mori, S., G. Cremers, C. Gracie, J.-J. de Granville, M. Hoff, and J. D. Mitchell. 1997.Guide to the vascular plants of central French Guiana. Part 1. Pteridophytes, gymnosperms, and monocotyledons. Memoirs of the New York Botanical Garden 76(1):1-422.

Mori, S., G. Cremers, C. Gracie, J.-J. de Granville, S. V. Heald, M. Hoff, and J. D.

Mitchell. 2002. Guide to the vascular plants of central French Guiana. Part 2. Dicotyledons. Memoirs of the New York Botanical Garden 76(2):1-944.

Prance, G. T. (ed.). 1982. Biological diversification in the tropics. Columbia University Press, New York, NY.

Ribeiro, José Eduardo L. da S. and Michael J.G. Hopkins. 1999. Flora de Reserva Ducke: Guia de identifacacao das plantas casculares de uma floresta de terra-firme na Amazônia Central. http://curupira.inpa.gov.br/projetos/ducke.

Rohlf, H. 1997. NTSYSpc: Numerical taxonomy and multivariate system. v. 2.01.

Sabatier, D., M. Grimaldi, M.-F. Prévost, J. Guillaume, M. Godron, M. Dosso, & P. Curmi. 1997. The influence of soil cover organization on the floristic and structural heterogeneity of a Guianan rain forest. Plant Ecology 131:81-108

Sokal, R. R. and F. J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research. W.H. Freeman, New York. pp 813-819.

Steege, H. T., M. J. Jansen-Jacobs, and V. K. Datadin. 2000. Can botanical collections assist in a national protected area strategy in Guyana? Biodiversity and Conservation 9:215-240.

Swartz, K. L. 2004. Great Circle Mapper. <http://gc.kls2.com/>

Townsend, C. R., J. L. Harper, and M. Begon. 2000. Essentials of Ecology. Blackwell Science, Malden, Massachusetts. pp 194-195.

Willis, K. J. and R. J. Whittaker. 2000. The refugial debate. Science 287: 1406-1407.

Chapter 4

A survey of the aquatic invertebrates of the Coppename River, Central Suriname Nature Reserve

Guido Pereira and Haydi J. Berrenstein

INTRODUCTION

Aquatic invertebrates represent an important group of organisms in the aquatic environment, among which the aquatic insects are the most diverse and abundant. The immature stages of many insects develop and grow in water and hence spend most of their lifetime in this environment. Benthic invertebrates (invertebrates that live on the bottom of a water body or in the sediment) play a very important role in energy transfer through the trophic levels in aquatic systems. Many of them incorporate, transform and transfer autochthonous material through the ecosystem (Wallace and Merrit 1980). Some groups, including many aquatic insects, feed on unicellular algae, bacteria, fungi, vascular plants and detritus, zooplankton, other invertebrates and small fish (McCafferty 1981). Other groups such as clams, some snails and some insects are filter feeders that ingest seston (particulate matter such as plankton, organic detritus and inorganic particles such as silt suspended in water). In addition, invertebrates constitute the main food source of juvenile stages of many fishes (Lowe-McConnell 1975), crabs, shrimps and birds (Epler 1995). The communities of benthic macro invertebrates have been widely used to predict water quality and aquatic contamination; methodologies developed with this end are a common tool applied in temperate areas (Hynes 1970, Epler 1995, Barbour et al. 1995).

Invertebrates play an important role in the ecosystem because of their grazing and detritivorous feeding habits, by which they contribute to the incorporation of energy into the system from the primary producers such as algae and vascular aquatic plants and from allochtonous material. Crustacea, such as the freshwater shrimps and crabs are larger animals that constitute the most important taxa of crustaceans inhabiting tropical fresh water streams. They usually feed on aquatic insect larvae and other invertebrates, dead animals and detritus. Additionally, larger aquatic vertebrates such as fishes, aquatic reptiles, birds and mammals often prey them on. Because of their abundance and central role that Crustacea play in the food web of aquatic ecosystems, Crustacea are often used as indicators of the health of the aquatic environment, providing insights and early warning signs of environmental perturbations and human disturbance.

Unfortunately, in the Neotropical region we face the problem of a great biodiversity but little taxonomic knowledge of aquatic invertebrates. For this reason, studies in which benthic macro invertebrates are used to evaluate anthropogenic intervention of the aquatic systems are rather scarce. For this reason, we should pay special attention and direct more effort to gain knowledge on the aquatic biodiversity of the benthic invertebrates of Neotropical rivers to have a solid base from which to carry out studies of environmental monitoring (Roldán 1999). The Aquatic Rapid Assessment (AquaRAP) methodology (Chernoff and Willink 2000) is a practical tool that has offered a great quantity of knowledge in little time about the diversity of benthic communities in several Neotropical countries such as Venezuela, Brazil and Bolivia (Chernoff and Willink 1999, 2000). In Venezuela it has been applied with a lot of success in the Caura River (Chernoff et al. 2003) and in the Orinoco Delta (Lasso et al. 2004) contributing significantly to increase the knowledge of the biodiversity of our aquatic systems.

For these reasons, a survey of the aquatic invertebrates of the Central Suriname Nature Reserve is a very important first step to understanding this ecosystem and to developing future monitoring activities to preserve the environment. However, to date there is not much knowledge on this subject. Holthuis did the most important work on Crustacea as part of the fauna of Suriname in 1959, which is a survey of previous work and a review of collections made by the experimental fish trawls of the boat Coquette and collections made by early scientific explorers. Their collections are in European museums. However, only few records mention the Coppename River and they are mainly from the lower estuarine region.

In addition, there is not much knowledge about the taxonomy of aquatic insects of Suriname. Most of the previous studies have been done in French Guyana. Therefore, the collections made in the Coppename River are among the first ever made in the country. It will therefore be very useful to conduct future research on the taxonomy of this interesting and important group of organisms. The Coppename River watershed contains vast expanses of uninterrupted forest, particularly in the Central Suriname Nature Reserve (CSNR). This wilderness is one of the few truly pristine areas remaining in the world – an area where biological and environmental processes are almost entirely free of human impact. Except for areas near Tafelberg, the portion of the watershed above Sidonkrutu is pristine. Nonetheless, the potential threat of human impact is growing. These threats include aluminum mining in the Bakhuis Mountains, increased potential for tourism, and unregulated hunting and fishing. Unlike many of the other large Surinamese rivers (e.g., Sipaliwini/Coeroeni, Tapanahoni, Ulemari, Saramacca, Commewijne, Coesewijne rivers), relatively little is known about the Coppename River system, especially in the region upriver from Raleighvallen.

METHODS

Semiquantitative sampling using the Surber net

This method was used in fast flowing stream waters, usually in habitats such as among Podostemacea plants and on sandy and gravel beds. In every habitat, we took four random samples. The material was preliminary rinsed through a series of sieves of 2.5, 1.5., and 0.5 mm mesh size; larger size invertebrates were carefully removed with entomological forceps from the 2.5 and 1.5 sieves. All the of samples retained in the 0.5 sieve (which usually contained most of the animals) was observed to briefly record taxa found and stored in a nalgene 200 cc bottle with a proper label. Large sized taxa were fixed in a 5% formalin solution while smaller taxa and all aquatic insects were fixed in a solution of 70% Ethyl Alcohol (Barbour et al. 1995, Hynes 1970, Garcia and Pereira 2003).

Qualitative sampling

A dip net with a sturdy rectangular metal frame and a 0.5 mesh size was used to collect large and motile invertebrates such as crabs and shrimps. The method was also used to collect in places where, because of the slow water current, it was not appropriate to use the Surber net. We sampled in habitats such as leaf beds, pools among the large rocks, the margins of creeks, and logs. Finally, a number of small to medium sized rocks (1 to 7 kg) were lifted by hand and carefully examined with the naked eye, and all invertebrates were removed with entomological forceps. Samples were placed in a nalgene bottle with a label that contained the date, geo-reference site and type of sample. The samples were then fixed in either formalin or ethyl alcohol. We sampled for 1 to 3 h at every study site. We took some samples using a seine net of 1 cm mesh size used by the Ichthyology team. We did a tentative identification by eye and using field magnifying lenses in order to write the preliminary field report.

Once in the laboratory samples were sorted to phyla and identified with the help of specialists and current literature: Mollusks and annelids were identified by Lic. Luis Ruiz and M.Sc. Rafael Martinez; Porifera by M.Sc. Sheila Marques, Aquatic Insects and Crustaceans by Guido Pereira.(Rodriguez 1982a,b, 1992; Pereira 1983, 1985; Kensley y Walker 1982; Magalhaes and Pereira 2001; Daigle 1991, 1992; Benedetto 1974; Bryce and Hobart 1972; Edmonson 1959; Edmunds et al. 1976; Epler 1995, 1996; Flint 1974; Hilsenhoff 1970; Hilsenhoff 1970; Hurlbert et al. 1981a,b; Johannsen, 1937a,b; Martínez and Royero 1995; McCafferty 1981; Milligan 1997; Merrit and Cummins 1978; Needham and Westfall 1955; Peters 1971; Roldán 1996; Stehr 1987; Van Deer Kuyp 1950; Wiggins 1927).

We arbitrary divided the study area into 4 main regions of the river: Main channel of the Coppename, Recther Coppename, Linker and Midden Coppename, and Adampada creek. In order to describe and compare the community in these four regions, after identification and quantification the data was sorted by major taxa, number of individuals and percentage of abundance. Then we calculated the Species Richness (S´), Evenness (E) and Shannon-Wiener Diversity Index (H') and Margalef Diversity Index (M), (Ludwig y Reynolds 1988). Insects were sorted to family level; Crustaceans and Mollusks to species level.

RESULTS

Over a period of 21 days of fieldwork, we covered an area around Tonckens falls, Bolletri falls, Linker Coppename, Rechter and Midden Coppename, Dreefoetoe Soela falls and Adampada creek corresponding to 24 georeference sites (Figure 4.1). Habitats such as riffles and Podostemacea leaf beds, pools and rocks in the main channel, creeks and tributaries of the main channel, logs in the water and isolated ponds on the rocks were sampled. The accumulation curve for all invertebrate taxa (Figure 4.2) shows a steady increment through time, then a tendency to stabilize at the end of the expedition, so it seems that we collected the most common and some uncommon species. We took 82 samples that contain at least 84 species among Insecta, Mollusca, Crustacea, Annelida and Porifera. The classification scheme is given in Table 4.1.

Table 4.1. Classification scheme of aquatic invertebrate taxa collected.

Phylum	Class	Order	Family	Genus and Species
Annelida	Hirudinea	Rynchobdellida	Glossiphonidae sp. 1	
Arthropoda	Crustacea	Decapoda	Caridea	
			Palaemonidae	*Macrobrachium brasiliensis*
				Macrobrachium faustinum
				Macrobrachium jelskii
				Palaemonetes carteri
			Eurhyrhynchidae	*Euryrhynchus wrzesniowskii*
		Decapoda (Brachyura)	Trichodactylidae	*Valdivia* sp.
				Dilocarcinus spinifer
			Pseudothelphusidae	*Kingsleya latifrons*
	Maxillopoda	Arguloida	Argulidae	*Argulus* sp. 1
				Dolops sp. 1
	Insecta	Coleoptera	Carabidae sp.	
			Dytiscidae spp.	
			Elmidae spp.	
			Gyrinidae sp.	
			Helodidae spp.	
			Hydrophilidae spp.	
			Sphaeridae sp.	
		Diptera	Chironomidae spp.	
			Culicidae sp.	
			Simulidae sp.	
			Typulidae sp.	
		Ephemeroptera	Baetidae sp.	
			Leptophlebiidae sp.	
			Polymitarcyidae sp.	
			Siphlonuridae sp.	
		Hemiptera	Belostomatidae	
			Corixidae	
			Guerridae	
			Nepidae	
		Lepidoptera	Piralidae	
		Megaloptera	Corydalidae	
			Sialidae	
		Odonata	Calopterygidae	
			Coenagrionidae	
			Cordulidae	
			Gomphidae	
			Lestidae	
			Libelulidae	
		Plecoptera	Perlidae	
		Trichoptera	Hydroxychidae	
			Rhyacophilidae	
Mollusca	Gastropoda	Architaenioglossa	Ampullariidae	*Pomacea granulosa*
				Pomacea sinamarina
				Pomacea glauca glauca
				Pomacea glauca orinocensis
		Basommatophora	Ancylidae	*Ancylidae* sp.
			Planorbidae	*Drepanotrema* sp.
		Neotaenioglossa	Thiaridae	*Doryssa derivans*
				Doryssa atra
				Doryssa hohenackeri hohenackeri
				Doryssa hohenackeri kappleri
				Doryssa geijskesi
				Doryssa sp. a
				Doryssa sp. b
	Bivalvia	Unionoida	Mycetopodidae	*Anodontites* sp.
		Veneroida	Pisidiidae	*Eupera* sp.
Porifera	Demospongiae	Haplosclerida	Metaniidae	*Drulia* cf. *uruguayensis*

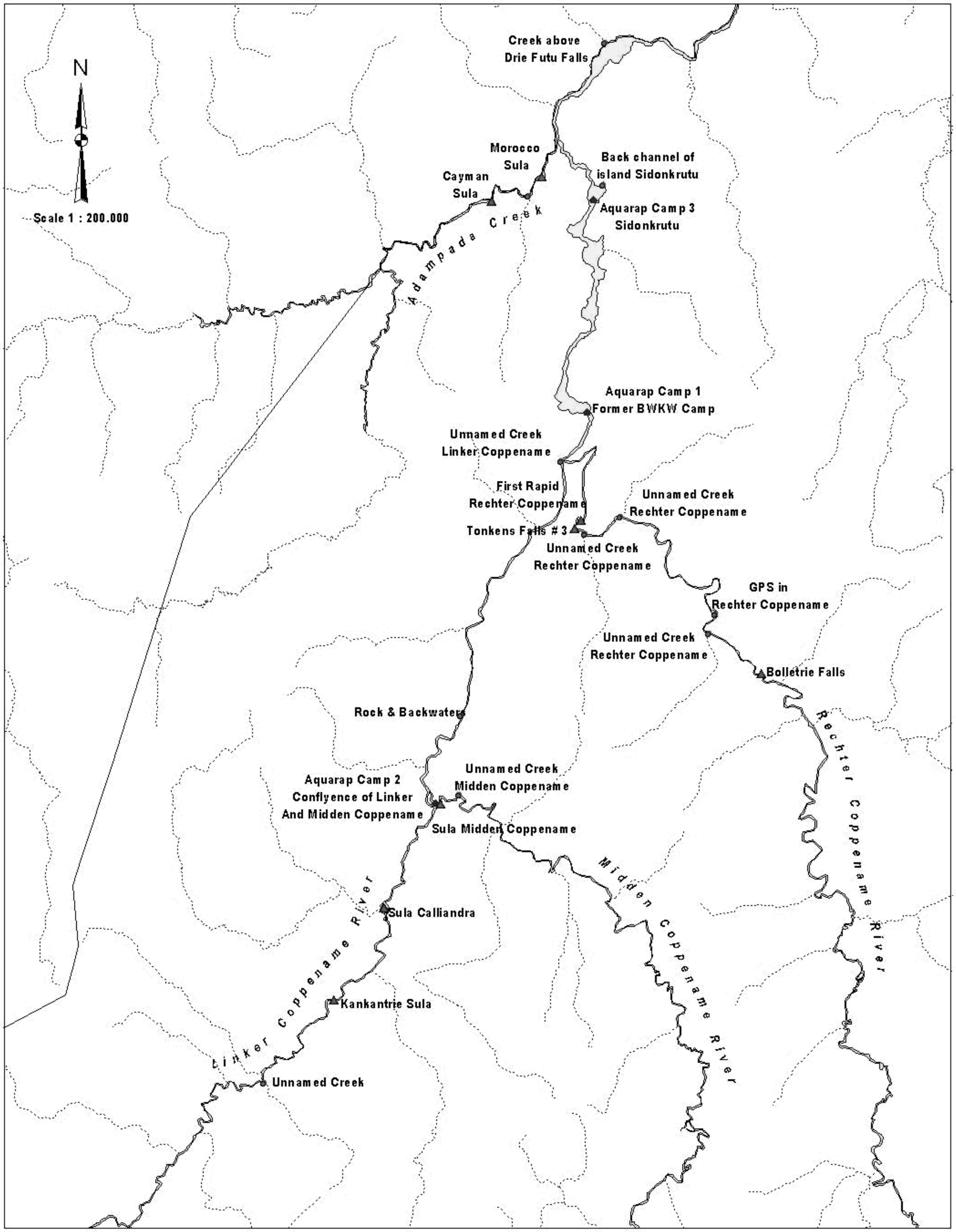


Figure 4.1. Map of the Coppename River indicating the georeference points sampled for invertebrates.

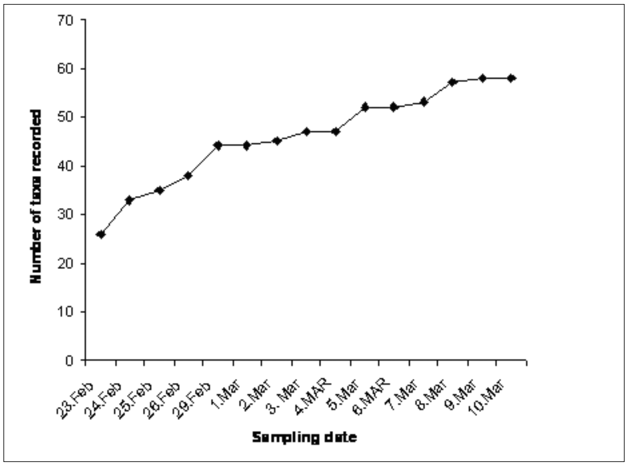


Figure 4.2. Accumulation curve for taxa collected by days of the AquaRAP expedition.

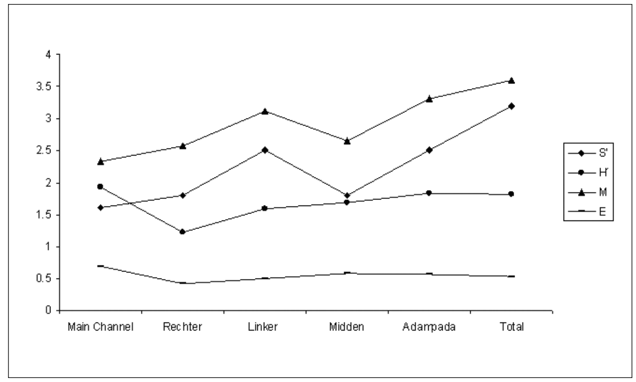


Figure 4.5. Community structure indicators for insects in the Coppename River Basin. (S´ expressed as No. of species/10 to fit in the scale.)

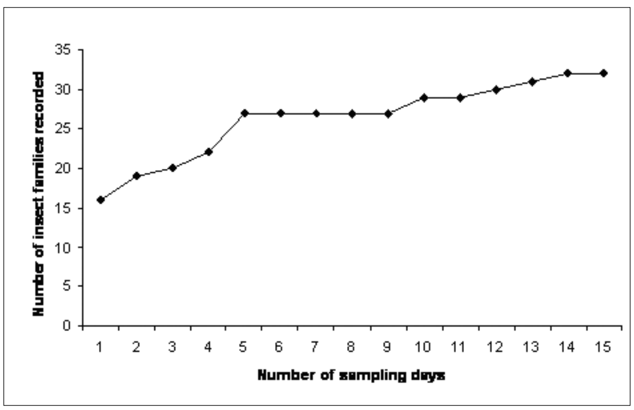


Figure 4.3. Accumulation curve for families of Insecta in the Coppename River Basin.

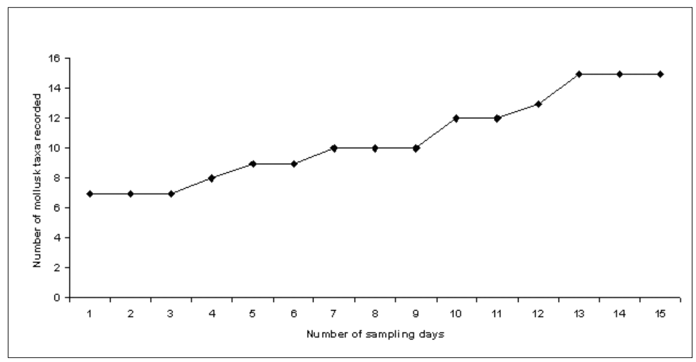


Figure 4.6. Species accumulation curve for the Mollusca of the Coppename River Basin.

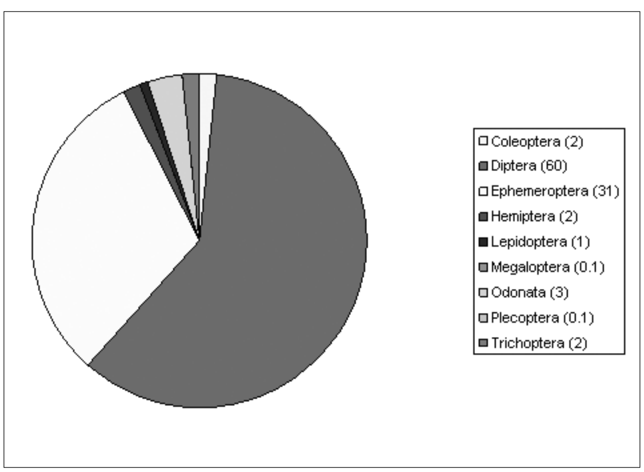


Figure 4.4. Relative composition of different orders of aquatic insects found in the Coppename River Basin. Relative abundance (%) in parenthesis next to the Order name.

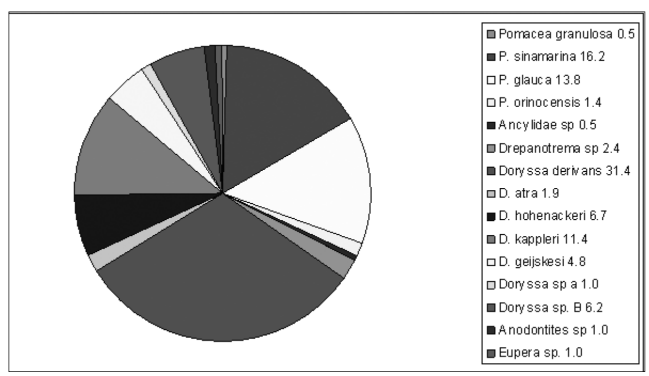


Figure 4.7. Relative abundance of mollusks in Coppename River Basin. Abundance (%) next to the name of taxa.

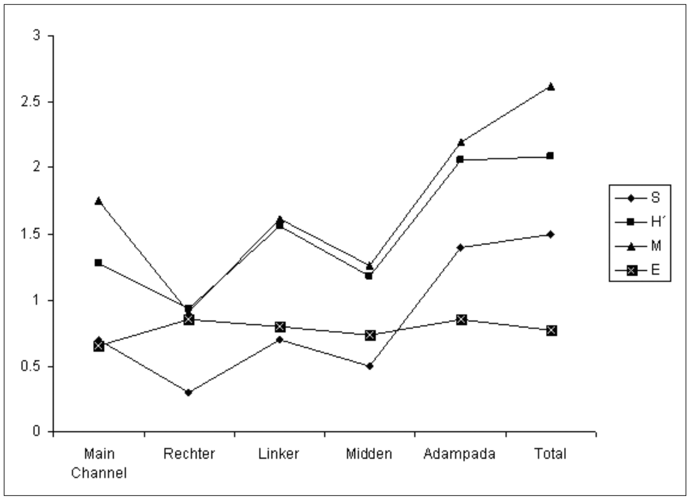


Figure 4.8. Community structure indicators for mollusks in the Coppename River Basin. (S´ expressed as No. of species/10 to fit in the scale.)

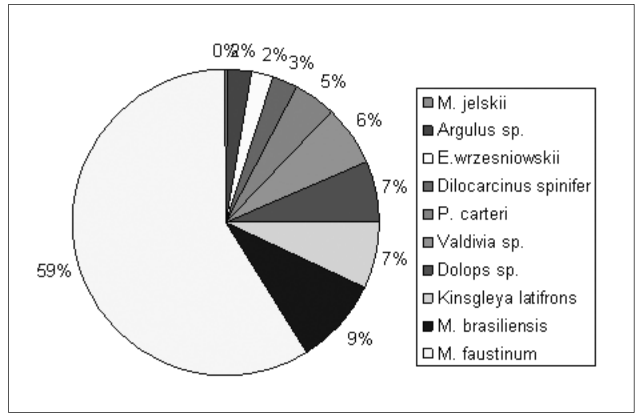


Figure 4.10. Relative abundance (%) of crustaceans in the Coppename River Basin.

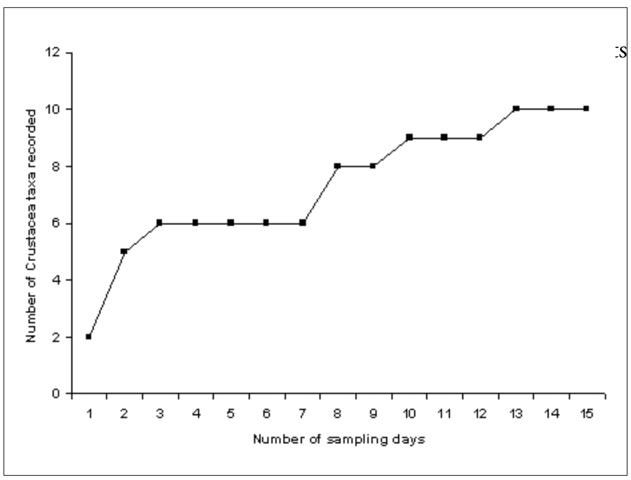


Figure 4.9. Species accumulation curve for the Crustacea of the Coppename River Basin.

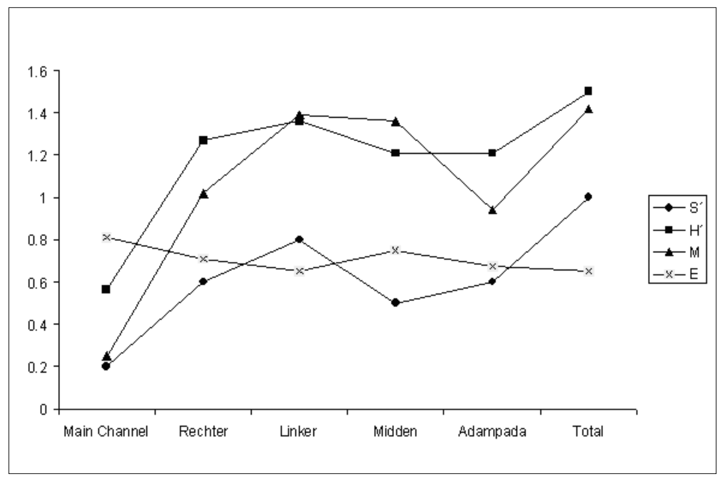


Figure 4.11. Community structure indicators for crustaceans in the Coppename River Basin. (S´ expressed as No. of especies/10 to fit in the scale.)

Table 4.2. Community descriptors for insects in the Coppename River. S' Richness, H' Shannon Wiener Diversity Index, M Margalef Diversity Index, E Evenness.

Area	S'	H´	M	E	No. Indiv.
Main Channel	1.6	1.931	2.325	0.696	633
Rechter	1.8	1.214	2.576	0.42	734
Linker	2.5	1.594	3.116	0.495	2212
Midden	1.8	1.682	2.654	0.581	605
Adampada	2.5	1.836	3.305	0.57	1422
Total	3.2	1.823	3.591	0.526	5606

Table 4.3. Community descriptors for mollusks in the Coppename River. S' Richness, H' Shannon Wiener Diversity Index, M Margalef Diversity Index, E Evenness.

Area	S'	H´	M	E	No. Indiv.
Main Channel	0.7	1.28	1.747	0.657	31
Rechter	0.3	0.936	0.91	0.852	9
Linker	0.7	1.559	1.615	0.801	41
Midden	0.5	1.176	1.258	0.731	24
Adampada	1.4	2.054	2.19	0.856	96
Total	1.5	2.086	2.62	0.77	210

with nine orders comprising 32 families (Table 4.1). Based on gross morphology we estimate that there are at least 54 species of insects. Next were the Mollusks with six families, six genera and 15 species. Crustaceans followed with five families, eight genera and 10 species. Finally, we recorded one species of Hirudinea within the Annelida and one species of freshwater sponge. The total number of species recorded was at least 84.

SPECIES COLLECTED AND COMMUNITY STRUCTURE

Aquatic Insects

The accumulation curve for all insect taxa is shown in Figure 4.3. It shows a tendency to reach a plateau after day 5 of collecting so we can reasonably say that we collected all major or common families of aquatic insects and also some rare ones. The composition of this vast community of insects is given in Figure 4.4. Diptera (flies) and Ephemeroptera (mayflies) dominated the insect community sampled. Dipterans were the dominant group with 60% relative abundance, within which the families Chironomidae and Simulidae were the dominant families. They were abundant especially in the riffles and the Podostemaceae beds. Ephemeroptera followed with 31% relative abundance, with the families Baetidae and Leptophlebidae the most abundant. Other taxa presented abundance values of 3 % or less. Species richness was higher in the Linker Coppename and Adampada creek (Table 4.2, Figure 4.5), however highest biodiversity index value was obtained for the Adampada region. Lowest values were in the Rechter Coppename and Main channel. Evenness was rather homogeneous in the different areas sampled (Figure 4.5).

Mollusks

Mollusks are a group of freshwater and saltwater animals with no skeleton and usually one or two hard shells made of calcium carbonate. Mollusks include oysters, clams, mussels, snails, conches, scallops, squid, and octopus. During the AquaRAP survey, we recorded 15 mollusk species. The species accumulation curve shows that different species were showing up gradually until day 13 when the curve tended to reach a plateau (Figure 4.6). The most common genera were the gastropods (snails) *Doryssa* and *Pomacea* (Figure 4.7). The genus *Doryssa* has several species, some of which were the most abundant: *Doryssa derivans* 31.6%, *D. kapleri* 11.4 % D. *honenackeri* 6.7 % *D. geijskesi* 4.8% and *Doryssa* sp. b 6.2%. This genus was especially abundant in the creeks and tributaries of the main Coppename. The next diverse genus was *Pomacea*, with four different species or subspecies, of which *P. sinamarina* had a relative abundance of 16.2 % and *Pomacea glauca* of 13.8%. The genus seems to be more widespread in the area. The rest of the species (including bivalve mollusks) did not reach more than 2% of relative abundance for any single species. Species richness was highest in the Adampada creek and the lowest value in the Rechter Coppename (Table 4.3, Figure 4.8). The Adampada region clearly exhibited the highest diversity while Evenness was lowest value in the main channel. No significant differences were found between the other regions (Figure 4.8).

Crustacea

The crustaceans (Crustacea) are a large group of arthropods that includes lobsters, crabs, shrimp, barnacles, and fish lice. They are found in marine and freshwater, with a few terrestrial members (such as woodlice). The most important work on the fauna of crustaceans from Suriname is a review by Holthuis (1959). This work deals mainly with the collections made by the fishtrawler ¨Coquette¨ in marine waters, freshwater collections made by D. C. Geijskes, and additional collections present in the most important museums in Europe and the United States. He reported nine species of freshwater shrimps and six species of freshwater crabs for Suriname.

During this AquaRAP study we recorded five species of freshwater shrimps, two species of fish lice, and three species of freshwater crabs. Most of them were collected after 8 days of sampling. The species accumulation curve through time shows a tendency to reach a plateau after day 12 (Figure 4.9) so we may consider that we collected most representative species of this ecosystem.

Table 4.4. Community descriptors for crustaceans in the Coppename River. S' Richness, H' Shannon Wiener Diversity Index, M Margalef Diversity Index, E Evenness.

Area	S´	H´	M	E	No. Indiv.
Main Channel	2	0.562	0.248	0.811	56
Rechter	6	1.267	1.016	0.707	137
Linker	8	1.357	1.393	0.652	152
Midden	5	1.209	1.358	0.751	19
Adampada	6	1.211	0.94	0.675	204
Total	10	1.502	1.419	0.652	568

Crustaceans were numerically abundant, especially the shrimp *Macrobrachium faustinum* (Figure 4.10) which made up 59% of the crustaceans. Immature individuals of *M. faustinum* were encountered in large numbers in the main channel and riffles in general. It is interesting to note that *M. faustinum* requires the coastal environment to complete its life cycle, since the larvae hatch and develop in the high salinity range of the marine estuary. Therefore, this species must go through a migration route from up river waters to the estuary in order to spawn, and post larvae and juveniles must migrate from the estuary to the headwaters of the river. This fact highlights the connectedness of ecosystems that must be considered when for conserving species in the freshwater ecosystem. Some species may need the whole system in order to complete their life cycle, and conservation measures most pay attention to the full system.

The other species of crustaceans recorded are strictly freshwater inhabitants, and so more restricted to the high waters and tributaries. The shrimp *Macrobrachium brasiliensis* was found with a relatively high frequency 9%, followed by *E. wrzesniowskii* with 5%. Among the shrimps the most uncommon was *Macrobrachium jelskii*; we collected only two individuals during the survey.

Crabs live in the borderline between land and freshwater systems: rocky, leaf beds and shores are the preferred habitats for this group. We collected two families, the Trichodactylidae with two genera and one species each: *Dilocarcinus spinifer* and *Valdivia* sp. (at this time we can not assign a specific name to this species). The taxonomic history of this group is full of synonyms and misidentifications so that we prefer to do a careful of the specimen. The family Pseudothelphusidae has one species *K. latifrons* (7%) that was very common in the main channel on rocky beds.

Finally, we frequently found (9%) two species of fish lice that were especially abundant on the fish called "Anyumara" by locals (*Hoplias aimara*). Occasionally we recorded up to 12 individuals on a recently caught fish. *Dolops* was more abundant (7%) than *Argulus* sp. (2%).

Table 4.4 and Figure 4.11 give a summary of community descriptors for the crustaceans. The highest number of species was found in the Linker Coppename and the lowest in the Main Channel (Table 4.4). Diversity indices also show the lowest value in the main channel and largest value in Linker Coppename. However differences between the Rechter, Linker, Midden and Adampada are not as striking as compared to the main channel (Figure 4.11).

Other Phyla

Within the phylum Porifera we found one species, *Drulia* cf. *uruguayensis*. Although we did not collect many individuals due to the sampling method, we can say that this freshwater sponge is common in the rocky areas of the river and tributaries. Freshwater sponges are usually associated with unpolluted and pristine fresh water systems. Finally, we collected some Hirudineans (Annelida) of the family Glossiphonidae, among the leaves in muddy areas of the river. The presence of the hirudineans is occasional seasonal?.

SPECIES DISTRIBUTION BY REGION

Main channel of the Coppename River

The main channel of the Coppename River has a wide riverbed. There are several major waterfalls and riffles with large rocks that create large areas of shallow and medium deep pools as well as shallow waters with riffles and Podostemaceae beds. Water is mainly clear turning to brown in deeper pools. Several of these main open and rocky areas, such as Sidonkroetoe Falls, are places for camping and tourism.

With regard to biodiversity, we collected 16 families of Insecta, seven species of Mollusca, two species of crustaceans, and one species of Porifera (Appendix 3). This is the main habitat for the freshwater crab *Kingsleya latifrons*; the largest numbers of individuals were found here compared to smaller tributaries of the main river channel. Among the Mollusks, the snails *Pomacea granulosa*, *Ancylidae* sp. and the bivalves *Anodontites* sp. and *Eupera* sp. were present only in the main channel. Podostemaceae beds form their largest patches in the main channel and populations of aquatic insects associated with them seem to have a very large biomass here, as compared to other riffle areas in smaller tributaries.

The Rechter Coppename

The Rechter Coppename is a large arm of the Coppename, with the unique characteristic of carrying black water. It has several well-defined ecological areas such as the main basin, small creeks on both sides of the river, large areas of rocky shores, and a large pool above and below the Bolletrie Falls. Here we collected 18 families of Insecta, three species of Mollusca, six species of crustacean, and one species of Hirudinean (Appendix 3). The freshwater shrimp *E. wrzesniowskii* was also documented here. This is a small shrimp species with low fecundity that is likely exposed to a high risk of predation in open areas of the system. We never collected this species outside of the smaller creek, which may suggest that the creeks act as refuge habitat for this species during the dry season. Another interesting feature is the presence of a significant number of juveniles of the species of freshwater shrimp *Macrobrachium faustinum* from the rapids area of Bolletrie Falls. It seems that the life cycle of this species might be related to this environment of fast flowing waters and the Podostemaceae beds. Finally, we found abundant populations of three species of crabs from two different families, one of which (*Kingsleya latifrons*) is typical of rocky areas and the other two are typical of leaf beds and muddy creeks (*Valdivia* sp. and *Dilocarcinus spinifer*).

Linker and Midden Coppename

Both the Linker and Midden Coppename branches seem to have smaller volume of water than the Rechter Coppename. It seems that channel borders are steeper and there are not many areas of inundation along the edges. Both branches have scattered riffles that harbor zones with Podostemaceae beds that seemed to be more common in the Linker than in the Midden Coppename. Few creeks came off the main channels.

The Linker and Midden Coppename branches were not as diverse as the Rechter Coppename. Regarding biodiversity, we collected in Linker Coppename 25 families of Insecta, seven species of Mollusca, eight species of crustacean, and one species of Porifera. In the Midden Coppename we collected 18 families of Insecta, five species of Mollusca, and five species of crustaceans (Appendix 3). However, there are several important results to highlight. Several insect groups were found only in this region, including species representing the Ephemeroptera, Polymitarcidae, Siphlonuridae, Hemiptera, and Belostomatidae. Similarly, among the Mollusks, several species were found only in this region incuding *Pomacea orinocencis*, *Doryssa atra*, *D. hohenackeri*, *D. kapleri*, and *D. geijskesi*. We recorded only two individuals of the shrimp species *Macrobrachium jelskii*. Population sizes may have been low due to the low water season so it we recommend additional surveys of the abundance of this species during the high water season. Other species recorded only in this area included all the specimens of fish lice *Dolops* sp. and *Argulus* sp. Podostemaceae beds appeared to be dominated by Ephemeroptera (mayfly) larvae of the families Baetidae and Leptophlebidae.

Adampada Creek

The Adampada Creek is a medium sized tributary of the Coppename River. Its principal characteristics are the very clear waters, rocky and sandy beds, as well as several central areas of shallow fast flowing waters with scattered and frequent pools containing boulder rubble and sandy bottoms. These places have patches of Podostemaceae beds in open areas of the system that occasionally become the main bottom type in the shallow fast flowing waters. There are also several small to large islands, some with riparian vegetation and some barren. The riversides have thick riparian vegetatio.

Regarding biodiversity, we collected 25 families of Insecta, 11 species of Mollusca, six species of crustaceans, one species of Porifera, and one family of Annelida (Appendix 3). Unique taxa found here included the Dipteran families: Typulidae, Megalopetra Corydalidae and Sialidae; the Mollusks Planorbidae (*Drepanotrema* sp.) and two species of *Doryssa* spp; and one species of crustacean, *P. carteri*. Creeks and small sub-tributaries are not common and we surveyed only a few. The community of decapod crustaceans did not seem to differ from the other survey areas during this study. It is important to note however, that the first collection of the shrimp species *Palaemonetes carteri,* was in this area during an expedition in Suriname. Specimens of *Macrobrachium brasiliensis* were collected in rather low numbers while the species *Macrobrachium faustinum* remained as the dominant species. Probably the low populations of *P. carteri* and *M. brasiliensis* have to do with the low water level conditions, the increased predation by fishes during this time of the year, and the low fecundity of this species (Pereira 1997). The small tributary creeks seem to act as a refuge for these species during this time of the year.

CONCLUSIONS AND CONSIDERATIONS FOR BIODIVERSITY CONSERVATION

1) **Several invertebrate groups and species were found associated with specific micro-habitats**; these specific requirements must be considered in conservation planning. Examples include:
   - There was a clear delineation of habitat (at least during the dry season, this study) for inland and littoral (shoreline) species of Palaemonid freshwater shrimps. They are restricted to either the main channel or the marginal smaller lateral creeks. This finding makes a very interesting ecological case of study for future research.
   - Pseudotelphusid crabs tend to be associated with rocky habitats while the Trychodactylidae crabs are more associated with leaves, muddy beds or fallen logs.
   - The smaller tributaries directly connected to the river channel contained different species in lower densities compared to the main channel. This was particularly true for crabs of the family Trichodactylidae and shrimps of the genus *Palaemonetes* and *Macrobrachium* spp.
   - Diptera were especially common in the Podostemaceae beds.
   - The shrimp *Macrobrachium faustinum* was recorded only from the rapids area of Bolletrie Falls. It seems that the life cycle of this species might be related to this environment of fast flowing waters and the *Podostemaceae* beds.
2) **Some species need the entire watershed to complete their life cycle**. The shrimp *Macrobrachium faustinum* requires both freshwater and the coastal environment to complete its life cycle, since the larvae hatch and develop in the high salinity range of the marine estuary. This fact highlights the connectedness of freshwater and marine ecosystems within the Coppename Basin.
3) **Several groups of invertebrates recorded indicate a high-quality pristine environment.**
   - Ephemeroptera were present in many habitats, which is a clear indicator of a pristine environment.
   - The frequent presence of freshwater sponges in areas of riffles and fast flowing streams is an exceptional feature that also indicates a healthy, non-polluted environment.
4) **There is a rich and diverse community of aquatic invertebrates in the Central Suriname Nature Reserve.** However, our taxonomic knowledge of the region is poor and we recommend that a joint project with several specialists be developed to build a reference collection and species check lists for the aquatic invertebrates.

AREA SPECIFIC RECOMMENDATIONS

- **Main channel.** The fact that large areas of the main channel may serve as places for tourist camping and human settlement means that measures for conservation should be carefully planned especially for these areas. The main channel of the river also has areas of high productivity with large standing biomass and an accumulation of energy in the biota and as such, is important to the energy flow of the ecosystem. These areas present the most appropriate sites for monitoring of invertebrate communities.

- **Rechter Coppename**. This region is very important area for conservation for several reasons: it is a pristine environment, has the unique nature of being a black water system, has high ecological significance for shrimps and crabs, and a high diversity of other invertebrates.

- **Linker and Midden Coppename**. These two river branches seem to have a different community structure of aquatic insects as compared to the Rechter Coppename. Future research is needed to confirm this but it should be considered during conservation planning.

- **Adampada**. This area has outstanding scenic value due to the combination of crystal clear waters, large shallow habitats with *Podostemaceae* beds, islands, and thick riparian vegetation. This is one of a few small sub-tributary creeks in the area that may act as a refuge for inland water species of shrimps. The water quality and microhabitats of the creek should be protected to ensure the life cycle of several shrimp species.

LITERATURE CITED

Barbour, M.T., J. Gerritsen., B. D. Snyder and J.B. Stribling. 1995. Revision to Rapid Bioassesment Protocols for use in streams and rivers: Peryphiton, Benthic Macroinvertebrates, and fish. EPA 841_D_97-002.

Benedetto, L. 1974. Clave para la determinación de los plecópteros suramericanos. Studies on the Neotropical Fauna 9: 141-170.

Bryce, D., and A. Hobart. 1972. The biology and identification of the larvae of the Chironomidae (Diptera). Entomologist's Gazette 23: 175-215.

Chernoff, B., and P.W. Willink (eds). 1999. A biological assessment of the aquatic ecosystem of the Upper Río Orthon Basin, Pando, Bolivia. RAP Bull. Biol. Assessment 15. Washington, DC: Conservation International.

Chernoff, B., and P.W. Willink. 2000. AquaRap sampling protocol. *In:* Willink, P. W., B. Chernoff, L. E. Alonso, J. R. Montambault and R. Lourival (eds). A biological assessment of the aquatic ecosystem of the pantanal , Mato Grosso do Sul, Brasil. RAP Bull. Biol. Asessment 18. Washington, DC: Conservation International Pp. 241-242.

Chernoff, B., A. Machado-Allison., K. Riseng and J. Montambault. 2003. A biological assessment of the aquatic ecosystem of the Caura river basin, Bolivar state, Venezuela. RAP Bull. Biol. Assessment 28. Washington, DC: Conservation International

Daigle, J.J. 1991. Florida Damselflies (Zygoptera): A species key to the aquatic larval stages. Department of Environmental Regulation. Florida State. Technical Series Vol. 11, No 1.

Daigle, J.J. 1992. Florida Dragonflies (Anisoptera): A species key to the aquatic larval stages. Department of Environmental Regulation. Florida State. Technical Series Vol. 12, No 1.

Edmonson, W.T. (Ed.). 1959. Fresh-Water Biology. Second Edition. John Wiley & Sons, Inc., New York. 1242p.

Edmunds, G. , S.L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. University of Minnesota Press, Minneapolis. 330p.

Epler, J.H. 1995. Identification manual for the larval Chironomidae (Diptera) of Florida). Final Report DEP Contract Number WM579. Department of Environmental Protection. Florida State, Tallahassee. 320p.

Epler, J.H. 1996. Identification manual for the water beetles of Florida (Coleoptera: Cryopidae, Dytiscidae, Elmidae, Gyrinidae, Haliplidae, Hydraenidae, Hidrophilidae, Noteridae, Psephenidae, Ptilodactyllidae, Scirtidae). Final Report DEP Contract Number WM621. Department of Environmental Protection. Florida State, Tallahassee.

Flint, O.S. 1974. Studies of Neotropical Caddisflies, XVII: The Genus *Smicridea* from North and Central America (Trichoptera: Hydropsichidae). Smithsonian Contributions to Zoology 167. Smitsonian Institution Press, Washington.

García, J.V., and G. Pereira. 2003. Diversity of Benthic Macroinvertebrates from the Caura River Basin, Bolivar State, Venezuela. *In:* Chernoff, B., A. Machado-Allison., K. Riseng and J. Montambault (eds.). A biological assessment of the aquatic ecosystem of the Caura river basin, Bolivar state, Venezuela. RAP Bull. Biol. Asessment 28. Washington, DC: Conservation International

Hilsenhoff, W.L. 1970. Key to genera of Wisconsin Plecoptera (stonefly) nymphs Ephemeroptera (mayfly) nymps and Trichoptera (caddisfly) larvae. Research Report 67. Departement of Natural Resources, Maddison, Wisconsin. 68p.

Holthuis, L.1959. The Crustacea, Decapoda of Surinam (Dutch Guyana). Zool. Verh. Leiden 44: 1-296.

Hurlbert, S.H., Rodríguez, G. and N.W. Dos Santos (Eds.). 1981. Aquatic Biota of Tropical South America. Parte 1. Arthropoda. San Diego University Press, San Diego. 323p.

Hurlbert, S.H., Rodríguez, G. y N.W. Dos Santos (Eds.). 1981. Aquatic Biota of Tropical South America. Parte 2. Anarthropoda. San Diego University Press, San Diego. 298p.

Hynes, H.B. 1970. The ecology of running waters. University of Toronto Press, Toronto.

Johannsen, O.A. 1937. Aquatic Diptera part III. Chironomidae: Subfamilies Tanypodinae, Diamesinae, and Orthocladiinae. Cornell University Experiment Station Memoir 205. New York.

Johannsen, O.A. 1937. Aquatic Diptera part IV. Chironomidae: Subfamily Chironominae. Cornell University Experiment Station Memoir 210. New York.

Kensley, B., & I. Walker. 1982. Palaemonid shrimps from the Amazon Basin, Brazil (Crustacea: Decapoda: Natantia).-- Smithsonian Contributions to Zoology 362: 1-28.

Lowe-McConnell, X. 1975. Fish communities in tropical freshwaters. Cap. 3, Equatorial forest rivers: ecological conditions and fish communities. Logman, New York. Pp 56-89.

Ludwig Jhon A., y J.F. Reynolds. 1988. Statistical Ecology: a primer on methods and computing. Jhon Wiley and Sons. New Cork, USA.

Magalhães, C and G. Pereira. 2001. Decapod Crustaceans Survey in The Middle Caura River Basin: Species Richness, Habitat, Zoogeographical Aspects, and Conservation Implications. *In:* B. Chernoff, K. Riseng, and A. Machado-Allison (eds). A Biological Assessment of the Aquatic Ecosystems of the Caura River Basin, Bolivar State, Venezuela.

Machado-Allison, A., B. Chernoff, F. Provenzano, P. Willink, A. Marcano, P. Petry and B. Sidlauskas. 2001. Inventory, relative abundance, diversity and importance of fishes in the Caura River basin. *In:* Chernoff, B., A.K. Riseng, and Machado-Allison (eds.), A Biological Assessment of the Aquatic Ecosystems of the Caura River Basin, Bolivar State, Venezeula. RAP Bulletin of Biological Assessment, No. 20??, Conservation International, Washington, D.C. Pp. XXX-XXX.

Martínez, R., y R. Royero. 1995. Contribución al conocimiento de *Diplodon (Diplodon) granosus granosus* Brugiere (Bivalvia: Hyriidae) y *Doryssa hohenackeri happleri* Vernhout (Gastropoda: Melaniidae) en el alto Siapa (Departamento de Río Negro), Estado Amazonas, Venezuela. Acta Biológica Venezuelica 16: 79-84.

McCafferty, W.P. 1981. Aquatic Entomology. Jones and Bartlett Publishers, Boston. 448p.

Milligan, M.R. 1997. Identification manual for the aquatic Oligochaeta of Florida. Volume 1. Freshwater Oligochaetes. Final Report DEP Contract Number WM550. Department of Environmental Protection. Florida State, Tallahassee.

Merrit, R.W. and K.W. Cummins. 1978. An introduction to the aquatic insects of North America. Kendall-Hunt Publishing Co., Dubuque, Iowa. 441p.

Needham, J.G., y M.J. Westfall. 1955. A manual of the Dragonflies of North America, including the Grater Antilles and provinces of Mexican border. University of California Press, Berkeley.

Pereira, G. 1985. Freshwater shrimps from Venezuela III: *Macrobrachium quelchi* De Man and *Euryrhynchus pemoni* n. sp. (Crustacea: Decapoda: Palaemonidae). Proceedings of the Biological Society of Washington, 3: 615-621.

Pereira, G. 1997 A cladistic analisis of the freshwater shrimps of the family Palaemonidae (CRUSTAEA, DECAPODA, CARIDEA). Acta Biológica Venezuélica, 17 (Suplemento) 68 pp.

Peters, W.L. 1971. A revision of the Leptophlebiidae of the West Indies (Ephemeroptera). Smithsonian Contributions to Zoology 62. Smithsonian Institution Press, Washington.

Richardson, H. 1905. Isopods of North America. Bulletin No. 54. United States National Museum, Washington. 727p.

Rodriguez, G. 1982a. Les crabes d'eau douce d'Amerique. Famille des Pseudothelphusidae. Collection Faune Tropicale, 22. Editions Office de la Recherche Scientifique et Technique Outre-mer (ORSTOM), Paris. 223 pp.

Rodriguez, G. 1982b. Fresh-water shrimps (Crustacea, Decapoda, Natantia) of the Orinoco basin and the Venezuelan Guayana. Journal of Crustacan Biology 2(3): 378-391.

Rodriguez, G. 1992. The Freshwater Crabs of America. Family Trichodactylidae and Supplement to the Family Pseudothelphusidae. Collection Faune Tropicale, 31. Editions Office de la Recherche Scientifique et Technique Outremer (ORSTOM), Paris. 189 pp.

Roldán G.P. 1996. Guia para el estudio de los macroinventebrados acuáticos del departamento de Antioquia. Impreades Presencia S.A. Colombia. Xi+217 pp

Roldán G.P. 1999. Los macroinvertebrados y su valor como indicadores de la calidad del agua. Revista de la academia colombiana de ciencias exactas, físicas y naturales. 23: 375-387.

Stehr, F.W. (Ed.). 1987. Inmature Insects. Vol. 1. Kendall-Hunt Publishing Co., Dubuque, Iowa. 754p.

Van Deer Kuyp, X. 1950. Mosquitoes of the Netherlands Antilles and their hygienic importance. Studies on the Fauna of Curacao and other Caribbean Islands, 23: 37-114.

Wallace, J.B. and W. Merrit. 1980. Filter-feeding ecology of aquatic insects. Annual Review of Entomology 25: 103-132.

Waltz, R.D. and W.P. McCafferty. 1979. Freshwater springtails (Hexapoda, Collembola) of North America. Purdue University Agricultural Experiment Station Research Bulletin 960. West Lafayette, Indiana.

Vásquez, E., Sánchez, L., L.E. Pérez and L. Blanco. 1990. Estudios hidrobiológicos y piscicultura en algunos cuerpos de agua (ríos, lagunas y embalses) en la cuenca baja del Río Orinoco. *In*: El Río Orinoco como ecosistema. Weibezahn F. H., H. Alvarez and W. Lewis (Eds.). Resultatos del Simposio: Ecosistema Orinoco: conocimiento actual y necesidades de estudios futuros. XXXVI Convención anual AsoVAC Caracas. 430p.

Wiggins, G.B. 1927. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press, Toronto. 401p.

Chapter 5

Fishes of the Coppename River, Central Suriname Nature Reserve, Suriname

Jan H. Mol, Phillip Willink, Barry Chernoff, and Michael Cooperman

ABSTRACT

The fish fauna of the Coppename River in the Central Suriname Nature Reserve was sampled at 36 sites within the 24 georeference stations of the 2004 Aquatic Rapid Assessment Program expedition. A total of 112 species were identified. Of these, four are new locality records for the country of Suriname and ten are potentially new species to science. The Coppename River has more species than most similar-sized rivers in the world, but its fish fauna is comparable to other Guayana Shield rivers and does not contain the high number of species that typify many other neotropical rivers. However, the Coppename River flows directly into the Atlantic Ocean (i.e., is not part of the Amazon or Orinoco drainages and their associated faunas), and this helps define its uniqueness. Each sub-drainage within the Coppename system has roughly the same number of species per sample and there is no indication that particular species are restricted to particular drainages. No perceptible biogeographic barriers are preventing the dispersal of fishes. Furthermore, there are no great differences in number of species per sample among habitats, although certain species are largely restricted to particular habitats. For example, rapids and creeks have their own unique environmental conditions that limit which species are found there.

A striking aspect of the Coppename fish community is the apparent shift from backwater habitats to primary river channel habitats of some species as compared to the same or closely related species in many other neotropical systems (e.g., the electric eel *Electrophorus electricus*, cichlids). A significant part of the explanation for this phenomenon is the paucity of backwater habitats in this section of the Coppename River. If fishes normally adapted to sluggish backwaters are to survive in river systems like the Coppename drainage, then they have to find a niche in the primary river channel. Also, there is an incredible abundance of large top-level predators, like anjumara (*Hoplias aimara*) exceeding a meter in length and red-eye piranha (*Serrasalmus rhombeus*) with an average size that appears to surpass just about all other localities in South America. We take this as an indication of extremely low fishing pressure, which consists mostly of upstream fishing trips during the low-water season by people from Witagron and Kaimanston and some sport fishing by tourists at Raleighvallen.

Although opportunities for conservation of the Coppename River watershed (as part of the Central Suriname Nature Reserve) are good, the potential threat of human impact is growing. Threats include bauxite and gold mining, forestry, increased tourism, and unregulated hunting and (sport)fishing. The pristine wilderness character of the Central Suriname Nature Reserve should be carefully protected, since that is what most differentiates this reserve from others and defines its highest value.

INTRODUCTION

The Neotropics has more species of freshwater fishes than any place else in the world. Although most of the attention is focused on the fishes of the giant Amazon and Orinoco Rivers, there is a series of globally unique rivers flowing directly off the Guayana Shield into the Atlantic Ocean. These rivers are not connected to the Amazon or Orinoco drainages, hence the fishes do not necessarily belong to the same species found elsewhere in South America or the world. The Coppename River, in the center of Suriname, is one of these unique rivers.

The Coppename River watershed (21,700 km^2), a major pristine, untouched forested area in central Suriname, lies for a large part in the Central Suriname Nature Reserve, a World Heritage Site. Although opportunities for conservation of the Coppename River watershed (as part of the Central Suriname Nature Reserve) are good, the potential threat of human impact is growing. Threats include bauxite mining in the Bakhuis Mountains, increased tourism, and unregulated hunting and fishing. Here we present the results of an inventory of the fish fauna of the upper Coppename River watershed, including the Rechter Coppename River, Midden Coppename River, Linker Coppename River, and Adampada Creek. We include estimates of species richness, relative abundance, and habitat distribution. We close with some remarks on potential environmental impacts on the fish fauna of the Coppename River.

BIOGEOGRAPHY

Suriname, up to 1975 known as Dutch Guiana, is a small country (163,820 km^2; population 480,000) in northwestern South America between 2-6ºN and 54-56ºW. To the east is French Guiana, to the west is Guyana, to the south is Brasil, and to the north is the Atlantic Ocean. Suriname covers about 10% of the 2.5 million km^2 Precambrium Guayana Shield, a thinly inhabited area (0.6-0.8 humans/ km^2) in northern South America covered with pristine rain forests, savannas and palm marshes. A characteristic feature of the Guayana Shield are the tepuis or sandstone table-mountains (e.g., Tafelberg Mountain in the upper Coppename basin).

Three major geographical zones can be distinguished in Suriname: the Coastal Plain, the Savanna Belt, and the Interior. Bordering the Atlantic Ocean is the Coastal Plain with Amazon-derived clays deposited in the Quarternary Period by the Guiana Current (Noordam 1993). Habitats include mangrove forests, brackish-water lagoons and river estuaries, fresh- and brackish-water swamps, agriculture lands (rice fields), and marsh forests. This is the most accessible, densely populated and disturbed area of Suriname. The fish fauna of the Coastal Plain has many brackish-water species and juveniles of marine species and a small number of freshwater-swamp fishes.

To the south of the Coastal Plain is the Savannah Belt with Pliocene sandy sediments deposited along the northern edge of the Guayana Shield by braided rivers from the Interior. It is characterized by savannas and savanna forests drained by blackwater streams (e.g., Cola Creek, Blaka-Watra Creek). The blackwater streams have many small-sized aquarium fishes (e.g., pencil fishes and tetras).

However, most Surinamese freshwater fishes live in the streams draining the *terra firme* rainforest of the Interior. The Interior is hilly and with Precambrium Shield rocks (80% of Suriname's land surface). Large rivers have a sandy bottom, but rapid complexes (Surinamese sula) with large boulders are common. Small tributary creeks have a sandy or muddy bottom substrate with large quantities of woody debris and thick beds of fallen leaves. In the Quarternary Period, floodplains, consisting of terraces (mostly less than 2 km wide), levees and backswamps, have been formed along the rivers. Going inland these fluvial deposits become less extensive and discontinuous, forming isolated patches. The water is clear (Secchi transparency up to 3 m), sometimes brown (small forest creeks) or even black in color (streams draining the sandstone Tafelberg Mountain). The streams draining the old, weathered Precambrium Guayana Shield are poor in sediment (0.001-0.1 g/l) and nutrients. Seasonal changes in water level may be large (up to 10 m) and fast (e.g., a 6-m rise in water level in 12 hours in the Mindrineti River).

Suriname's land surface is drained by seven river systems, from west to east: Corantijn River (with tributaries Kaboeri, Kabalebo, Lucie, Zuid, Coeroeni, Sipaliwini, and Oronoque), Nickerie River (with tributaries Nanni, and Maratakka), Coppename River (with tributaries Coesewijne, Tibiti, Wayombo, Adampada, Rechter Coppename, Midden Coppename, and Linker Coppename), Saramacca River (with tributaries Mindrineti, and Kleine Saramacca), Suriname River (with tributaries Para, Sara, Gran Rio and Pikien Rio, and the hydroelectric reservoir Lake Brokopondo (Lake Van Blommestein; dam completed in 1964)), Commewijne River (with tributaries Cottica, and Mapane), and Marowijne River (with tributaries Lawa, Tapanahoni, Paloemeu, Gonini, Oelemari, and Litani). The border rivers, Corantijn in the west and Marowijne in the east, together drain nearly half of the Surinamese land surface (Amatali 1993).

HISTORY OF FRESHWATER FISH COLLECTING IN SURINAME

Our knowledge of the fishes of Suriname appears to have started with popular information in a general description of Suriname compiled by Keye (1659) and many similar accounts in books and journals. Subsequently, numerous prominent ichthyologists (e.g., Gronovius and Linnaeus (Appendix 1), Houttuyn, Bloch, Schneider, Lacépède, Cuvier, Valenciennes, Heckel, Müller, Schomburgk, Troschel, Kner, Castelnau, Kaup, Günther, Steindachner, Peters, Cope, Lütken, C.H. Eigenmann, R.S. Eigenmann, Garman, Vaillant, Pellegrin, Popta, Regan, Fowler, and Ogle) added to our knowledge of Surinamese fishes, although none of these authors restricted a paper to the fishes of Suriname. Exceptions are the species lists published by Kappler (e.g., 1887) and Bleeker (1862-1876). Kappler's specimens were identified by Peters (Berlin Museum) and then went to museums in Stuttgart and London. Bleeker published eleven papers on freshwater fishes collected by the Paramaribo apothecary Dieperink (most of his specimens were obtained from the Suriname River, probably collected in the neighborhood of Paramaribo) (Appendix 5). One of the first compilations of our knowledge of the freshwater fish fauna of Suriname was written by Eigenmann (1912) in a book dealing mainly with the freshwater fishes of (British) Guyana. While Eigenmann reported more than 340 fish species for Guyana, only 112 are given for Suriname (the difference in numbers can be partially attributed to the efforts of Eigenmann, who described more than 130 new Guyana species and recorded numerous others for the first time from the region). Although, Eigenmann made several errors when compiling his lists, omitting species for which Surinamese records are given in his descriptive text and including several brackish-water species, the correct number of Surinamese freshwater fishes known at the time may be estimated at approximately 110.

Most of the previously mentioned authors give only "Suriname" as collection locality and it is evident that almost all the specimens reported upon must have been collected in the easily accessible Coastal Plain. The collecting of natural history objects from the Interior, although on a small scale, started during a series of expeditions between 1900 and 1930 (e.g., Coppename Expedition 1901, Saramacca Expedition 1902-1903, Gonini Expedition 1903-1904, and Corantijn Expedition 1910-1911; see Holthuis 1959, Appendix F.2). However, the number of fishes collected was limited. Specimens from these expeditions to the Interior and extensive collections by D.C. Geijskes (Appendix 5), enabled Boeseman (1952) to add 84 species to Eigenmann's list, making up a total of about 200 freshwater fishes known to occur in Suriname before the start of ichthyological research related to the Brokopondo project.

In the period 1960-present, the Lake Brokopondo (Westermann 1971) and West Suriname (Geijskes 1973, Vari 1982) projects boosted ichthyological explorations in the Interior of Suriname and resulted in large collections of Surinamese freshwater fishes in the museums of Leiden (Naturalis, formerly Rijksmuseum van Natuurlijke Historie, RMNH) and Amsterdam (Zoölogisch Museum Universiteit van Amsterdam, ZMA). With the border river collections by R.P. Vari (Corantijn River, 1979-1980; Vari 1982) and P. Planquette et al. (Marowijne River, 1978-1995; Planquette et al. 1996, Keith et al. 2000, Le Bail et al. 2000), abundant material is now available for the study of Surinamese freshwater fishes (Appendix 5). Principal works based on these collections include Nijssen (1970) on *Corydoras*, Boeseman (1968, 1971) on Loricariidae, Géry (1972) on Serrasalmidae, Mees (1974) on Pimelodidae and Auchenipteridae, Kullander and Nijssen (1989) on Cichlidae, and the Freshwater Fish Fauna of French Guiana (including the Marowijne River) by Planquette et al. (Planquette et al. 1996, Keith et al. 2000, Le Bail et al. 2000). Ouboter and Mol (1993) listed 318 freshwater fish species known to occur in Suriname and this number has recently increased dramatically to approximately 450 (J.H. Mol and P.E. Ouboter, unpublished results) mainly due to the inventory of the Marowijne River fish fauna by Planquette et al. (Planquette et al. 1996, Keith et al. 2000, Le Bail et al. 2000). However, new species are still discovered (e.g., Vari et al. 2003).

Fishes of the Coppename River were collected by H.A. Boon (1901), D.C. Geijskes (1943-1944), H. Nijssen (1967), and G.F. Mees (1972) (Appendix 5). Boon traveled by boat to the confluence of the Linker and Rechter Coppename River (with stops at Raleighvallen, Langadansula, Sidonkrutu and Tonckens falls) and then up the Linker Coppename to about 4°10' N. Geijskes collected in small streams draining Tafelberg Mountain, Rechter Coppename River at Cremer Falls, Coppename River (Krutu Mountain Creek, Langa Sula, Tonckens Fall), and the Coppename River estuary. Nijssen collected in Linker Coppename River (3º51'N, 56º45'W; 3º54'N, 56º46'W; 3º54'N, 56º46'W) and Coppename River (3º48'N, 56º57'W; 3º49'N, 56º57'W; 3º52'N, 56º55'W; 3º52'30"N, 56º53'W). Mees collected at Raleighvallen. At least six species have been described from specimens collected in the Coppename River: *Centromochlus concolor* (Mees 1974), *Corydoras coppenamensis* Nijssen 1970, *Corydoras heteromorphus* Nijssen 1970, *Corydoras surinamensis* Nijssen 1970, *Hypostomus coppenamensis* Boeseman 1969, and *Parotocinclus britskii* Boeseman 1974.

METHODS

Fishes were collected at all 24 georeference stations (see Map and Gazetteer). If significantly different habitats were found within a given georeference site, then each habitat was sampled independently and the fishes were kept separate to facilitate later ecological analysis. The result was 36 different fish samples.

Fishes were collected primarily with 5 meter by 1.2 meter seines (1 centimeter mesh), 38 meter by 2.4 meter experimental gillnets (five panels each 7.6 meters long, each panel with a different mesh size: 2.54, 3.81, 5.08, 6.35, and 7.62 centimeters), as well as hook and line. Several fishes were donated by the macroinvertebrate/crustacean group, who were using dipnets and minnow traps. The seines worked well for small to medium size fish, gill nets for medium to large fish, hook and line for large fish, and dip nets for small fish. Because of our methods, we probably undersampled the very small fishes. We probably also undersampled some of the larger fishes, but fishermen are familiar with the larger fishes, so we can get a good idea of what is present.

When a particular area was chosen we sampled all available habitat types observed (e.g., riffles, pools, rapids, backwaters, undercut banks, secondary channels, root masses, accumulations of tree trunks, leaf packs, etc.). In quiet backwaters and rivers or creeks with moderate current, the seine was pulled. In rapids with strong current, the seine was set and held in place while people upstream kicked the woody debris, vegetation beds, and rocks. Gill nets were set, left alone, then retrieved a couple of hours later. It was unwise to leave the gill nets longer than this because piranhas would eat the trapped fishes, destroying both the specimens and nets. We sampled in daylight only.

Specimens were initially fixed in 4% formaldehyde, then later transferred to 70% ethanol for long term storage at the National Zoological Collection of Suriname (NZCS) in Anton de Kom University of Suriname, Paramaribo, Suriname and The Field Museum (FMNH), Chicago, USA. Identifications were made to the lowest taxonomic level possible. Usually this meant to species, but some juveniles and damaged specimens could only be identified to genus or family. Publications used to identify the fishes included regional contributions like 'The Freshwater Fishes of British Guiana' (Eigenmann 1912) and 'Atlas des Poissons d'Eau Douce de Guyane' (Planquette et al. 1996, Keith et al. 2000, Le Bail et al. 2000), general taxonomic treatises like 'Characoids of the World' (Géry 1977) and 'Systematics of the Neotropical Characiform Genus *Cyphocharax* Fowler (Pisces: Ostariophysi)' (Vari 1992), and taxonomic surveys specific to Suriname like 'The Cichlids of Surinam' (Kullander and Nijssen 1989), 'The 'comb-toothed' Loricariinae of Surinam' (Boeseman 1971), 'Revision of the Surinam catfishes of the genus *Corydoras* Lacépède, 1803' (Nijssen 1970), and many others.

RESULTS

We collected 5686 specimens in 112 species (Appendix 6; please note that 117 taxa are listed in the appendix, but 5 taxa are not included in the tally because they are juveniles or damaged specimens of species probably listed elsewhere in the appendix). These species can be divided into seven orders and 26 families. The largest order is Characiformes (64 species, 57% of the total), followed by Siluriformes (29 species, 27%), Gymnotiformes and Perciformes (each with 8 species, 7%), and finally Rajiformes, Cyprinodontiformes, and Synbranchiformes (each with 1 species, <1%). The largest family is Characidae (32 species, 28%), followed by Loricariidae (17 species, 14%), Anostomidae and Cichlidae (each with 7 species, 6%), and then the others. Of the 112 species, four (4%) are new locality records for the country of Suriname and ten (9%) are potentially new species to science (Table 5.1). All specimens collected were in good condition (e.g., good color, low parasite load, etc.). Appendix 4 provides taxonomic information on several select species.

It is difficult to estimate how many species occur in this section of the Coppename watershed. The species accumulation curve is continuing to rise at a rate of 2 species per day, but it appears to be reaching an asymptote (Figure 5.1). We are aware of at least seven species that are known from the Coppename River, but not collected during the present AquaRAP: *Helogenes marmoratus*, *Rivulus holmiae*, and *Rivulus waimacui* (Boeseman 1952); *Microglanis secundus* and *Centromochlus concolor* (Mees 1974); *Aequidens tetramerus* and *Crenicichla saxatilis* (Kullander and Nijssen 1989). At least 25 additional taxa have been reported from both rivers to the east and the west, so it is likely that they also occur in the Coppename River. Continued sampling and a change in sampling method/gear would add species to the total. We estimate at least 150 species in the region, if you sample all year round and include seasonal migrants.

All the drainages have roughly the same number of species per sample (6.66 – 9.28; Table 5.2), with the exception of the Midden Coppename River that has 15 species per sample. The higher number of species per sample of the Midden Coppename River is probably an artifact of the low number of samples (n=3) in this drainage.

Many taxa are found in all the sub-basins (Appendix 6). There is no real indication that any taxa are endemic to a particular drainage. Some species may appear to be restricted to a particular sub-basin, but additional sampling would likely indicate that they are more widespread. For example, we collected only one specimen of electric eel, *Electrophorus electricus*, and that was in the Rechter Coppename. However, we saw them just about everywhere, but did not make any special effort to capture these difficult to handle and preserve fishes.

We distinguished six habitat types in the upper Coppename River basin. The most common habitat is the main-channel habitat. Rapids and creeks are relatively common. Rocky-shores and backwaters are less common. Sand beaches are rare. The creek, rapid, backwater, and main-

Table 5.1. Lists of fish species that are new locality records for the country of Suriname or are potentially new species to science.

New Locality Records for Suriname	Potentially New Species
Ctenoluciidae sp.	*Eigenmannia* sp. 1
Hyphessobrycon copelandi	*Eigenmannia* sp. 2
Moenkhausia browni	*Hemiodus* cf. *quadrimaculatus*
? Pseudancistrus depressus	*Hyphessobrycon* cf. *minimus*
	Knodus sp. 1
	Leporinus cf. *cylindriformis*
	Melanocharacidium cf. *melanopteron*
	Peckoltia sp. 1
	Phenacogaster sp. 1
	Phenacogaster sp. 2

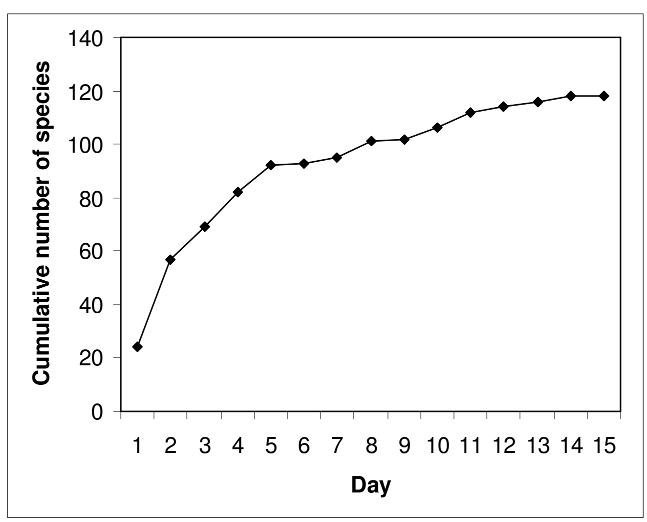


Figure 5.1. Species accumulation curve for fishes collected during the 2004 AquaRAP expedition to the Coppename River, Suriname.

channel habitats have roughly the same number of species per sample (6-8; Table 5.3). The sand beach and rocky-shore habitats have a higher number of species per sample (24.5 and 11.34 respectively), but this is probably an artifact of the low number of samples in both habitats (n=2 and 3 respectively). However, the sand beach habitat has a higher number of species than other habitats (rocky-shore, main-channel, and backwater) that were sampled more frequently. This is interesting because sand beaches are very rare.

Although there are no great differences in number of species among habitats, certain species are largely restricted to particular habitats. For example, *Brachychalcinus orbicularis, Jupiaba meunieri, Jupiaba pinnata, Harttia surinamensis*, and *Lithoxus surinamensis* are common in rapids. *Hyphessobrycon rosaceus, Cyphocharax helleri, Erythrinus erythrinus, Hoplerythrinus unitaeniatus, Callichthys callichthys, Megalechis thoracata,* knifefishes*, Rivulus lungi*, and *Nannacara anomala* appear to be largely restricted to creeks. *Parotocinclus britskii* was only collected at a sand beach. No species appear to be restricted to backwaters, rocky shores, or main channel. Some species are abundant in all six habitat classes. Examples of these widespread species include *Bryconops melanurus, Moenkhausia lepidura, Moenkhausia oligolepis*, and *Guianacara owroewefi*.

Abundances of individuals of most taxa were high. The only habitat that consistently produced low abundances of individuals was creeks with relatively low dissolved oxygen concentrations.

Table 5.2. Number of species, number of samples, and number of species/sample in five drainages of the Coppename River, Central Suriname Nature Reserve.

Drainage	Number of species	Number of samples	Species/ sample
Rechter Coppename	80	12	6.66
Linker Coppename	65	7	9.28
Midden Coppename	45	3	15
Coppename	73	8	9.12
Adampada	47	6	7.84

Table 5.3. Number of species, number of samples, and number of species/sample in six habitats of the Coppename River, Central Suriname Nature Reserve.

Habitat category	Number of species	Number of samples	Species/ sample
Creek	74	11	6.73
Rapid	62	8	7.75
Backwater	48	6	8
Sand beach	49	2	24.5
Rocky shore	34	3	11.34
Main channel	36	6	6

DISCUSSION

We can compare the results of our inventory of the fish fauna of the upper Coppename River with fish faunas of other rivers in Suriname, French Guiana, and Guyana. Data are available for the Corantijn River (Vari 1982), Saramacca River (J.H. Mol and P.E. Ouboter, unpublished results), Suriname River (J.H. Mol, unpublished inventory of the 1963-1964 collection of M. Boeseman in the Naturalis Museum, Leiden), Marowijne River (Planquette et al. 1996, Keith et al. 2000, Le Bail et al. 2000) and its tributary Oelemari River (Ouboter et al. 1999), Sinnamary River (Tito de Morais et al. 1995), Approuage River (Boujard et al. 1997) and its tributary Arataye River (Boujard et al. 1990a,b), and Essequibo/Potaro River (Hardman et al. 2002) (Table 5.4). When taking into account catchment area and sampling effort the number of species we collected in the upper Coppename River (112) compares well with data on the fish faunas of other eastern Guayana Shield rivers (Table 5.4). The Suriname River upstream of the first rapids had 175 species, but its catchment is larger than the catchment of the Coppename River and sampling effort was more extensive and more effective (because rotenone was used) than in the present study. The Saramacca River had 146 species, probably due to the relative large sampling effort in the period 1994-2001 and the fact that samples from the tributary Mindrineti also included several species characteristic of Costal Plain streams (these species are not present in our Coppename collection).

The border rivers, Corantijn (192 species) and Marowijne (225 species), have a much larger catchment than the Coppename River and this also holds for the Essequibo River. In addition, the Essequibo has many Amazonian species that are not found in Surinamese rivers (e.g., *Arapaima gigas*, *Osteoglossum bicirrhosum*) because of its connection with the Rio Branco through the flooded savannas in the Rupununi Area (Mol 2002). The Approuage River in French Guiana (158 species) has a relatively high number of species because Coastal Plain species from the swamp Marais de Kaw are included in the list. The Sinnamary River has slightly less species than the Coppename River, but it has a smaller catchment. The proportional composition of the Coppename River fish fauna (Characiformes, Gymnotiformes, Siluriformes, Perciformes and a group of miscellaneous families) compares well with other Guayana Shield rivers flowing directly into the Atlantic Ocean (Table 5.4). The characoids make up about half of the species, followed by the catfishes (25-40%), the cichlids and knifefishes (both about 5-10%) and finally the smaller remaining groups.

Data are also available for rivers on the northern and western sides of the Guayana Shield. Comparable rivers in Venezuela have 120-169 recorded species (see references and Table 6.1 in Machado-Allison et al. 2003), but also tend to have slightly larger drainages. A better example would be the 103 species collected during an AquaRAP expedition on the Caura River above the first waterfall (Machado-Allison et al. 2003), an area that is geographically similar to the Coppename River with its 112 species.

In regards to similarly sized rivers not found on the Guayana Shield, the Coppename River is richer than most in the world (see Balon and Stewart 1983 and references therein). The only likely exceptions would be rivers associated with much larger watersheds, such as those found close to the main stem of the Congo, Mekong, Mississippi, Orinoco, Paraguay-Parana, or Amazon. During other AquaRAP surveys, Machado-Allison et al. (2003) collected 226 species in the section of the Caura River adjacent to the Orinoco River and downstream from the first waterfall, and Willink et al. (2000) collected 193 species from the southern Pantanal in the Paraguay-Parana drainage. It is possible that the area with the highest richness of freshwater fishes in the world is the region encompassing the arc of the Amazon drainage along the base of the Andes Mountains. AquaRAP expeditions to the Orthon River in Bolivia (Chernoff et al. 1999) and Pastaza River in Ecuador and Perú (Willink et al. 2005) collected 313 and 315 species respectively, and their species accumulation curves were not close to leveling off. Although the Coppename River is richer than most rivers in the world, it is similar to other Guayana Shield rivers, but does not contain the high number of species that typify many other neotropical rivers.

It is difficult to comment upon endemism of fishes in South America because our understanding of fish taxonomy and distributions is so incomplete. Three taxa are currently considered to be endemic to the Coppename River, and several more have only been reported from adjacent drainages (Table 5.5). We have no reason to believe that the fish fauna of the Coppename River is unique in and of itself. However, many of the rivers in Suriname and French Guiana flow directly into the Atlantic Ocean. They are not connected to the Amazon or Orinoco, hence do not share many of the same species of fishes. Therefore, there is a high degree of endemism in this region (Vari 1988, Kullander and Nijssen 1989), of which the Coppename River is a part. The entire Guayana Shield (which includes sections of Venezuela, Brasil, Guyana, Suriname, and French Guiana) is believed to have 2200 freshwater fishes, of which an estimated 30% are endemic (Huber and Foster 2003).

There is no clear indication that particular species are restricted to particular drainages within the Coppename River study area. This should not be a surprise since there are no perceptible biogeographic barriers preventing the dispersal of fishes throughout the region. There are some moderate waterfalls/rapids (5 meters high), but fishes can probably bypass these during the rainy season when water levels rise.

This is not to say that all species are evenly distributed throughout the Coppename River drainage. Rapids and creeks have their own unique environmental conditions that limit the number of species found there. The torrential current in the rapids eliminates most species from this habitat. Only dorso-ventrally flattened species (e.g., *Harttia surinamensis* and *Lithoxus surinamensis*) or others that are able to negotiate the crevasses and gaps amidst the rocks and aquatic vegetation (e.g., *Brachychalcinus orbicularis, Jupiaba meunieri*, and *Jupiaba pinnata*) are able to avoid being washed downstream.

Root masses, fallen trees and branches are more common in creeks. This creates a habitat with many small hiding places, which knifefishes, *Hyphessobrycon rosaceus,* and *Nannacara anomala* seem to prefer. Some creeks have low oxygen concentrations, at least seasonally. This eliminates many fishes from this habitat. Only species that have the ability to utilize atmospheric oxygen, such as *Erythrinus erythrinus, Hoplerythrinus unitaeniatus, Callichthys callichthys, Megalechis thoracata,* and *Rivulus lungi*, are able to survive (Graham 1997).

A striking aspect of the Coppename fish community is the apparent shift in habitat utilization of some species as compared to the same or closely related species in many other neotropical systems. For example, the electric eel (*Electrophorus electricus*) is distributed throughout the Amazon and Orinoco drainages, where it usually inhabits sluggish backwaters or pools with no current (Mago-Leccia 1994, Barthem and Goulding 1997). However, the electric eels in the Coppename are extremely abundant and found in the primary river channel. They particularly seem to like pools at the foot of rapids, but were observed swimming about in the open river channel over rubble and boulders. In the Coppename River, cichlids, which typically prefer waters with little to no current, are also abundant in faster moving waters. Deep-bodied characids, like *Brachychalcinus orbicularis, Jupiaba meunieri*, and *Jupiaba pinnata*, can be found in rapids, although they are usually taking refuge among aquatic plants.

A significant part of the explanation for this phenomenon is the paucity of backwater habitats in this section of the Coppename River. The primary river channel and associated habitats (e.g., rapids, rocky shore, sand beach, etc.) occupy the vast majority of the area. There are sluggish habitats in creeks, but they are not common and very seasonal. If fishes normally adapted to sluggish backwaters are to survive in river systems like the Coppename drainage, then they have to find a niche in the primary river channel. So what we are seeing in the Coppename River is either a niche shift within a species or these are different species with different ecologies when compared to closely related fishes in other neotropical river systems. Furthermore, we are not suggesting that the Coppename River is unique in this regard. Adjacent rivers flowing off the Guayana Shield in Suriname and probably French Guiana, Guyana, Brasil, Venezuela, and elsewhere in South America possibly exhibit the same phenomenon. More work needs to be done to better document this apparent shift in habitat utilization from slower-water habitats to faster-water habitats.

Another fascinating aspect of the community ecology is the incredible abundance of large top-level predators. Anjumara (*Hoplias aimara*) exceeding a meter in length are common. They can be found in the mouths of almost every stream. Red-eye piranha (*Serrasalmus rhombeus*) are also abundant, with an average size that appears to surpass just

Table 5.4. Comparison of fish faunas of rivers draining the Guayana Shield in Suriname, French Guiana and Guyana. The Oelemari River is a tributary of the Marowijne River. The Arataye River is a tributary of the Approuage River.

Drainage	Catchment	Number of fresh- water fish species	Characiformes		Gymnotiformes		Siluriformes		Perciformes		Misc. Groups		Reference
		(km²)	n	%	n	%	n	%	n	%	n	%	
Suriname													
Coppename	21,700 (14,200)[1]	112 [2]	64	57.1	8	7.1	29	25.1	8	7.1	3	2.7	present study
Corantijn	67,600 (60,840)[1]	192 [2]	85	44.3	13	6.8	74	38.5	16	8.3	4	2.1	Vari (1982)
Saramacca	9,000 (6,670)[1]	146 [2]	74	50.7	10	6.8	40	27.4	14	9.6	8	5.5	Mol and Ouboter, unpublished
Suriname	16,500 (12,400)[1]	175 [2]	83	47.4	11	6.3	53	30.3	15	8.6	13	7.4	Mol, unpublished
Marowijne	68,700	225	111	49.3	12	5.3	76	33.8	17	7.6	9	4.0	Keith, Le Bail & Planquette
Oelemari	?	103	65	63.1	3	2.9	25	24.3	7	6.8	3	2.9	Ouboter et al. (1999)
French Guiana													
Sinnamary	6,560	92 [2]	53	57.6	5	5.4	24	26.1	8	8.7	2	2.2	Tito de Morais et al. (1995)
Approuage	10,850	158	65	41.1	12	7.6	52	32.3	15	9.5	15	9.5	Boujard et al. (1997)
Arataye	1,850	101	52	51.1	7	6.9	31	30.7	7	6.9	4	4.0	Boujard et al. (1990a,b)
Guyana													
Essequibo/Potaro	?	288	147	51.0	23	8.0	79	27.4	23	8.0	16	5.6	Hardman et al. (2002)

1) part of catchment situated on the Guayana Shield (i.e., upstream of the first rapids in the Interior)
2) include only species caught upstream of the first rapids (on the Guayana Shield; excluding species from black-water streams draining the Savanna Belt)

about all other localities in South America. One specimen at The Field Museum is 435 millimeters (17 inches) in standard length and weighs 2.24 kilograms (4.94 pounds). These measurements were taken several months after the specimen had been placed in ethanol, which is known to cause significant shrinkage of tissues. Immediately after capture, this piranha would have weighed significantly more. Prior to this expedition, the largest piranhas reported from Suriname included a 385 millimeter standard length individual from Lake Brokopondo (Géry 1972) and a 313 millimeter standard length, 1.2 kilogram individual from Lake Brokopondo (J.H. Mol, personal observation).

The explanation for the large fishes is simple: almost complete absence of fishing pressure. Once people start fishing an area, the largest individuals are the first to disappear (Goulding 1981). Continued fishing pressure ensures that no other individuals will reach large sizes. They are caught and eaten before they have a chance to grow. Eventually a species will begin to mature at smaller sizes and will not grow as large, since larger and slower-maturing individuals in the population are selected against by the fishermen (Sutherland 1990, Lee and Safina 1995). The incredible abundance of large top-level predators is a sign of the pristineness of the watershed, making it truly unique on the planet. But, this is also an extremely fragile situation. Even moderate fishing pressure will upset the current dynamics of the aquatic ecosystem.

Streams in the upper Coppename watershed typically have a sandy or rocky bottom and oxygen-rich, very clear water (Secchi transparency up to 2 m; Ouboter and Landburg 2006) and the fishes are adapted to these environmental conditions. Mining, which basically is artificial erosion at a very high rate, releases fine sediments into the streams, increasing the turbidity (siltation) and depositing a layer of fine sediments (mud) on the streambed and associated structures (woody debris, leaf litter), thus altering the instream habitat of the fishes. Forestry also leads to increased surface erosion. Mol and Ouboter (2004) showed that a Surinamese rainforest stream affected by mining-related erosion had low fish species diversity, low proportion of young fishes, high proportion of midchannel surface-feeding fishes (e.g., hatchet fish *Gasteropelecus*) and fishes adapted to low light (e.g., gymnotoids and some catfishes), low proportion of visually-oriented fishes (e.g., cichlids) and fishes that hide in leaf litter and woody debris, and low biomass of food fishes. Many of the fish species of the Central Suriname Nature Reserve are benthic scrappers/pickers commonly found over rocks and clean sandy bottoms in clear water. These species would be particularly sensitive to the negative impacts of increased sediment loads. Podostemaceae beds in rapids and their associated fish species (and aquatic invertebrates) are also vulnerable to sedimentation (Odinetz Collart et al. 1996).

Table 5.5. Species currently considered endemic to the Coppename River or with restricted distributions.

Endemic	Restricted distribution
Corydoras coppenamensis	*Crenicichla coppenamensis* (Coppename and Saramacca rivers)
Corydoras surinamensis	*Corydoras heteromorphus* (Coppename, Marowijne and Nickerie rivers)
Hypostomus coppenamensis	*Corydoras guianensis* (Nickerie, Coppename and Saramacca rivers)
	? *Hypostomus saramaccensis*
	? *Pyrrhulina stoli*

Many neotropical rivers, particularly those flowing off the Guayana Shield, have low nutrient levels (Lowe-McConnell 1987, Haripersad-Makhanlal and Ouboter 1993, Riseng and Sparks 2003 and references therein). The Coppename River is no exception (Ouboter and Landburg 2006). This means that nutrients and primary production (i.e., food) can be difficult to find, and fishes need to be able to acquire food from a variety of sources. A source of fish food that is often overlooked by people is the terrestrial environment. Terrestrial insects, leaves, fruits, etc. falling into a river are an extremely important component of neotropical aquatic food webs (Knöppel 1970, Saul 1975, Castro and Casatti 1997). The pakusi (*Myleus* spp.) and the dominance of fruit in their diet is an excellent example of this in the Coppename River. *Brycon*, *Gasteropelecus*, and many others also rely heavily on terrestrial food sources. Riparian vegetation not only prevents erosion by holding the soil in place, but is also a critical food source for aquatic ecosystems.

Many neotropical aquatic communities are dominated by seasonal flooding. Feeding, migrations, and spawning are often timed according to the water level (Roberts 1972, Goulding 1980, Lowe-McConnell 1987). The situation in the Central Suriname Nature Reserve does not appear to be as extreme as in other areas. The Coppename River typically posses high, steep banks that confine the waters within narrow channels. River levels may rise 5 meters or so, but the lateral extent of seasonal flooding is only a few hundred meters, as opposed to kilometers in lowland Amazonia. Yet, the AquaRAP expedition took place just before the rainy season and rising water levels, and many of the fishes we collected were full of eggs or milt (e.g., *Serrasalmus rhombeus*, *Chalceus macrolepidotus, Electrophorus electricus*). These individuals were getting ready to spawn with the rising waters. As river levels rise, water floods into the adjacent forests, and hence additional nutrients from the terrestrial ecosystem become available to the fishes. This means additional food for the young that will help ensure their survival during the critical first few weeks of their lives. Adults will also feed heavily in flooded forests (Goulding 1980, Lowe-McConnell 1987). Any modifications to the hydrological regime of the river, such as dams or water diversions, would have a severe negative impact on the life-history of the fishes.

FISHERIES

Fishing in the upper Coppename River mostly consists of upstream fishing trips during the low-water season by Maroons of the Kwinti villages Witagron and Kaimanston and some sport fishing by tourists at Raleighvallen. Almost all commercial fishing in Suriname is in (1) the Atlantic Ocean (industrial shrimp trawlers and line fishing for snappers), (2) estuaries and shallow coastal waters (stake-nets, drift nets, long lines, and njawari (method in which nets are set parallel to shore in shallow coastal waters at high tide and then collect fishes when the water recedes during low tide) for catfish and sciaenids), (3) brackish lagoons (tilapia, snook, mullet), (4) downstream sections of large rivers (haritité or purse seine fishery for kubi *Plagioscion* spp.), and (5), seasonally, freshwater swamps (e.g., kwikwi *Hoplosternum littorale*). Fishermen villages are located in the estuaries of the large rivers, like Boskamp in the Coppename River estuary. Fisheries in the upstream sections of Surinamese rivers are mostly subsistence or artisanal and very light because of a lack of demand for the fishes of the Interior in the market centers where coast and estuarine fishes are abundant and well-accepted. For example, 40 years after its formation there is still no commercial fishing in the Lake Brokopondo reservoir. Although fish is traditionally the most important source of animal protein for the Amerindians and Maroons living in the Interior, there exists little information on fisheries in the Interior. Inland fisheries are not monitored by the Fisheries Department of the Ministry of Agriculture.

Subsistence and artisanal fishery in the upper Coppename River by Kwinti Maroons is not a special profession, but rather a part-time activity of vital interest. Most men have participated in it since early childhood and the Kwintis therefore have a profound knowledge of the behavior of fish and where and how to catch them during the different seasons. The Kwintis use both traditional methods like hook-and-line, bow-and-arrow, fish traps (Surinamese baskita or maswa), and fish poisons (Surinamese neku, toxic substance is rotenone from the liana *Lonchocarpus* spp. and kunami *Clibadium* spp.), and modern gill nets. Target food fishes are anjumara (*Hoplias aimara*), patakka (*Hoplias malabaricus*), tukunari (*Cichla ocellaris*), kubi (*Plagioscion* spp.), piren (*Serrasalmus rhombeus* and *S. eigenmanni*), paku/pakusi (*Myleus rubripinnis* and *M. ternetzi*), kumaru (*Myleus rhomboidalis*), moroko (*Brycon falcatus*), sardine (*Triportheus rotundatus*), kwimata (*Prochilodus rubrotaeniatus*), waraku (*Leporinus* spp.), prake or stroomfisi (*Electrophorus electricus*), spikrikati (*Pseudoplatystoma* spp.), plarplari (*Ageneiosus* spp.), kwikwi (*Megalechis thoracata* and *Callichthys callichthys*), krobia (Cichlidae spp.), and other species. Fruits of riparian trees are used as bait to catch fruit-eating *Myleus* species, thus showing that the flooded (riparian) forest is an important food source for these fishes. The majority of the catch is consumed fresh, but considerable quantities are also salted, dried, and smoked for preservation. Some are transported to Paramaribo. The main target species for sport fishing with hook-and-line are anjumara and tukunari.

Uncontrolled use of gill nets can have a strong impact on fish populations and has already resulted in overfishing in some areas in the Amazon. We do not expect a long-term increase of yield of utilized fish species because of further introductions of modern equipment. Experiments with electrofishing had little success in the electrolyte-poor waters of the Interior (A.L. Sheldon, P.E. Ouboter, and J.H. Mol, personal observations) and trawls have only limited success because of the many snags and rocks in the rivers. Fishing pressure is still light in the upper Coppename River as shown by the large specimens of important food fishes (anjumara, piranha, pakusi, tukunari) that were caught during the present study (AquaRAP). Anecdotally, we note that in this region there would seem to be higher fishing pressure downstream than upstream. We say this because within a species we saw smaller fishes in the downstream portion than in the upstream subregions. Fewer fishes than expected were collected near the rapids of Sidonkroetroe Soela. We are unsure if this was due to higher fishing pressure than at other sample locations or other factors, like habitat structure. There is a lack of information on fishing localities, fishing effort, yield, potential sustainable yield, biology, ecology, and distribution of the most valuable food fishes. For example, information on timing and extent of migrations of food fishes (e.g., *Prochilodus*, *Leporinus*, catfishes) in the Coppename River is critical for fisheries management. As a consequence of the lack of information and the lack of administrative and political interest there exists no plan for long-term development of inland fisheries in Suriname. When developing protective legislation it should be taken into account that governmental fishery control will be difficult given the vastness of the area of concern (Interior, upper Coppename River basin). However, it should be feasible to establish a Fisheries Department control/inspection post at Raleighvallen.

Amazonian ornamental fish species (e.g., cardinal tetra, neon tetra, angelfish, discus) are famous and popular with fish hobbyists all over the world because of their great diversity, brilliant colors, strange morphology, and interesting behavior (Junk 1984). Collection and exportation of ornamental (aquarium) fish could be a small, but important trade for the Kwintis of Witagron and Kaimanston (as it is for people in the Rio Negro area of Amazonia) because the Kwintis live in a remote area with little opportunity to earn money in other ways. Information about the catch and export of ornamental fishes in Suriname is scarce. Fisheries for ornamental fishes in Suriname started in the late 1960s, mainly in blackwater streams in the Zanderij area near the Johan Adolf Pengel airport. Ornamental fishes were also imported from Brasil and in 1980 Suriname was one of the six principal countries for export of Brasilian ornamental fishes (Junk 1984). Some of the imported Amazonian species have been released and subsequently established healthy populations in streams near Johan Adolf Pengel airport (e.g., cardinal tetra, angelfish, the pencil fish *Nannostomus harrisoni*, and possibly the cichlid *Mesonauta festivus*).

Ornamental fishes that were exported from Suriname to the USA (Miami), Germany and the Netherlands in the period 1970-1990 include: silver hatchetfish (*Gasteropelecus sternicla*), marble hatchetfish (*Carnegiella strigata*), head-and-tail tetra (*Hemigrammus ocellifer*), splashing tetras (*Copella* spp. and *Pyrrhulina* spp.), pristella tetra (*Pristella maxillaris*), sailfin tetra (*Crenuchus spilurus*), woodcat or noja (*Trachelyopterus galeatus*), pencil fish (*Nannostomus* spp), headstander (*Anostomus anostomus*), leaf fish (*Polycentrus schomburgkii*), dogfish (*Acestrorhynchus* spp.), *Charax* sp., cichlids (e.g., *Apistogramma* spp., *Cichlasoma bimaculatum*, *Cleithracara maronii*, *Crenicichla* spp., *Mesonauta festivus*, *Nannacara anomala*), knifefishes (e.g., *Apterontus albifrons*, *Eigenmannia* spp., *Brachyhypopomus* spp.), spiny catfish or merki kwi (*Acanthodoras cataphractus*), *Corydoras* spp., banjo catfish (*Bunocephalus coracoideus*), and introduced species like angel fish (*Pterophyllum* spp.) and cardinal tetra (*Paracheirodon axelrodi*). In 1989, Surinamese ornamental fishes shipped by two exporters, Kersenhout (to USA) and Henzen (to the Netherlands), had a value of 35,000 US$. The upper Coppename River has many fishes that could be of interest to ornamental fish hobbyists. Examples include silver hatchetfish *Gasteropelecus sternicla*, headstander *Anostomus anostomus*, four *Corydoras* species, a new *Peckoltia* species and other loricariid catfishes, cichlids, and tetras.

ENVIRONMENTAL ISSUES AND CONSERVATION RECOMMENDATIONS

Although 95% of the population of Suriname lives in the Coastal Plain and access to the Interior is restricted to small dugout boats (Surinamese korjaal) and small airplanes, mining for bauxite and gold has caused major environmental problems in the terra firme rainforest of Suriname. The completion of a dam in the Suriname River at Afobakka in 1964 (to fuel aluminum smelters of Suralco/Alcoa) resulted in the formation of the hydroelectric reservoir Lake Brokopondo and the loss of (1) 1560 km^2 tropical rainforest (Westermann 1971) and (2) over 100 fish species (Mol et al. unpublished results; comparison of 2002-2004 catches in Lake Brokopondo with fishes of the Suriname River in the 1963-1964 collection of M. Boeseman in the Naturalis Museum, Leiden). In the 1990s, small-scale gold mining caused widespread destruction of forest (Peterson and Heemskerk 2001), mercury pollution (Mol et al. 2001), and siltation and sedimentation of streams (Mol and Ouboter 2004). A large gold-mining operation in the Gros Rosebel area (in production since February 2004) and planned bauxite mining in the Bakhuis Mountains are expected to cause major environmental disturbances in the future.

The Central Suriname Nature Reserve, a World Heritage Site since 2000, is a key component of a larger, international protection plan for the Guayana Shield (Huber and Foster 2003). Our fish survey shows that the Central Suriname Nature Reserve upriver from Raleighvallen is one of the most intact and pristine watersheds on Earth. The effects of human impact are extremely low. In many years of collective experience across the Neotropics, we never worked in an area where, during one month of extensive traveling by boat, we did not meet other human beings. We also drank the water from the river without ill effects. The fishes were in excellent condition. Predators such as anjumara (*Hoplias aimara*) and red-eye piranha (*Serrasalmus rhombeus*) were abundant and of very large size. Colors of ornamental fishes were brilliant. Almost no parasites or infections were found on the fishes. Fish species richness was comparable to other lowland rivers of the Guayana Shield. We encountered no exotic or invasive fish species in the Central Suriname Nature Reserve.

The current abundance of fishes and excellent condition of the fish fauna in the Central Suriname Nature Reserve and the Coppename River downstream of Raleighvallen is dependent upon the preservation of the healthy and pristine condition of the Coppename watershed. We believe that the buffer zone currently delineated in the Central Suriname Nature Reserve management plan does not provide adequate protection (e.g., the upper catchment of Adampada Creek is not included in the Central Suriname Nature Reserve, exposing this stream with exceptionally clear water to sediments from future mining in the Bakhuis Mountains) and we recommend an extension of the Central Suriname Nature Reserve to include the entire Coppename watershed. Because stream fish are usually not widely distributed and most species are rare in a species-rich fauna, Sheldon (1988) argued that conservation efforts should focus on the largest natural drainages as possible (the entire Coppename River watershed). In other words, ecosystem management as opposed to species management. Activities inside of or external to the Central Suriname Nature Reserve that cause erosion, siltation, sedimentation, changes to the natural hydrological cycle of the river, and/or pollution, have the capacity to diminish forever (1) the pristine character and biological value of the Central Suriname Nature Reserve and (2) the contribution of the Coppename River to the health and sustenance of the people downstream of the reserve. Such activities that lead to degradation of the pristine environmental conditions must be prevented. Although opportunities for conservation of the Coppename River watershed (as part of the Central Suriname Nature Reserve) are good, the potential threat of human impact is growing. Threats include not only bauxite and gold mining, but also forestry, increased tourism, and unregulated hunting and (sport)fishing.

The flora and fauna of the Central Suriname Nature Reserve is very fragile. Hunting and fishing should be regulated and monitored carefully, involving local people in setting regulations or limits. Fishing and hunting for commercial purposes should be prohibited in the reserve. Sport fishing should be prohibited above Raleighvallen and daily catch limits should be set for all species and strictly monitored. Catch limits and management policies must be based upon sound scientific data. Ecotourism is excellent for developing public awareness and appreciation of the Central Suriname Nature Reserve, but it can also easily have a negative impact upon the reserve because of the fragility of its ecosystems. All tourism should be regulated and monitored. Tours should not extend upriver from Dreefoetoe Sula, except some limited tourism in higher elevation areas (e.g., near Rudi Kappel airstrip).

Future research should include surveys of small, high-gradient headwaters in the upper Coppename watershed (i.e., mountain streams draining Tafelberg Mountain, Bakhuis Mountains or Wilhelmina Mountains). We did not visit the headwaters of any of the three branches of the Coppename system, the upper reaches of Adampada Creek, or the Coppename River and its tributaries below Dreefoetoe Sula. Data on the fish diversity and fisheries resource condition of the Central Suriname Nature Reserve would be largely improved with additional fish sampling in the higher and lower elevations of the watershed. Surveys downstream from the Central Suriname Nature Reserve are also important, since rivers are continuums and fishes routinely swim in and out of the reserve.

The clear waters and research station at Raleighvallen provide an ideal opportunity to study fish ecology. The results of these studies could be compared to similar studies conducted in Amazon or Orinoco floodplains, to determine if community structure, habitat utilization, etc. is the same. This would help discern the global uniqueness of the Coppename and adjacent rivers.

In conclusion, the pristine wilderness character of the Central Suriname Nature Reserve should be carefully protected, since that is what most differentiates this reserve from others and defines its highest value to Suriname and the World.

LITERATURE CITED

Amatali, M.A. 1993. Climate and surface water hydrology. *In*: Ouboter, P.E. (ed.) The freshwater ecosystems of Suriname. Dordrecht: Kluwer. Pp. 29-51.

Balon, E.K. and D.J. Stewart. 1983. Fish assemblages in a river with unusual gradient (Luongo, Africa - Zaire system), reflections on river zonation, and description of another new species. Environmental Biology of Fishes 9: 225-252.

Barthem, R. and M. Goulding. 1997. The catfish connection: ecology, migration, and conservation of Amazon predators. New York: Columbia University Press.

Bleeker, P. 1862-1876. See Weber, M. and L.F. de Beaufort. 1911. The fishes of the Indo-Australian Archipelago 1, Index bibliographicus: 1-43 (nos. 297, 298, 303, 332, 336, 362, 363, 366, 378, 446, 467).

Boeseman, M. 1952. A preliminary list of Surinam fishes not included in Eigenmann's enumeration of 1912. Zoölogische Mededelingen (Leiden) 31: 179-200.

Boeseman, M. 1968. The genus *Hypostomus* Lacépède, 1803, and its Surinam representatives. Zoölogische Verhandelingen (Leiden) 99: 1-89.

Boeseman, M. 1969. Additional new species of *Hypostomus* Lacépède, 1803, from Surinam; with remarks on the apparent "gymnorhynchus-complex" (Siluriformes, Loricariidae). Beaufortia 16: 119-136.

Boeseman, M. 1971. The 'comb-toothed' Loricariinae of Surinam, with reflections on the phylogenetic tendencies within the family Loricariidae. Zoölogische Verhandelingen (Leiden) 116: 1-56.

Boeseman, M. 1974. On two Surinam species of Hypoptopomatinae, both new to science (Loricariidae, Siluriformes, Ostariophysi). Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen (Series C: Biological and Medical Sciences) 77: 251-271.

Boujard, T., F. Meunier, M. Pascal and J.F. Cosson. 1990a. Les teleosteens d'un haut bassin fluvial guyanais, l'Arataye. I. Inventaire des characoides. Cymbium 14: 175-182.

Boujard, T., F. Meunier, M. Pascal and J.F. Cosson. 1990b. Les teleosteens d'un haut bassin fluvial guyanais, l'Arataye. II. Inventaire des "non-characoides". Cybium 14: 345-351.

Boujard, T., M. Pascal, J.F. Meunier and P.Y. Le Bail. 1997. Poissons de Guyane: Guide Ecologique de l'Approuague et de la Reserve des Nouragues. Paris: Institut de la Recherche Agronomique.

Castro, R.M.C. and L. Casatti. 1997. The fish fauna from a small forest stream of the upper Paraná River basin, southeastern Brazil. Ichthyological Exploration of Freshwaters 7: 337-352.

Chernoff, B., P.W. Willink, J. Sarmiento, S. Barrera, A. Machado-Allison, N. Menezes, and H. Ortega. 1999. Fishes of the ríos Tahuamanu, Manuripi and Nareuda, Depto. Pando, Bolivia: diversity, distribution, critical habitats and economic value. *In*: Chernoff, B. and P.W. Willink (eds.). A biological assessment of the aquatic ecosystems of the upper Río Orthon basin, Pando, Bolivia. Bulletin of Biological Assessment 15. Washington D.C.: Conservation International. Pp. 39-46.

Eigenmann, C.H. 1912. The freshwater fishes of British Guiana, including a study of the ecological grouping of species and the relation of the fauna of the plateau to that of the lowlands. Memoirs Carnegie Museum 5: 1-578.

Geijskes, D.C. 1973. Reisverslag van de Expeditie West Suriname 1971. Zoölogische Bijdragen 15: 1-41.

Géry, J. 1972. Poissons characoïdes des Guyanes. I. Généralités. II. Famille des Serrasalmidae. Zoölogische Verhandelingen (Leiden) 122: 1-250

Géry, J. 1977. Characoids of the world. Neptune City, New Jersey: T.F.H. Publications.

Goulding, M. 1980. The fishes and the forest. Berekeley: University of California Press.

Goulding, M. 1981. Man and fisheries on an Amazon frontier. Boston: Dr. W. Junk Publishers.

Graham, J.B. 1997. Air-breathing fishes: evolution, diversity, and adaptation. San Diego: Academic Press.

Hardman, M., L.M. Page, M.H. Sabaj, J.W. Armbruster and J.H. Knouft. 2002. A comparison of fish surveys made in 1908 and 1998 of the Potaro, Essequibo, Demarara, and coastal river drainages of Guyana. Ichthyological Explorations of Freshwaters 13: 225-238.

Haripersad-Makhanlal, A. and P.E. Ouboter. 1993. Limnology: physico-chemical parameters and phytoplankton composition. *In*: Ouboter, P.E. (ed.) The freshwater ecosystems of Suriname. Dordrecht: Kluwer. Pp. 53-75.

Holthuis, L.B. 1959. The Crustacea Decapoda of Suriname (Dutch Guiana). Zoölogische Verhandelingen (Leiden) 44: 1-296.

Huber, O. and M.N. Foster. 2003. Guayana Shield conservation priorities: 2002 concensus. Washington D.C.: Conservation International.

Junk, W.J. 1984. Ecology, fisheries and fish culture in Amazonia. *In*: Sioli, H. (ed.) The Amazon: limnology and landscape ecology of a mighty tropical river and its basin. Dordrecht: Kluwer. Pp. 443-476.

Kappler, A. 1887. Surinam, sein Land, seine Natur, Bevölkerung und seine Kultur-Verhältnisse mit Bezug auf Kolonisation. Stuttgart, 1-383.

Keith, P., P.-Y. Le Bail, and P. Planquette. 2000. Atlas des poissons d'eau douce de Guyane. Tome 2 – fascicule I. Batrachoidiformes, Mugiliformes, Beloniformes, Cyprinodontiformes, Synbranchiformes, Perciformes, Pleuronectiformes, Tetraodontiformes. Paris: Museum National d'Histoire Naturelle.

Keye, O. 1659. Het waere onderscheyt tusschen koude en warme landen, aengewesen in de nootsakelijckheden die daer vereyscht worden, etc. 'a-Gravenhage, 1-16, 1-178, 1-4.

Knöppel, H.A. 1970. Food of central Amazonian fishes. Amazoniana 2: 257-352.

Kullander, S.O. and H. Nijssen. 1989. The cichlids of Surinam. Leiden: E.J. Brill.

Le Bail, P.-Y., P. Keith, and P. Planquette. 2000. Atlas des poissons d'eau douce de Guyane. Tome 2 – fascicule II. Siluriformes. Paris: Museum National d'Histoire Naturelle.

Lee, M. and C. Safina. 1995. The effects of overfishing on marine biodiversity. Current: The Journal of Marine Education 13: 5-9.

Lowe-McConnell, R.H. 1987. Ecological studies in tropical fish communities. Cambridge: Cambridge University Press.

Machado-Allison, A., B. Chernoff, F. Provenzano, P.W. Willink, A. Marcano, P. Petry, B. Sidlauskas, and T. Jones. 2003. Inventory, relative abundance and importance of fishes in the Caura River Basin, Bolívar, Venezuela. *In*: Chernoff, B., A. Machado-Allison, K. Riseng, and J.R. Montambault (eds.). A biological assessment of the aquatic ecosystems of the Caura River Basin, Bolívar State, Venezuela. RAP Bulletin of Biological Assessment 28. Washington, D.C.: Conservation International. Pp. 64-74.

Mago-Leccia, F. 1994. Electric fishes of the continental waters of America: classification and catalogue of the electric fishes of the order Gymnotiformes (Teleostei: Ostariophysi), with descriptions of new genera and species. Caracas: Fundacion para el Desarrollo de las Ciencias Fisicas, Matematicas y Naturales.

Mees, G.F. 1974. The Auchenipteridae and Pimelodidae of Suriname. Zoölogische Verhandelingen (Leiden) 132: 1-256.

Mol, J.H. 2002. A preliminary assessment of the fish fauna and water quality of the eastern Kanuku Mountains: lower Kwitaro River and Rewa River at Corona Falls. *In*: Montambault, J.R. and O. Missa (eds.) A biodiversity assessment of the eastern Kanuku Mountains, lower Kwitaro River, Guyana. RAP Bulletin of Biological Assessment 26. Washington D.C., Conservation International. Pp. 38-42.

Mol, J.H. and P.E. Ouboter. 2004. Downstream effects of erosion from small-scale gold mining on the instream habitat and fish community of a small neotropical rainforest stream. Conservation Biology 18: 201-214.

Mol, J.H., J.S. Ramlal, C. Lietar and M. Verloo. 2001. Mercury contamination in freshwater, estuarine and marine fishes in relation to small-scale gold mining in Suriname, South America. Environmental Research 86: 183-197.

Noordam, D. 1993. The geographical outline. *In*: Ouboter, P.E. (ed.) The freshwater ecosystems of Suriname. Dordrecht: Kluwer. Pp. 13-28.

Nijssen, H. 1970. Revision of the Surinam catfishes of the genus *Corydoras* Lacépède, 1803. Beaufortia 18: 1-75.

Odinetz Collart, O., M. Jegu, V. Thatcher and A.S. Tavares. 1996. Les praires aquatiques de l'Amazonie bresilienne. ORSTOM Actualités 49: 8-14.

Ouboter, P and G. Landburg. 2006. Water Quality of the Coppename River Basin, with notes on aquatic fauna distribution. *In:* L.E. Alonso and H.J. Berrenstein (eds.). 2006. A Rapid Biological Assessment of the Aquatic Ecosystems of the Coppename River Basin, Suriname. RAP Bulletin of Biological Assessment 39. Conservation International, Washington, DC.

Ouboter, P.E. and J.H. Mol. 1993. The fish fauna of Suriname. *In:* Ouboter, P.E. (ed.) The freshwater ecosystems of Suriname. Dordrecht: Kluwer. Pp. 133-154.

Ouboter, P.E., B.P.E. De Dijn and U.P.D. Raghoenandan. 1999. Biodiversity inventory Ulemari Area: preliminary technical report. Paramaribo: National Zoological Collection of Suriname & National Herbarium of Suriname.

Peterson, G.D. and M. Heemskerk. 2001. Deforestation and forest regeneration following small-scale gold mining in the Amazon: the case of Suriname. Environmental Conservation 28: 117-126.

Planquette, P., P. Keith and P.-Y. Le Bail. 1996. Atlas des poissons d'eau douce de Guyane. Tome 1. Paris: Museum National d'Histoire Naturelle.

Riseng, K.J. and J.S. Sparks. 2003. A limnological analysis of the Caura River Basin, Bolívar, Venezuela. *In*:

Chernoff, B., A. Machado-Allison, K. Riseng, and J.R. Montambault (eds.). A biological assessment of the aquatic ecosystems of the Caura River Basin, Bolívar State, Venezuela. RAP Bulletin of Biological Assessment 28. Washington, D.C.: Conservation International. Pp. 44-48.

Roberts, T.R. 1972. Ecology of the fishes in the Amazon and Congo basins. Bulletin of the Museum of Comparative Zoology 143: 117-147.

Saul, W.G. 1975. An ecological study of fishes at a site in upper amazonian Ecuador. Proceedings of the Academy of Natural Sciences of Philadelphia 127: 93-134.

Sheldon, A.L. 1988. Conservation of stream fishes: patterns of diversity, rarity, and risk. Conservation Biology 2: 149-156.

Sutherland, W.J. 1990. Evolution and fisheries. Nature 344: 814-815.

Tito de Morais, L., M. Lontier and M. Hoff. 1995. Extent and role for fish populations of riverine ecotones along the Sinnamary River (French Guiana). Hydrobiologia 303: 163-179.

Vari, R.P. 1982. Inventory, biology and ecology of the fishes in the Corantijn River system, Suriname. Washington D.C.: Smithsonian Institution.

Vari, R.P. 1988. The Curimatidae, a lowland neotropical fish family (Pisces: Characiformes); distribution, endemism, and phylogenetic biogeography. *In*: Heyer, W.R. and P.E. Vanzolini (eds.). Proceedings of a workshop on neotropical distribution patterns. Rio de Janeiro: Academia Brasileira de Ciências. Pp. 343-377.

Vari, R.P. 1992. Systematics of the neotropical characiform genus *Cyphocharax* Fowler (Pisces: Ostariophysi). Smithsonian Contributions to Zoology 529: 1-137.

Vari, R.P., C.J. Ferraris and P. Keith. 2003. A new *Pseudocetopsis* species (Siluriformes: Cetopsidae) from Suriname and Frenmch Guiana. Proceedings of the Biological Society of Washington 116: 692-698.

Westermann, J.H. 1971. Historisch overzicht van de wording en het onderzoek van het Brokopondo-stuwmeer. Nieuwe West-Indische Gids 48: 1-55.

Willink, P.W., B. Chernoff, H. Ortega, R. Barriga, A. Machado-Allison, H. Sanchez, and N. Salcedo. 2005 . Fishes of the Pastaza River watershed: assessing the richness, distribution, and potential threats. *In:* Willink, P.W., B. Chernoff, and J. McCullough (eds.). A rapid biological assessment of the aquatic ecosystems of the Pastaza River Basin, Ecuador and Perú. RAP Bulletin of Biological Assessment 33. Washington, D.C.: Conservation International. Pp. 75-84.

Willink, P.W., O. Froehlich, A. Machado-Allison, N. Menezes, O. Oyakawa, A. Catella, B. Chernoff, F.C.T. Lima, M. Toledo-Piza, H. Ortega, A.M. Zanata, and R. Barriga. 2000. Fishes of the rios Negro, Neginho, Taboco, Taquari, and Miranda, Pantanal, Brasil: diversity, critical habitats, and value. *In:* Willink, P.W., B. Chernoff, L.E. Alonso, and J.R. Montambault (eds.). A biological assessment of the aquatic ecosystems of the Pantanal, Mato Grosso do Sul, Brasil. RAP Bulletin of Biological Assessment 18. Washington, D.C.: Conservation International. Pp. 63-81.

Gazetteer

Description of georeferenced localities and sampling stations during the AquaRAP survey of the Coppename River, Suriname, 2004.

Georeference Station: S2004-1

Site Name: Former Bureau Waterkracht Werken (BWKW) Camp (Upstream from Tonckens Falls)(AquaRAP Camp 1)

Dates: 22 February, 5 & 6 March

Lat-Long: N 04° 25' 16.6" W 56° 31' 13.6"

General Description: Water is mixed, black and clear, and turbid. It is slightly acidic and not well oxygenated. Water levels are low. There are rapids downstream and calm water upstream. Channel bottom consists of exposed rock and some sand. River width is 50-100 meters. Shores are forested with exposed rock and some sand. Podostemaceae on rocks is dormant. Rheophytic (growing beside and periodically flooded by streams) vegetation. Seasonally inundated forest with *Astrocaryum*, *Trichilia*, *Jacaranda* and legumes. Small areas of secondary forest. Stratified canopy up to 30 meters in height. Rocks form pools before the shore with dried leaves.

Notes: Spectacled (*Caiman crocodilus*) and Smooth-fronted/Schneider's dwarf caiman (*Paleosuchus trigonatus*) are quite abundant.

Georeference Station: S2004-2

Site Name: Coppename River at Tonckens Falls # 3

Date: 23 February

Lat-Long: N 04° 25' 21.7" W 56° 31' 34.2"

General Description: The water has a high percentage of oxygen, low conductivity, is slightly acidic and has a relatively high temperature. Water is relatively shallow. Site is near or in a rapid and has many small pools with Podostemaceae and many side channels with quiet water. Bottom is rocky with sand in between rocks. Backwater forested areas with rock and soil shores and overhanging vegetation. Much debris (leaves and sticks) is present. No terra firma forest. Vegetation subjected to inundation and siltation. Scrub forest and rheophytic vegetation. Medium height non-stratified canopy. Erosional area.

Notes: Three giant river otters (*Pteronura brasiliensis*) and two cormorants were seen.

Georeference Station: S2004-3

Site Name: Unnamed creek 1 of Rechter Coppename

Date: 23 February

Lat-Long: N 04° 21' 18.1" W 56° 31' 08.2"

General Description: Creek has clear water with a temperature much lower than the main river. It is shallow with a slow current. The mouth is narrow, sandy and muddy, with the sand beginning about 20 meters from it. Width is 10 meters at most. Logs and leaves on bottom. A log jam occurs 100 meters from mouth. Very narrow perimeter of flooded forest and beyond that is a poorly drained but not inundated forest with a multiple tiered canopy. No levee, steep bank with terra firma behind it. Dominant species include *Astrocaryum*, *Euterpe*, *Pouteria* and *Eperua*.

Georeference Station: S2004-4
Site Name: Lower Rechter Coppename at first rapids
Date: 23 February
Lat-Long: N 04° 21' 41.2" W 56° 31' 14.0"
General Description: Water is slightly dark. Temperature was quite high (29ºC) for a river, conductivity was low and some phosphate was present. Depositional reach and bend pool. *Croton* growing on rocks in the river. Water depth is shallow with many sandy beaches consisting of coarse sand and some pebbles. Large areas of sand and rock occurred in the middle of the river. Many channels are present. Very narrow perimeter of flooded forest. Beyond that is a poorly drained but not inundated forest with a multiple tiered canopy. No levee, steep bank with terra firma behind it. Dominant species include *Astrocaryum*, *Euterpe*, *Pouteria* and *Eperua*.

Georeference Station: S2004-5
Site Name: Unnamed creek 2 of Rechter Coppename
Date: 23 February
Lat-Long: N 04° 18' 9" W 56° 27' 13.7"
General Description: Water temperature was quite cool (24ºC). The dissolved oxygen was not too high; it was slightly acidic and has low conductivity. It is a relatively shallow creek that's 4-7 meters at its widest point and has a swift current. The bottom is fine white sand with scattered leaf beds. A lot of woody debris (small logs, trees) is in the creek. High steep outer bank (2-3 m high). The canopy is closed in most places, which may explain the cool water temperature. Bank was highly erosional and looked like deposition on south bank. There is a narrow band of riparian vegetation. Bank was dominated by tree fall. North bank had terra firma forest dominated by palms and Lecythidaceae. There are alternating banks of high erosion and deposition.
Notes: A poison arrow frog was observed and a giant river otter was seen at the mouth of the creek.

Georeference Station: S2004-6
Site Name: Rechter Coppename River
Date: 23 February
Lat-Long: N 04° 18' 37.4" W 56° 27' 6.2"
General Description: Water is slightly acidic, has a high temperature (~28ºC), the dissolved oxygen was ~6 mg/L and has a very low conductivity. Phosphate was high for an interior river. River is 50-100 m wide. It has big, deep backwater and small rapid with rocks in water, sandy beaches and leaves at the edges. Pools behind rocks have slow moving water. The bottom is sand and rocks. Near the forested shore there are sticks and fallen logs. The steep narrow bank is dominated by mosses and riparian vegetation. There is terra firma forest above the bank. The terrain has moderate relief and a very high incidence of *Astrocaryum* and terrestrial ferns.
Notes: Few fishes were found in the large backwater behind the sand beach even though the pool was calm and deep. Fewer invertebrates were found at this site than expected.

Georeference Station: S2004-7
Site Name: Bolletri Falls
Date: 25 February
Lat-Long: N 04° 16' 51.1" W 56° 25' 32.0"
General Description: Water is slightly black and a bit acidic with a pH of 5.4. The oxygen (76 % saturation) content was not as high as expected. A big rapid with a large area of stone with dried Podostemaceae. The rapid has one main channel and two smaller ones. A small creek or side channel flows into a well-formed bay on one side of the falls. On the other side of the falls are shallow remnant pools of the main channels. These are full of electric eels (*Electrophorus electricus*) among other aquatic organisms. The waterfalls were mostly covered with Podostemaceae. Below the rapids is a deep whirlpool with large sized piranhas (*Serrasalmus rhombeus*).

Depositional sandy beaches are also present. *Psidium* (guava) dominated the sandy side channel. The bottom is composed of coarse sand, rocks, boulders and exposed bedrock. The forest at the top of the falls is terra firma forest with a multi-tiered canopy to 30 m, with emergents to 40 m. The bottom of the falls is a seasonally flooded forest with a single-tiered canopy (10-15 m). Only the left bank (as one looked upriver [northeast]) is inundated to at least 50-100 m.
Notes: The local name for this site is Watra dagoe falls (otter falls). Most of the waterfalls consisted of jasper. Signs of otters (*Lutra longicaudis)* were seen. Capybara (*Hydrochaeris hydrochaeris*) feces and the tracks of a small cat were also observed. Additionally, there were sightings of a white-necked heron (*Ardea cocoi*), two great egrets (*Casmerodius albus*) and a large caiman.

Georeference Station: S2004-8
Site Name: Unnamed creek 3 of Rechter Coppename
Date: 26 February
Lat-Long: N 04° 21' 49.1" W 56° 29' 59.2"
General Description: Water is clear and little bit blackish when first entered. Conductivity compared to previous sites was relatively high and the dissolved oxygen was variable, sometimes being quite low. The pH was the same as the river. It is a shallow creek with a sandy, muddy bottom that contained many leaves and dead branches. The current is very slow to standing water. The outer banks are high and steep (at least 3 m). The creek is formed by a series of pools with shallow flow between them (dry season observation). One pool perhaps 60 meters from the mouth was almost 1 meter deep. This pool seemed cooler and contained many fishes. Macrophytes (perhaps *Pterophyllum*?) were found in the creek, this is not usually seen in small forested creeks. There is a relatively narrow band of flooded forest on a relatively steep slope that integrated into terra firma forest terrain. The canopy height is to 10 m in the flooded forest and 30 m in the terra firma forest. A high incidence of palms in the understory occurred in the terra firme forest.

Georeference Station: S2004-9

Site Name: Confluence of Linker & Midden Coppename (AquaRAP Camp 2)

Date: 28 February

Lat-Long: N 04° 13' 09.0" W 56° 36' 00.0"

General Description: Clear to muddy water with high measurements for temperature, conductivity, DO and aluminum concentrations. Fewer nutrients were found when compared with the Rechter Coppename. The Secchi disk was only 70 cm. Scattered rocky habitat, very few sandy beaches. Steep banks on the river. Riparian vegetation on the banks. Rocks, sand, exposed bedrock, especially on Linker side. More mud on the Midden side. Mostly a flooded forest on alluvial brown sandy place with levees, berms and terraces. Single and multi-tiered forest. Dominant species include *Eperua*, *Cecropia*, and *Phenakospermum*.

Notes: The day before sampling there were heavy rains. Many toucans, capybara, electric eels, brown-bearded sakis and large black ants (~4 cm in length) were seen. One small anaconda (~1 m long) was also observed.

Georeference Station: S2004-10

Site Name: Unnamed creek 2 of Linker Coppename

Date: 29 February

Lat-Long: N 04° 3' 55.6" W 56° 41' 6.8"

General Description: About 20 m above the mouth the water is very clear. The water is cold (24°C), pH was stable at 6.1 and the DO level was high (7.15 mg/L). The Secchi reading was greater than 1.20 m. This big tributary is fully shadowed with a muddy, sandy bottom. It's about 10 m wide and about 1 m deep with a moderate current. A few leaf beds and numerous logs were observed. Three types of large water striders were seen as well as many large anjumara.

Upstream there were alternating patterns of erosion with steeply-cut banks on active side. There is much structure in the river with overhanging vegetation coming into the water and lots of logs. There were alternating patterns of pools and shallow stream. A large levee is present along the main river. On the north side of creek there were three sets of river terraces with the highest being about 3 m. Soils were alluvial brown sandy clays. There was a large tree fall with many lianas. Seasonally inundated forest with a high incidence of palms. Large canopy with buttressed *Slonaea*.

Georeference Station: S2004-11

Site Name: Kankantrie Falls

Date: 1 March

Lat-Long: N 04° 6' 30.8" W 56° 38' 52.1"

General Description: Clear waters. The conductivity and DO were high, ~22 µS/cm and 7.5 mg/L respectively. The temperature was low for the time of day (26° C). Nutrients were low and the aluminum reading was high. It is a wide rapid complex including sandy and stone islands with small trees and bushes. There was a large area of rocky pools, rapids and narrow channels with sandy beaches and Podostemaceae beds. The bottom is rocky with exposed bedrock and boulders. Water depth is about 1 m, while the in the main channel depth reached 2 m. Along the river was a levee that had behind it a seasonally flooded channel with terraces on both sides. The river terraces were dominated by *Geonoma* (palms) in the understory, *Apeiba* in midstory, and *Ceiba pentandra* as the canopy emergent. Soils were alluvial brown sandy clays. Terra firma forest began within 50m of river.

Notes: A caiman (*Paleosuchus trichonatus*) was seen. The rocks were covered with lots of algae.

Georeference Station: S2004-12

Site Name: Sula Calliandra

Date: 1 March

Lat-Long: N 04° 09' 21.0" W 56° 37' 17.7"

General Description: The DO was high at ~7 mg/L and one phosphate reading was high (0.07) while other nutrients were low. The sula was a large semi-open area of river with two large pools, rapids and fast flowing streams. Rocks have a lot of algae growth. The bottom is bedrock and sand. This island is larger than ones in the Kankantrie sula. In one old side channel huge (2 m) free boulders were present. The substrate is thin sandy soil or exposed rock. There is large complex of forested and semi-forested islands with several backwater channels and a few sandy beaches. It is seasonally inundated near the forest rising up to non-flooded forest. Epiphytes were growing at low levels in scrub forest with a low canopy height (~6 m). Low diameter stems dominance included *Zygia*, *Calliandra*, *Catopsis*.

Notes: A Neotropic otter, *Lutra longicaudis,* was seen in the morning. A couple of freshwater sponges of significant size were collected.

Georeference Station: S2004-13

Site Name: Sula of Midden Coppename

Date: 2-3 March

Lat-Long: N 04° 12' 53.3" W 56° 35' 54"

General Description: Due to prior rain and current rain during sampling the water was turbid. The aluminum reading was high. The area is rocky with large rocks and Podostemaceae. The waterfall is about 2 m high with the maximum width of the river being 100m. Under the falls is a sandy, muddy bottom with stones. Invertebrate samples were taken at a wide medium sized pool at the base. Along the banks was flooded vegetation with a non-stratified canopy height of 8 m. There were two river terraces above the banks with *Ceiba pentandra* as dominant canopy emergent and *Geonoma* as understory palm. There is a levee above the terraces with terrain sloping down behind levee. This is poorly drained and essentially a seasonally inundated forest with *Astrocaryum*, *Eschweilera* and *Trichilia*. The canopy height is to 35 m with emergents (*Couratari*) to 45 m.

Georeference Station: S2004-14
Site Name: Rocks and backwater of Linker Coppename
Date: 2-3 March
Lat-Long: N 04° 15' 14.7" W 56° 35' 01.8"
General Description: It was raining during sampling and measurements were taken at 18:00. Water temperature was about 27º C and the DO was high at 7 mg/L. There was a rocky sand island blocking the shore with emergent *Psidium* forming a small channel on the shore side. There was also an ample backwater with leaves, sticks and a muddy bottom. It was very shallow without any current. A steep bank near the river with flooded vegetation occupied a 10 m wide buffer dominated by Myrtaceae. Canopy height was to 8 m and non-stratified with many small diameter stems. There was a levee at the top of the bank with the forest sloping away from the levee. This forest would be poorly drained or seasonally inundated. Canopy height was to 35 m with emergents (*Ceiba pentandra*). *Rinorea* dominant in understory and many lianas present with a large Bignoniaceae.
Notes: The flooded vegetation along the main shore was filled with many Cichlids.

Georeference Station: S2004-15
Site Name: Creek above falls in Midden Coppename
Date: 2-3 March
Lat-Long: N 04° 12' 54.1" W 56° 34' 53.8"
General Description: Water had high conductivity (29 µS/cm) and phosphate (1.12) and low pH (5.5) and DO (4.9 mg/L). The creek is a system of feeder tributaries and many were dry. It changed elevation after coming over a small waterfall that was cut through clay substrates. This gray colored clay was also in the main channel. This very shallow creek with a moderate current had leaves, branches and logs in the water and a sandy, clay bottom. In the center of the creek mouth was coarse white sand and around 20 m upstream were large leaf beds. Outer banks were steep (4-5 m) and the inner banks would flood in rainy season. Canopy was overhanging.
Notes: Capped heron (*Pilherodius pileatus*), *Paleosuchus trichonatus* and two *Pipa* cf. *aspera* were seen.

Georeference Station: S2004-16
Site Name: Unnamed creek in Linker Coppename above AquaRAP Camp 1
Date:
Lat-Long: N 04° 23' 25.1" W 56° 31' 52.1"
General Description: Water had low DO (5.8mg/L), high ammonium levels (2.5) and the pH was 5.6. The creek was about 50 cm deep with a slow to medium current and a muddy and sandy creek bottom. Trees shaded one part of the creek. Leaves, branches and logs were in the water and sedges were growing on the shore. The creek is about 10 m wide at the mouth and muddy upstream for approximately 20 m. About 200 m above the mouth there is a stretch of 50 m where sun penetrated and submerged vegetation grew. There is a levee along main river with berms parallel to main levee and side channel. Flooded forest is present at the confluence of the main river rising into terra firma forest about 100 m away from confluence. Soils were brown sandy clay. Classic riparian elements along river included *Gustavia* and *Duroia*. Terra firma species included *Eschweilera* and *Trichilia*.

Georeference Station: S2004-17
Site Name: Caiman sula in Adampada Creek
Date: 7 March
Lat-Long: N 04° 31' 46.8" W 56° 34' 05.3"
General Description: Water is clear and over saturated with oxygen. Conductivity, alkalinity, chloride and hardness were relatively high and pH was 6.3. Aluminum was also high. This is a shallow rapid on solid rock with lots of Podostemaceae. The sula has medium sized pools going down with several smaller pools after it. Scrub forest on rock and sand and riparian vegetation. All but the highest elevations would be exposed to flooding. The scrub forest has a canopy height up to 10 m and many small diameter stems. Dominants included *Montrichardia*, *Vochysia*, *Psidium* and *Mourera*.
Notes: The boatmen caught many large anjumara above and below the rapids. A stingray was collected. Jaguar and capybara feces were seen. Sharpening marks were found indicating that Amerindians impacted this area.

Georeference Station: S2004-18
Site Name: Unnamed creek off of Adampada Creek
Date: 7 March
Lat-Long: N 04° 31' 55.4" W 56° 32' 54.1"
General Description: Conductivity and pH were same as main channel. DO was between 5.5-5.9 mg/L. It's a partly shaded creek with clear water about 10 m wide. It's shallow at the mouth and deeper inside the creek. It has a muddy and sandy bottom and many trunks, logs, sticks, leaves. Depth was about 1.5 meters with no current and some patches with aquatic vegetation. About 50 m above the mouth were alternating pools and streams for over 100 meter. There was dense forest found on brown sandy clay. *Schwartzia* was the buttressed canopy element. Understory dominated by *Rinorea* and *Psychotria*. This is a mixture of terra firma and flooded forest. The bank was less than 3 m high with terra firma above bank.

Georeference Station: S2004-19
Site Name: Sidonkroetoe (AquaRAP Camp 3)
Date: 9 March
Lat-Long: N 04° 31' 50.9" W 56° 30' 56.0"
General Description: The fast flowing water is clear with a Secchi depth of 110 cm but slightly turbid. The DO was oversaturated. The rapids are terraced and had complexes of pools and riffles. A lot of Podostemaceae is present and some rocks have blue green algae. The depth in the rapids is less than 1 m. Rock and sand beaches exist downstream from rapids. Flooded rainforest with *Inga*, *Duroia* and *Jacaranda* occurs near the river. There is a gradual transition to flooded

forest within 50m of river. Terra firma forest with canopy emergents to 45m including *Couratari*. Canopy dominants include *Eschweilera*, *Licania* and *Trichilia*. *Astrocaryum* was dominant in midstory. *Rinorea* the dominant understory tree.
Notes: Smooth-nosed caiman were seen in the rapids and spectacled caiman were seen downstream of the rapids. Cormorants and white-necked herons were also observed.

Georeference Station: S2004-20
Site Name: Morocco sula
Date: 8 March
Lat-Long: N 04° 32' 30.0" W ° 32' 35.0"
General Description: The water is very clear with a Secchi depth of 2 m. Open areas had Podostemaceae. The conductivity and pH were same as Caiman sula. The DO was oversaturated. Water is about 1 m deep and the bottom is sand and rock. Boulders and gravel are present with open areas and riparian vegetation. There are open rapids, forested side channels and pools with standing water with blue green algae and detritus. There is a complex series of terraces. The current had medium to fast flowing water and the creek was 30 - 50 m at its narrowest point. A steep bank with flooded forest descends down river to an open reedy area at the mouth of small creek with emergent aquatic vegetation. There is terra firma forest behind bank. Area sampled was dominated by large tree fall. Lianas are dominant as was *Protium*, *Eschweilera* and *Astrocaryum*.
Notes: Smooth-fronted caiman (*Paleosuchus trigonatus*) were seen. Jaguar feces present.

Georeference Station: S2004-21
Site Name: Unnamed creek below Morocco sula
Date: 8 March
Lat-Long: N 04° 32' 9.4" W 56° 32' 17"
General Description: Water conductivity and pH was the same as the main river. The dissolved oxygen was 5.0-5.9 mg/L. This is a shaded creek with rocks and logs. The mouth is about 5 m wide with a sandy and muddy bottom. Upstream it was completely dry with several fallen logs and leaf beds. Large rocks in the margin and the bottom of the creek. The creek was drying and about 20 m was only 1-3 m wide. Banks were steeply cut from the creek to the forest and reached more than 3 m in height. Terra firma forest but poorly drained above it with a slight levee. Dominates in terra firma were *Schwartzia*, *Eschweilera* and *Astrocaryum*. The side creek was dominated by disturbed vegetation including grasses and sedges (*Ludwigia* and *Palicourea*).
Notes: A partially eaten anaconda tail was found. Jaguar and tapir tracks were also present. Medium sized anjumara were seen at the mouth. Tadpoles were found in the creek as well as nests of *Hyla boans*.

Georeference Station: S2004-22
Site Name: Back channel of island of Sidonkroetoe
Date: 8 March
Lat-Long: N 04° 32' 14.9" W 56° 30' 52.5"
General Description: Shallow channel with clear water, moderate stream flow and low conductivity. The mouth was 30-35 m wide, 1 m deep and had a muddy, sandy bottom. There was also a patch of aquatic macrophytes near the mouth. There are a lot of stones and fallen logs. In deeper pools depths reached 2-2.5 m. The sample area had a bottom of leaves and hydrogen sulfide was released when walking on the bottom. There is a steep bank on the main river channel and a sloping bank on a side channel at a height of 2 m. The forest was flooded and haad many small diameter stems. There was terra firma forest behind the bank with no discernable levee or berms. Dominants included *Eschweilera*, *Astrocaryum*, and *Moraceae*.

Georeference Station: S2004-23
Site Name: Dreefoetoe Rapids
Date: 10 March
Lat-Long: N 04° 36' 41.9" W 56° 30' 24.6"
General Description: The clear water had moderate to swift currents. The DO was oversaturated at 130-140%. The width of the river was 100-300 m wide. There were rocky islands and beaches with some terracing. Scrub vegetation on rocky island with many epiphytes. Dry side channels were present. Podostemaceae beds in small pools were present. The deep bank of the main river channel is covered with flooded forest. Flooding was evident behind bank with dense understory of *Astrocaryum* and *Rinorea*. Canopy relatively non-stratified and dominated by *Eschweilera*.

Georeference Station: S2004-24
Site Name: Creek above Dreefoetoe Falls
Date: 10 March
Lat-Long: N 04° 36' 41.8" W 56° 30' 24.7"
General Description: This wide creek (50 m) was 1.5 m deep had a slow current. The DO was much lower than the main river. There were many logs and upstream there is overhanging vegetation. The muddy bottom was easily to penetrate to at least .5 m with methane gas coming up when bottom was disturbed. Some exposed bedrock and evidence of a sand channel in the middle. The sloping bank had a gradual transition from terra firma to flooded forest rising up to 20m above the river. Transition from flooded to terra firma forest evidenced by the switch from *Ischnosiphon* to *Astrocaryum* in the understory.

Appendix 1

Plants collected in the Central Suriname Nature Reserve during the AquaRAP survey

David Clarke and Jayne Rhodes

Georeference station	Collection number	Family	Species
S2004-1	11036	Boraginaceae	*Heliotropium indicum* L.
	11037	Boraginaceae	*Heliotropium filiforme* Lehm.
	11038	Myrtaceae	*Myrciaria vismeifolia* (Benth.) O. Berg
	11039	Cyperaceae	*Cyperus luzulae* (L.) Rottb. ex Retz.
	11040	Solanaceae	*Solanum schomburgkii* Sendtn.
	11041	Rubiaceae	*Amaioua guianensis* Aubl.
	11042	Ebenaceae	*Diospyros artanthifolia* Mart. ex Miq.
	11043	Fabaceae-Caesal.	*Cassia* sp.
	11044	Hippocrateaceae	*Peritassa pruinosa* (Seem.) A.C. Sm.
	11045	Burseraceae	*Tetragastris hostmannii* (Engl.) Kuntze
	11046	Annonaceae	*Duguetia calycina* Benoist
	11047	Sapindaceae	*Talisia* sp.
	11048	Apocynaceae	
	11049	Bignoniaceae	
	11050	Fabaceae	
S2004-2	11051	Orchidaceae	*Zygosepalum labiosum* (Rich.) Garay
	11052	Rubiaceae	*Faramea sessilifolia* (Kunth) DC.
	11053	Poaceae	*Panicum laxum* Sw.
	11054	Rubiaceae	*Psychotria apoda* Steyerm.
	11055	Bromeliaceae	*Guzmania lingulata* (L.) Mez
	11056	Fabaceae-Papil.	*Swartzia panacoco* (Aubl.) R.S. Cowan var. *polyanthera* (Steud.) R.S. Cowan
	11057	Orchidaceae	*Pleurothallis* sp.
	11058	Polypodiaceae	*Microgramma baldwinii* Brade
	11059	Cyperaceae	*Calyptrocarya glomerulata* (Brongn.) Urb.
	11060	Chrysobalanaceae	*Parinari campestris* Aubl.
	11061	Fabaceae-Caesal.	*Paloue riparia* Pulle
	11062	Orchidaceae	
	11063	Aquifoliaceae	*Ilex jenmanii* Loes.
	11064	Ochnaceae	*Ouratea leblondii* (Tiegh.) Lemée
	11065	Rubiaceae	*Psychotria polycephala* Benth.

Georeference station	Collection number	Family	Species
	11066	Bromeliaceae	*Aechmea mertensii* (G. Mey.) Schult. & Schult. f.
	11067	Acanthaceae	
	11068	Onagraceae	*Ludwigia hyssopifolia* (G. Don) Exell
	11069	Turneraceae	*Piriqueta cistoides* (L.) Griseb.
	11070	Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H. Raven
	11071	Cyperaceae	*Cyperus odoratus* L.
	11072	Cyperaceae	*Cyperus haspan* L.
	11073	Podostemaceae	*Mourera fluviatilis* Aubl.
	11074	Loranthaceae	*Phthirusa rufa* (Mart.) Eichler
	11075	Fabaceae-Mimos.	*Zygia cataractae* (Kunth) L. Rico
	11076	Clusiaceae	*Calophyllum brasiliense* Cambess.
	11077	Rubiaceae	*Posoqueria latifolia* (Rudge) Roem. & Schult.
S2004-3	11078	Violaceae	*Rinorea amapensis* Hekking
	11079	Sapotaceae	*Pouteria ambelaniifolia* (Sandwith) T.D. Penn.
	11080	Adiantaceae	*Adiantum latifolium* Lam.
	11081	Orchidaceae	*Pleurothallis* sp.
S2004-4	11082	Melastomataceae	*Miconia lasseri* Gleason
	11083	Poaceae	*Panicum pilosum* Sw.
	11084	Cyperaceae	*Scleria microcarpa* Nees ex Kunth
	11085	Fabaceae-Caesal.	*Eperua falcata* Aubl.
	11086	Verbenaceae	*Vitex orinocensis* Kunth var. *multiflora* (Miq.) Huber
S2004-5	11087	Orchidaceae	*Pleurothallis* sp.
	11088	Orchidaceae	*Pleurothallis* sp.
	11089	Olacaceae	*Heisteria cauliflora* Sm.
	11090	Bryophyte	
	11091	Piperaceae	*Peperomia* sp.
	11092	Myrtaceae	*Myrciaria vismeifolia* (Benth.) O. Berg
	11093	Fabaceae-Papil.	*Swartzia panacoco* (Aubl.) R.S. Cowan var. *polyanthera* (Steud.) R.S. Cowan
	11094	Fabaceae-Caesal.	*Paloue riparia* Pulle
	11095	Rubiaceae	*Psychotria hoffmannseggiana* (Willd. ex Roem. & Schult.) Müll. Arg.
	11096	Euphorbiaceae	*Phyllanthus lindbergii* Müll. Arg.
	11097	Liliaceae	*Hymenocallis tubiflora* Salisb.
	11098	Arecaceae	*Attalea maripa* (Aubl.) Mart.
	11099	Lecythidaceae	*Lecythis corrugata* Poit.
S2004-6	11100	Bignoniaceae	*Cydista* sp.
	11101	Hymenophyllaceae	
	11102	Selaginellaceae	*Selaginella* sp.
	11103	Aspleniaceae	*Asplenium serratum* L.
	11104	Adiantaceae	*Adiantum tetraphyllum* Humb. & Bonpl. ex Willd.
	11105	Tectariaceae	*Triplophyllum funestum* (Kunze) Holttum
	11106	Gentianaceae	*Voyria caerulea* Aubl.

Georeference station	Collection number	Family	Species
S2004-7	11107	Orchidaceae	*Dichaea picta* Rchb. f.
	11108	Selaginellaceae	*Selaginella* sp.
	11109	Rubiaceae	*Palicourea croceoides* Desv. ex Ham.
	11110	Celastraceae	*Maytenus guyanensis* Klotzsch ex Reissek
	11111	Melastomataceae	*Clidemia pustulata* DC.
	11112	Fabaceae-Caesal.	*Cassia* sp.
	11113	Heliconiaceae	*Heliconia hirsuta* L. f.
	11114	Clusiaceae	*Vismia guianensis* (Aubl.) Choisy
	11115	Meliaceae	*Trichilia* sp.
	11116	Flacourtiaceae	*Laetia procera* (Poepp.) Eichler
	11117	Bignoniaceae	*Jacaranda obtusifolia* Bonpl.
	11118	Sapindaceae	*Talisia* sp.
	11119	Melastomataceae	*Clidemia anisophylla* DC.
	11120	Rubiaceae	*Genipa spruceana* Steyerm.
	11121	Cyperaceae	*Diplasia karatifolia* Rich.
	11122	Liliaceae?	
	11123	Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand ssp. *heptaphyllum*
	11124	Bromeliaceae	*Ananas parguazensis* L.A. Camargo & L.B. Sm.
	11125	Bignoniaceae	*Memora schomburgkii* (DC.) Miers
	11126	Sapindaceae	*Matayba camptoneura* Radlk.
	11127	Myrtaceae	*Psidium acutangulum* DC.
	11128	Fabaceae	
S2004-8	11129	Piperaceae	*Peperomia* sp.
	11130	Aspleniaceae	*Asplenium angustum* Sw.
	11131	Rubiaceae	*Psychotria polycephala* Benth.
	11132	Flacourtiaceae	*Carpotroche surinamensis* Uittien
	11133	Adiantaceae	*Adiantum latifolium* Lam.
	11134	Orchidaceae	
	11135	Orchidaceae	*Dichaea picta* Rchb. f.
	11136	Cyperaceae	*Calyptrocarya glomerulata* (Brongn.) Urb.
	11137	Cyperaceae	*Scleria microcarpa* Nees ex Kunth
	11138	Fabaceae-Mimos.	*Inga* sp.
	11139	Rubiaceae	*Genipa spruceana* Steyerm.
	11140	Hydrocharitaceae	*Apalanthe* sp.
S2004-7	11141	Euphorbiaceae	*Euphorbia prostrata* Aiton
	11142	Flacourtiaceae	*Homalium guianense* (Aubl.) Oken
	11143	Fabaceae-Caesal.	
	11144	Polypodiaceae	*Pleopeltis percussa* (Cav.) Hook. & Grev.
	11145	Violaceae	*Rinorea amapensis* Hekking
	11146	Rubiaceae	*Diodia hyssopifolia* (Willd. ex Roem. & Schult.) Cham. & Schltdl.
	11147	Piperaceae	*Peperomia* sp.

Georeference station	Collection number	Family	Species
	11148	Rubiaceae	*Faramea irwinii* Steyerm.
	11149	Rubiaceae	*Psychotria albert-smithii* Standl.
	11150	Bombacaceae	*Catostemma* sp.
	11151	Caryocaraceae	*Caryocar microcarpum* Ducke
S2004-9	11152	Sapindaceae	
	11153	Adiantaceae	*Adiantum tetraphyllum* Humb. & Bonpl. ex Willd.
	11154	Cyperaceae	*Rhynchospora cephalotes* (L.) Vahl
	11155	Ochnaceae	*Sauvagesia erecta* L.
	11156	Cyperaceae	*Hypolytrum longifolium* (Rich.) Nees ssp. *longifolium*
S2004-10	11156a	yperaceae	*Rhynchospora cephalotes* (L.) Vahl
	11157	Fabaceae-Mimos.	*Inga* sp.
	11158	Selaginellaceae	*Selaginella* sp.
	11159	Malpighiaceae	*Tetrapterys glabrifolia* (Griseb.) Small
	11160	Violaceae	*Rinorea amapensis* Hekking
	11161	Piperaceae	*Piper* sp.
	11162	Pteridophyte	
	11163	Bromeliaceae	*Guzmania lingulata* (L.) Mez
	11164	Polypodiaceae	*Microgramma reptans* (Cav.) A.R. Sm.
	11165	Hymenophyllaceae	
	11166	Flacourtiaceae	*Carpotroche* sp.
	11167	Vitaceae	*Cissus erosa* Rich.
	11168	Flacourtiaceae	*Carpotroche surinamensis* Uittien
	11169	Cyperaceae	*Scleria microcarpa* Nees ex Kunth
	11170	Poaceae	*Pariana radiciflora* Sagot ex Döll
	11171	Myrtaceae	
	11172	Costaceae	*Costus scaber* Ruiz & Pav.
	11173	Heliconiaceae	*Heliconia acuminata* Rich.
	11174	Myrtaceae	
	11175	Melastomataceae	*Clidemia japurensis* DC.
	11176	Cyperaceae	*Hypolytrum longifolium* (Rich.) Nees ssp. *longifolium*
	11177	Poaceae	*Panicum pilosum* Sw.
S2004-11	11178	Tiliaceae	*Apeiba glabra* Aubl.
	11179	Olacaceae	*Heisteria densifrons* Engl.
	11180	Polypodiaceae	*Pecluma plumula* (Humb. & Bonpl. ex Willd.) M.G. Price
	11181	Polypodiaceae	*Campyloneurum phyllitidis* (L.) C. Presl
	11182	Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H. Raven
	11183	Euphorbiaceae	*Amanoa guianensis* Aubl.
	11184	Arecaceae	*Geonoma baculifera* (Poit.) Kunth
	11185	Sapindaceae	*Talisia* sp.
	11186	Polypodiaceae	*Pleopeltis percussa* (Cav.) Hook. & Grev.
	11187	Poaceae	*Panicum laxum* Sw.

Georeference station	Collection number	Family	Species
	11188	Cyperaceae	*Hypolytrum longifolium* (Rich.) Nees ssp. *longifolium*
	11189	Ochnaceae	*Sauvagesia erecta* L.
	11190	Hymenophyllaceae	
	11191	Euphorbiaceae	*Euphorbia prostrata* Aiton
	11192	Euphorbiaceae	*Phyllanthus lindbergii* Müll. Arg.
S2004-12	11193	Ochnaceae	*Ouratea leblondii* (Tiegh.) Lemée
	11194	Rubiaceae	*Palicourea croceoides* Desv. ex Ham.
	11195	Orchidaceae	
	11196	Orchidaceae	*Maxillaria* sp. a
	11197	Rubiaceae	*Morinda tenuiflora* (Benth.) Steyerm.
	11198	Bromeliaceae	*Tillandsia bulbosa* Hook.
	11199	Bromeliaceae	*Guzmania lingulata* (L.) Mez
	11200	Orchidaceae	*Maxillaria* sp. b
	11201	Gesneriaceae	*Codonanthe crassifolia* (H. Focke) C.V. Morton
	11202	Fabaceae-Mimos.	*Calliandra* sp.
	11203	Fabaceae-Mimos.	*Zygia cataractae* (Kunth) L. Rico
	11204	Euphorbiaceae	*Phyllanthus lindbergii* Müll. Arg.
	11205	Ochnaceae	*Sauvagesia erecta* L.
	11206	Turneraceae	*Piriqueta cistoides* (L.) Griseb.
S2004-13	11207	Olacaceae	*Heisteria cauliflora* Sm.
	11208	Myristicaceae	*Virola sebifera* Aubl.
	11209	Orchidaceae	*Maxillaria* sp. b
	11210	Myrtaceae	*Myrciaria vismeifolia* (Benth.) O. Berg
	11211	Violaceae	*Rinorea amapensis* Hekking
	11212	Flacourtiaceae	*Carpotroche surinamensis* Uittien
	11213	Bignoniaceae	
	11214	Lecythidaceae	*Lecythis corrugata* Poit. ssp. *corrugata*
	11215	Meliaceae	*Trichilia surinamensis* (Miq.) C. DC.
S2004-14	11216	Rubiaceae	*Palicourea croceoides* Desv. ex Ham.
	11217	Poaceae	*Panicum stoloniferum* Poir.
	11218	Cyperaceae	*Scleria microcarpa* Nees ex Kunth
	11219	Poaceae	*Panicum stoloniferum* Poir.
	11220	Liliaceae	*Hymenocallis tubiflora* Salisb.
	11221	Malpighiaceae	*Hiraea faginea* (Sw.) Nied.
	11222	Apocynaceae	*Mesechites trifida* (Jacq.) Müll. Arg.
	11223	Olacaceae	*Heisteria cauliflora* Sm.
	11224	Pteridophyte	
	11225	Gesneriaceae	*Codonanthe calcarata* (Miq.) Hanst.
	11226	Violaceae	*Rinorea amapensis* Hekking
S2004-13	11227	Ixonanthaceae	*Cyrillopsis paraensis* Kuhlm.
	11228	Flacourtiaceae	*Carpotroche surinamensis* Uittien
	11229	Piperaceae	*Piper* sp.

Georeference station	Collection number	Family	Species
	11230	Piperaceae	*Piper* sp.
	11231	Marantaceae	*Calathea* sp.
	11232	Marantaceae	*Ischnosiphon* sp.
	11233	Rubiaceae	*Psychotria albert-smithii* Standl.
	11234	Violaceae	*Rinorea amapensis* Hekking
	11235	Arecaceae	*Geonoma macrostachys* Mart. var. *poiteauana* (Kunth) A.J. Hend.
	11236	Heliconiaceae	*Heliconia acuminata* Rich.
	11237	Annonaceae	*Duguetia inconspicua* Sagot
	11238	Rubiaceae	*Psychotria albert-smithii* Standl.
	11239	Sapindaceae	*Matayba camptoneura* Radlk.
	11240	Olacaceae	*Heisteria ovata* Benth.
S2004-1	11241	Cactaceae	*Rhipsalis baccifera* (J.S. Muell.) Stearn
	11242	Araceae	*Caladium bicolor* (Aiton) Vent.
S2004-16	11243	Violaceae	*Rinorea amapensis* Hekking
	11244	Cyperaceae	*Calyptrocarya glomerulata* (Brongn.) Urb.
	11245	Sapindaceae	*Talisia* sp.
	11246	Fabaceae	
	11247	Lecythidaceae	*Eschweilera* sp.
	11248	Rubiaceae	*Psychotria polycephala* Benth.
	11249	Marantaceae	*Ischnosiphon* sp.
	11250	Hydrocharitaceae	*Elodea* sp.
	11251	Poaceae	*Olyra longifolia* Kunth
	11252	Lecythidaceae	*Gustavia augusta* L.
S2004-1	11253	Cucurbitaceae	*Gurania bignoniacea* (Poepp. & Endl.) C. Jeffrey
S2004-17	11254	Lauraceae	*Endlicheria multiflora* (Miq.) Mez
	11255	Apocynaceae	
	11256	Fabaceae-Mimos.	*Zygia cataractae* (Kunth) L. Rico
	11257	Vochysiaceae	*Vochysia tetraphylla* (G. Mey.) DC.
	11258	Ebenaceae	*Diospyros artanthifolia* Mart. ex Miq.
	11259	Rubiaceae	*Isertia parviflora* Vahl
	11260	Podostemaceae	*Mourera fluviatilis* Aubl.
	11261	Araceae	*Montrichardia arborescens* (L.) Schott
	11262	Rubiaceae	*Faramea sessilifolia* (Kunth) DC.
	11263	Myrtaceae	*Myrciaria vismeifolia* (Benth.) O. Berg
	11264	Cyperaceae	*Diplasia karatifolia* Rich.
	11265	Cyperaceae	*Hypolytrum longifolium* (Rich.) Nees ssp. *longifolium*
	11266	Turneraceae	*Piriqueta cistoides* (L.) Griseb.
	11267	Turneraceae	*Turnera rupestris* Aubl. var. *frutescens* (Aubl.) Urb.
	11268	Violaceae	*Rinorea amapensis* Hekking
	11269	Solanaceae	*Solanum schomburgkii* Sendtn.
	11270	Onagraceae	*Ludwigia hyssopifolia* (G. Don) Exell

Georeference station	Collection number	Family	Species
	11271	Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H. Raven
	11272	Bromeliaceae	*Catopsis berteroniana* (Schult. & Schult. f.) Mez
	11273	Rubiaceae	*Diodia hyssopifolia* (Willd. ex Roem. & Schult.) Cham. & Schltdl.
	11274	Chrysobalanaceae	*Hirtella racemosa* Lam.
	11275	Euphorbiaceae	*Mabea piriri* Aubl.
	11276	Podostemaceae	*Apinagia surumuensis* (Engl.) P. Royen
	11277	Rubiaceae	*Genipa spruceana* Steyerm.
	11278	Poaceae	*Panicum pilosum* Sw.
	11279	Cyperaceae	*Rhynchospora cephalotes* (L.) Vahl
S2004-18	11280	Fabaceae-Papil.	*Swartzia panacoco* (Aubl.) R.S. Cowan var. *polyanthera* (Steud.) R.S. Cowan
	11281	Bignoniaceae	
	11282	Marantaceae	*Ischnosiphon* sp.
	11283	Malpighiaceae	*Hiraea faginea* (Sw.) Nied.
	11284	Melastomataceae	*Miconia prasina* (Sw.) DC.
	11285	Rubiaceae	*Tocoyena sp.*
	11286	Verbenaceae	*Petrea volubilis* L.
	11287	Rubiaceae	*Psychotria hoffmannseggiana* (Willd. ex Roem. & Schult.) Müll. Arg.
	11288	Apocynaceae	
	11289	sterile aquatic	
	11290	Nymphaeaceae	*Nymphaea glandulifera* Rodschied
	11291	Piperaceae	
	11292	Olacaceae	*Heisteria cauliflora* Sm.
	11293	Annonaceae	*Anaxagorea dolichocarpa* Sprague & Sandwith
	11294	Euphorbiaceae	*Alchorneopsis floribunda* (Benth.) Müll. Arg.
S2004-20	11295	Sapotaceae	*Pouteria sagotiana* (Baill.) Eyma
	11296	Araceae	*Monstera adansonii* Schott
	11297	Bignoniaceae	
	11298	Cucurbitaceae	*Cayaponia cruegeri* (Naudin) Cogn.
	11299	Combretaceae	*Combretum pyramidatum* Desv.
	11300	Sapindaceae	*Matayba camptoneura* Radlk.
	11301		
	11302	Euphorbiaceae	*Phyllanthus lindbergii* Müll. Arg.
	11303	Ochnaceae	*Sauvagesia*
	11304	Onagraceae	*Ludwigia*
	11305	Myrtaceae	*Psidium acutangulum* DC.
	11306	Lecythidaceae	*Eschweilera sagotiana* Miers
	11307	Cyperaceae	*Cyperus odoratus* L.
	11308	Gentianaceae	*Coutoubea ramosa* Aubl.
	11309	Araceae	*Montrichardia linifera* (Arruda) Schott
	11310	Convolvulaceae	

Georeference station	Collection number	Family	Species
	11311	Asteraceae	*Struchium sparganophorum* (L.) Kuntze
	11312	Vitaceae	*Cissus verticillata* (L.) Nicolson & C.E. Jarvis
	11313	Apocynaceae	
S2004-21	11314	Melastomataceae	*Miconia prasina* (Sw.) DC.
	11315	Melastomataceae	*Henriettea succosa* (Aubl.) DC.
	11316	Gentianaceae	*Coutoubea ramosa* Aubl.
	11317	Poaceae	*Panicum pilosum* Sw.
	11318	Onagraceae	*Ludwigia latifolia* (Benth.) H. Hara
	11319	Cyperaceae	*Cyperus miliifolius* Poepp. & Kunth
	11320	Polypodiaceae	*Microgramma reptans* (Cav.) A.R. Sm.
	11321	Rubiaceae	*Palicourea croceoides* Desv. ex Ham.
	11322	Fabaceae-Papil.	*Swartzia panacoco* (Aubl.) R.S. Cowan var. *polyanthera* (Steud.) R.S. Cowan
	11323	Fabaceae-Caesal.	
S2004-19	11324	Flacourtiaceae	*Carpotroche surinamensis* Uittien
	11325	Anacardiaceae	*Spondias mombin* L.
	11326	Ochnaceae	*Ouratea leblondii* (Tiegh.) Lemée
	11327	Fabaceae-Mimos.	*Zygia cataractae* (Kunth) L. Rico
	11328	Meliaceae	*Trichilia schomburgkii* C. DC. ssp. *schomburgkii*
	11329	Araceae	*Philodendron acutatum* Schott
	11330	Proteaceae	*Panopsis sessilifolia* (Rich.) Sandwith
	11331	Lecythidaceae	*Couratari guianensis* Aubl.
S2004-22	11332	Euphorbiaceae	*Conceveiba guianensis* Aubl.
	11333	Rubiaceae	*Psychotria polycephala* Benth.
	11334	Rubiaceae	
	11335	Melastomataceae	*Miconia prasina* (Sw.) DC.
	11336	Siparunaceae	*Siparuna decipiens* (Tul.) A. DC.
	11337	Moraceae	*Maquira guianensis* Aubl.
	11338	Fabaceae-Caesal.	*Paloue riparia* Pulle
	11339	Annonaceae	*Anaxagorea acuminata* (Dunal) A. DC.
	11340	Mayacaceae	*Mayaca longipes* Mart. ex Seub.
	11341	Malpighiaceae	*Hiraea faginea* (Sw.) Nied.
	11342	Solanaceae	
S2004-23	11343	Turneraceae	*Piriqueta cistoides* (L.) Griseb.
	11344	Verbenaceae	*Vitex compressa* Turcz.
	11345	Rubiaceae	*Genipa spruceana* Steyerm.
	11346	Aquifoliaceae	*Ilex jenmanii* Loes.
	11347	Melastomataceae	*Miconia aplostachya* (Bonpl.) DC.
	11348	Bromeliaceae	*Tillandsia bulbosa* Hook.
	11349	Rubiaceae	*Isertia parviflora* Vahl
	11350	Orchidaceae	*Maxillaria* sp. a
	11351	Melastomataceae	*Tibouchina aspera* Aubl.

Georeference station	Collection number	Family	Species
	11352	Gesneriaceae	*Codonanthe crassifolia* (H. Focke) C.V. Morton
	11353	Aquifoliaceae	*Ilex jenmanii* Loes.
	11354	Ochnaceae	*Ouratea leblondii* (Tiegh.) Lemée
	11355	Polypodiaceae	*Pleopeltis percussa* (Cav.) Hook. & Grev.
	11356	Rubiaceae	*Faramea sessilifolia* (Kunth) DC.
	11357	Heliconiaceae	*Heliconia hirsuta* L. f.
	11358	Myrtaceae	*Myrciaria vismeifolia* (Benth.) O. Berg
	11359	Annonaceae	*Anaxagorea acuminata* (Dunal) A. DC.
	11360	Araceae	*Heteropsis flexuosa* (Kunth) G.S. Bunting
	11361	Marantaceae	*Ischnosiphon* sp.
	11362	Olacaceae	*Heisteria cauliflora* Sm.
	11363	Chrysobalanaceae	*Acioa guianensis* Aubl.
	11364	Lecythidaceae	*Eschweilera micrantha* (O. Berg) Miers
	11365	Polypodiaceae	*Dicranoglossum desvauxii* (Klotzsch) Proctor
	11366	Vittariaceae	*Antrophyum cajenense* (Desv.) Spreng.
	11367	Meliaceae	*Trichilia surinamensis* (Miq.) C. DC.
	11368	Cyperaceae	*Cyperus luzulae* (L.) Rottb. ex Retz.
	11369	Poaceae	
	11370	Bromeliaceae	*Vriesea procera* (Mart. ex Schult. f.) Wittm.
S2004-24	11371	Tectariaceae	*Tectaria trifoliata* (L.) Cav.
	11372	Adiantaceae	*Adiantum cajennense* Willd. ex Klotzsch
	11373	Verbenaceae	*Petrea volubilis* L.
	11373a	Verbenaceae	*Petrea macrostachya* Benth.
	11374	Fabaceae-Caesal.	*Paloue riparia* Pulle
	11375	Fabaceae-Caesal.	*Eperua rubiginosa* Miq. var. *rubiginosa*
	11376	Olacaceae	*Heisteria cauliflora* Sm.
	11377	Bromeliaceae	*Ananas parguazensis* L.A. Camargo & L.B. Sm.
	11378	Moraceae	*Sorocea muriculata* Miq. ssp. *uaupensis* (Baill.) C.C. Berg
	11379	Rubiaceae	*Psychotria apoda* Steyerm.
	11380	Bignoniaceae	
	11381	Violaceae	*Rinorea amapensis* Hekking
	11382	Heliconiaceae	*Heliconia hirsuta* L. f.
	11383	Annonaceae	*Anaxagorea acuminata* (Dunal) A. DC.
	11384	Marantaceae	*Ischnosiphon* sp.

Appendix 2

Checklist of the Plants of the AquaRAP Expedition to the Central Suriname Nature Reserve

David Clarke and Jayne Rhodes

Family Indet.: 11301

Acanthaceae
Indet.: 11067

Adiantaceae
Adiantum cajennense Willd. ex Klotzsch: 11372
Adiantum latifolium Lam.: 11080, 11133
Adiantum tetraphyllum Humb. & Bonpl. ex Willd.: 11153, 11104

Anacardiaceae
Spondias mombin L.: 11325

Annonaceae
Anaxagorea acuminata (Dunal) A. DC.: 11359, 11339, 11383
Anaxagorea dolichocarpa Sprague & Sandwith: 11293
Duguetia calycina Benoist: 11046
Duguetia inconspicua Sagot: 11237

Apocynaceae
Indet.: 11048, 11255, 11288, 11313
Mesechites trifida (Jacq.) Müll. Arg.: 11222

Aquifoliaceae
Ilex jenmanii Loes.: 11353, 11063, 11346

Araceae
Caladium bicolor (Aiton) Vent.: 11242
Heteropsis flexuosa (Kunth) G.S. Bunting: 11360
Monstera adansonii Schott: 11296
Montrichardia arborescens (L.) Schott: 11261
Montrichardia linifera (Arruda) Schott: 11309
Philodendron cf. *acutatum* Schott: 11329

Arecaceae
Attalea maripa (Aubl.) Mart.: 11098
Geonoma baculifera (Poit.) Kunth: 11184
Geonoma macrostachys Mart. var. *poiteauana* (Kunth) A.J. Hend.: 11235

Aspleniaceae
Asplenium angustum Sw.: 11130
Asplenium serratum L.: 11103

Asteraceae
Struchium sparganophorum (L.) Kuntze: 11311

Bignoniaceae
Indet.: 11297, 11281, 11213, 11049, 11380
Cydista: 11100
Jacaranda obtusifolia Bonpl.: 11117
Memora schomburgkii (DC.) Miers: 11125

Bombacaceae
Catostemma: 11150

Boraginaceae
Heliotropium filiforme Lehm.: 11037
Heliotropium indicum L.: 11036

Bromeliaceae
Aechmea mertensii (G. Mey.) Schult. & Schult. f.: 11066
Ananas parguazensis L.A. Camargo & L.B. Sm.: 11377, 11124
Catopsis berteroniana (Schult. & Schult. f.) Mez: 11272
Guzmania lingulata (L.) Mez: 11199, 11163, 11055
Tillandsia bulbosa Hook.: 11348, 11198
Vriesea procera (Mart. ex Schult. f.) Wittm.: 11370

Bryophyte
Indet.: 11090

Burseraceae
Protium heptaphyllum (Aubl.) Marchand ssp. *heptaphyllum*: 11123
Tetragastris hostmannii (Engl.) Kuntze: 11045

Cactaceae
Rhipsalis baccifera (J.S. Muell.) Stearn: 11241

Caryocaraceae
Caryocar microcarpum Ducke: 11151

Celastraceae
Maytenus guyanensis Klotzsch ex Reissek: 11110

Chrysobalanaceae
Acioa guianensis Aubl.: 11363
Hirtella racemosa Lam.: 11274
Parinari campestris Aubl.: 11060

Clusiaceae
Calophyllum brasiliense Cambess.: 11076
Vismia guianensis (Aubl.) Choisy: 11114

Combretaceae
Combretum pyramidatum Desv.: 11299

Convolvulaceae
Indet.: 11310

Costaceae
Costus scaber Ruiz & Pav.: 11172

Cucurbitaceae
Cayaponia cf. *cruegeri* (Naudin) Cogn.: 11298
Gurania bignoniacea (Poepp. & Endl.) C. Jeffrey: 11253

Cyperaceae
Calyptrocarya glomerulata (Brongn.) Urb.: 11136, 11059, 11244
Cyperus haspan L.: 11072
Cyperus luzulae (L.) Rottb. ex Retz.: 11368, 11039
Cyperus miliifolius Poepp. & Kunth: 11319
Cyperus odoratus L.: 11071, 11307
Diplasia karatifolia Rich.: 11264, 11121
Hypolytrum longifolium (Rich.) Nees ssp. *longifolium*: 11176, 11265, 11188, 11156
Rhynchospora cephalotes (L.) Vahl: 11154, 11279, 11156a
Scleria microcarpa Nees ex Kunth: 11137, 11084, 11169, 11218

Ebenaceae
Diospyros artanthifolia Mart. ex Miq.: 11258, 11042

Euphorbiaceae
Alchorneopsis floribunda (Benth.) Müll. Arg.: 11294
Amanoa guianensis Aubl.: 11183
Conceveiba guianensis Aubl.: 11332
Euphorbia prostrata Aiton: 11191, 11141
Mabea piriri Aubl.: 11275
Phyllanthus cf. *lindbergii* Müll. Arg.: 11302, 11096, 11204, 11192

Fabaceae
Indet.: 11246, 11128, 11050

Fabaceae-Caesal.
Indet.: 11143, 11323
Cassia: 11112, 11043
Eperua falcata Aubl.: 11085
Eperua rubiginosa Miq. var. *rubiginosa*: 11375
Paloue riparia Pulle: 11374, 11338, 11094, 11061

Fabaceae-Mimos.
Calliandra: 11202
Inga: 11157, 11138
Zygia cataractae (Kunth) L. Rico: 11203, 11327, 11075, 11256

Fabaceae-Papil.
Swartzia panacoco (Aubl.) R.S. Cowan var. *polyanthera* (Steud.) R.S. Cowan: 11056, 11093, 11280, 11322

Flacourtiaceae
Carpotroche: 11166
Carpotroche surinamensis Uittien: 11324, 11132, 11228, 11212, 11168
Homalium guianense (Aubl.) Oken: 11142
Laetia procera (Poepp.) Eichler: 11116

Gentianaceae
Coutoubea ramosa Aubl.: 11316, 11308
Voyria caerulea Aubl.: 11106

Gesneriaceae
Codonanthe calcarata (Miq.) Hanst.: 11225
Codonanthe crassifolia (H. Focke) C.V. Morton: 11201, 11352

Heliconiaceae
Heliconia acuminata Rich.: 11236, 11173
Heliconia hirsuta L. f.: 11113, 11357, 11382

Hippocrateaceae
Peritassa cf. *pruinosa* (Seem.) A.C. Sm.: 11044

Hydrocharitaceae
Apalanthe cf.: 11140
Elodea cf.: 11250

Hymenophyllaceae
Indet.: 11190, 11165, 11101

Ixonanthaceae
Cyrillopsis paraensis Kuhlm.: 11227

Lauraceae
Endlicheria multiflora (Miq.) Mez: 11254

Lecythidaceae
Couratari guianensis Aubl.: 11331
Eschweilera micrantha (O. Berg) Miers: 11364
Eschweilera sagotiana Miers: 11306
Eschweilera sp.: 11247
Gustavia augusta L.: 11252
Lecythis corrugata Poit.: 11099, 11214

Liliaceae
Hymenocallis tubiflora Salisb.: 11220, 11097

Liliaceae?
Indet.: 11122

Loranthaceae
Phthirusa rufa (Mart.) Eichler: 11074

Malpighiaceae
Hiraea faginea (Sw.) Nied.: 11221, 11341, 11283
Tetrapterys glabrifolia (Griseb.) Small: 11159

Marantaceae
Calathea: 11231
Ischnosiphon: 11361, 11232, 11249, 11282, 11384

Mayacaceae
Mayaca longipes Mart. ex Seub.: 11340

Melastomataceae
Clidemia anisophylla DC.: 11119
Clidemia japurensis DC.: 11175
Clidemia pustulata DC.: 11111
Henriettea aff. *succosa* (Aubl.) DC.: 11315
Miconia aplostachya (Bonpl.) DC.: 11347
Miconia lasseri Gleason: 11082
Miconia cf. *prasina* (Sw.) DC.: 11335, 11314, 11284
Tibouchina aspera Aubl.: 11351

Meliaceae
Trichilia: 11115
Trichilia schomburgkii C. DC. ssp. *schomburgkii*: 11328
Trichilia surinamensis (Miq.) C. DC.: 11215, 11367

Moraceae
Maquira guianensis Aubl.: 11337
Sorocea muriculata Miq. ssp. *uaupensis* (Baill.) C.C. Berg: 11378

Myristicaceae
Virola sebifera Aubl.: 11208

Myrtaceae
Indet.: 11174, 11171
Myrciaria vismeifolia (Benth.) O. Berg: 11092, 11038, 11358, 11210, 11263
Psidium acutangulum DC.: 11127, 11305

Nymphaeaceae
Nymphaea glandulifera Rodschied: 11290

Ochnaceae
Ouratea leblondii (Tiegh.) Lemée: 11064, 11326, 11354, 11193
Sauvagesia: 11303
Sauvagesia erecta L.: 11189, 11205, 11155

Olacaceae
Heisteria cauliflora Sm.: 11292, 11223, 11362, 11376, 11089, 11207
Heisteria densifrons Engl.: 11179
Heisteria ovata Benth.: 11240

Onagraceae
Ludwigia: 11304
Ludwigia hyssopifolia (G. Don) Exell: 11068, 11270
Ludwigia latifolia (Benth.) H. Hara: 11318
Ludwigia octovalvis (Jacq.) P.H. Raven: 11070, 11182, 11271

Orchidaceae
Indet.: 11195, 11134, 11062
Dichaea cf. *picta* Rchb. f.: 11107, 11135
Maxillaria sp. a: 11196, 11350
Maxillaria sp. b: 11200, 11209
Pleurothallis sp.: 11087, 11081, 11088, 11057
Zygosepalum labiosum (Rich.) Garay: 11051

Piperaceae
Indet.: 11291
Peperomia: 11091, 11129, 11147
Piper: 11161, 11229, 11230

Poaceae
Indet.: 11369
Olyra longifolia Kunth: 11251
Panicum laxum Sw.: 11187, 11053
Panicum pilosum Sw.: 11278, 11083, 11177, 11317
Panicum stoloniferum Poir.: 11219, 11217
Pariana radiciflora Sagot ex Döll: 11170

Podostemaceae
Apinagia surumuensis (Engl.) P. Royen: 11276
Mourera fluviatilis Aubl.: 11073, 11260

Polypodiaceae
Campyloneurum phyllitidis (L.) C. Presl: 11181
Dicranoglossum desvauxii (Klotzsch) Proctor: 11365
Microgramma baldwinii Brade: 11058
Microgramma reptans (Cav.) A.R. Sm.: 11164, 11320
Pecluma plumula (Humb. & Bonpl. ex Willd.) M.G. Price: 11180
Pleopeltis percussa (Cav.) Hook. & Grev.: 11144, 11186, 11355

Proteaceae
Panopsis sessilifolia (Rich.) Sandwith: 11330

Pteridophyte
Indet.: 11162, 11224

Rubiaceae
Indet.: 11334
Amaioua guianensis Aubl.: 11041
Diodia hyssopifolia (Willd. ex Roem. & Schult.) Cham. & Schltdl.: 11273, 11146
Faramea irwinii Steyerm.: 11148
Faramea sessilifolia (Kunth) DC.: 11052, 11262, 11356
Genipa spruceana Steyerm.: 11277, 11139, 11345, 11120
Isertia parviflora Vahl: 11349, 11259
Morinda tenuiflora (Benth.) Steyerm.: 11197
Palicourea croceoides Desv. ex Ham.: 11109, 11321, 11194, 11216
Posoqueria latifolia (Rudge) Roem. & Schult.: 11077
Psychotria albert-smithii Standl.: 11238, 11149, 11233
Psychotria apoda Steyerm.: 11054, 11379
Psychotria hoffmannseggiana (Willd. ex Roem. & Schult.) Müll. Arg.: 11287, 11095
Psychotria polycephala Benth.: 11065, 11333, 11248, 11131
Tocoyena sp.: 11285

Sapindaceae
Indet.: 11152
Matayba camptoneura Radlk.: 11126, 11239, 11300
Talisia: 11047, 11118, 11245, 11185

Sapotaceae
Pouteria ambelaniifolia (Sandwith) T.D. Penn.: 11079
Pouteria sagotiana (Baill.) Eyma: 11295

Selaginellaceae
Selaginella: 11102, 11158, 11108

Siparunaceae
Siparuna decipiens (Tul.) A. DC.: 11336

Solanaceae
Indet.: 11342
Solanum schomburgkii Sendtn.: 11269, 11040

sterile aquatic
Indet.: 11289

Tectariaceae
Tectaria ? trifoliata (L.) Cav.: 11371
Triplophyllum funestum (Kunze) Holttum: 11105

Tiliaceae
Apeiba glabra Aubl.: 11178

Turneraceae
Piriqueta cistoides (L.) Griseb.: 11206, 11343, 11069, 11266
Turnera rupestris Aubl. var. *frutescens* (Aubl.) Urb.: 11267

Verbenaceae
Petrea macrostachya Benth.: 11373a
Petrea volubilis L.: 11373, 11286
Vitex compressa Turcz.: 11344
Vitex orinocensis Kunth var. *multiflora* (Miq.) Huber: 11086

Violaceae
Rinorea amapensis Hekking: 11160, 11226, 11145, 11268, 11234, 11078, 11243, 11211, 11381

Vitaceae
Cissus erosa Rich.: 11167
Cissus verticillata (L.) Nicolson & C.E. Jarvis: 11312

Vittariaceae
Antrophyum cajenense (Desv.) Spreng.: 11366

Vochysiaceae
Vochysia tetraphylla (G. Mey.) DC.: 11257

Appendix 3

Aquatic invertebrate taxa (family, genus, species) and number of individuals collected in each of the AquaRAP sampling areas

Guido Pereira and Haydi J. Berrenstein

Phylum/Class	Order	Family	Genus and Species	Area				
				Main Channel	Rechter	Linker	Midden	Adampada Creek
Annelida/Hirudinea	Rynchobdellida	Glossiphonidae			24			3
Arthropoda/Crustacea	Decapoda	Palaemonidae	*Macrobrachium brasiliensis*		35	3		14
			Macrobrachium faustinum	42	73	81	11	127
			Macrobrachium jelskii			1	1	
			Palaemonete carteri					26
		Eurythynchidae	*Euryrhynchus wrzesniowskii*		14			
			Valdivia sp.		7	3	1	24
	Decapoda (Brachyura)	Trichodactylidae	*Dilocarcinus spinifer*		2	5	3	5
		Pseudothelphusidae	*Kingsleya latifrons*	14	6	9	3	8
Arthropoda/Maxillopoda	Arguloida	Argulidae	*Argulus* sp.			13		
			Dolops sp.			37		
Arthropoda/Insecta		Coleoptera				1		
		Dytiscidae			6	9	7	11
		Elmidae			2	14	7	7
		Gyrinidae					2	1
		Helodidae			1		1	19
		Hydrophilidae					1	5
		Sphaeridae				1		
	Diptera	Chironomidae		155	507	875	171	198
		Culicidae		64		1		
		Simulidae		179	28	512	219	485
		Typulidae						1
	Ephemeroptera	Baetidae		12	85	536	125	339
		Leptophlebiidae		132	53	137	13	230
		Polymitarcyidae				8		7
		Siphlonuridae				2		

Phylum/Class	Order	Family	Genus and Species	Area				
				Main Channel	Rechter	Linker	Midden	Adampada Creek
		Tricorythidae		6	4	18	10	23
	Hemiptera	Belostomatidae				2	1	
		Corixidae		14				1
		Guerridae		18	7	20	10	13
		Nepidae			2	2	2	
	Lepidoptera	Piralidae		8		8	19	2
	Megaloptera	Corydalidae						2
		Sialidae						2
	Odonata	Calopterygidae		1		10	1	1
		Coenagrionidae		3	4	3		17
		Cordulidae		11	18	5		2
		Gomphidae		4	6	4	5	4
		Lestidae		5	5	6		1
		Libelulidae		13	1	10	2	6
	Plecoptera	Perlidae			1	3		
	Trichoptera	Hydroxychidae		8	1	13		11
		Rhyacophilidae			3	12	9	34
Mollusca/Gastropoda	Architaenioglossa	Ampullariidae	*Pomacea granulosa*	1				
			Pomacea sinamarina	5	3	15	4	4
			Pomacea glauca glauca		5	8	4	7
			Pomacea glauca orinocensis			2		1
	Basommatophora	Ancylidae		1				
		Planorbidae	*Drepanotrema* sp.					5
	Neotaenioglossa	Thiaridae	*Doryssa derivans*	19	1	11	14	20
			Doryssa atra	2		1	1	
			Doryssa hohenackeri hohenackeri			1		13
			Doryssa hohenackeri kappleri				1	23
			Doryssa geijskesi			3		7

Phylum/Class	Order	Family	Genus and Species	Area				
				Main Channel	Rechter	Linker	Midden	Adampada Creek
			Doryssa sp. a					2
			Doryssa sp. b					13
Mollusca/Bivalvia	Unionoida	Mycetopodidae	*Anodontites* sp.	1				1
	Veneroida	Pisidiidae	*Eupera* sp.	2				
Porifera/ Demospongiae	Haplosclerida	Metaniidae		1		1		1
TOTAL # TAXA				**26**	**28**	**41**	**28**	**44**

Appendix 4

Taxonomic notes on select fishes collected during the 2004 AquaRAP expedition to the Coppename River, Central Suriname Nature Reserve, Suriname

Philip W. Willink and Brian L. Sidlauskas

Comments by P.W. Willink:

OLDEST PRESERVED FRESHWATER NEOTROPICAL FISH SPECIMENS

Suriname holds an important place in the history of freshwater neotropical ichthyology because some of the oldest, if not The Oldest, preserved fish specimens came from this country in the early 18th Century (Kullander and Nijssen 1989). It should be noted that André Thevet traveled to Brasil in 1555. In 1558, he published an account of his travels in 'Les singularitez de la France antarctique, autrement nommée Amérique, and de plusieurs terres and isles decouvertes de nostre temps', in which he included a couple woodcuts and accounts of fishes. These are possibly the first illustrations of neotropical fishes (Cuvier 1995(1828), Dean 1923). Jean de Léry traveled to Brasil in 1556. In 1578, he published an account of his travels in 'Histoire d'un voyage faict en la terre du Brésil, autrement dite Amérique', in which he named several fishes. These are possibly the first 'formal' descriptions of neotropical fishes (Cuvier 1995(1828), Dean 1923). Georg Marcgrave (and Willem Piso) described and drew over one hundred fishes from Brasil between 1637-1644(?). As far as we know, these naturalists and others wrote about and illustrated fishes, but did not preserve specimens (Cuvier 1995(1828)).

The official beginning of modern taxonomic nomenclature is 'Systema Naturae' by Carolus Linnaeus (1758, 1766). He acquired some of his information from students that traveled throughout the world. Of these students, Pehr Löfling visited South America in 1751, and Daniel Rolander visited Suriname in 1755 (Linnaeus 1758, Cuvier 1995(1828)). It is not clear if they brought specimens to Linnaeus, but they did provide him with information. Linnaeus also examined the collections and read the publications of Peter Artedii (who examined Albertus Seba's collection) (1738), King Adolf Fredrik (Linnaeus 1754, 1764), and Johan Frederic Gronovius and Laurens Theodorus Gronovius (1754-1756). It is not always possible to determine how or where specimens were collected. However, there is documentation that Daniel Luyx Massis, director of the famous West India Company, acquired fishes from Suriname for the Gronovius collection (Wheeler 1958). Some of the Surinamese specimens still exist (Table A 4.1). They are either preserved in alcohol or dried skins pressed onto paper, and can be seen at the British Museum (Natural History) (London), Zoological Museum (Copenhagen), and the Swedish Museum of Natural History (Stockholm) (Wheeler 1958, 1989, Fernholm and Wheeler 1983).

***Eigenmannia* species**

Planquette et al. (1996) report two species of *Eigenmannia* from French Guiana, the common and widespread *E. virescens* with three dark longitudinal lines and the less common *Eigenmania* n.sp. with broad alternating dark and pale vertical bands. Eigenmann (1912) lists two species of *Eigenmannia* from Guyana, *E. macrops* with an eye diameter greater than maxillary length and *E. virescens* with an eye diameter equal to maxillary length.

None of the specimens collected during the Coppename AquaRAP have alternating dark and pale vertical bands, so they are not *Eigenmannia* n.sp. Nor do they have an eye diameter greater than maxillary length, so they are not *E. macrops*. This provisionally identifies them as *E. virescens*. However, two forms are recognized, differing by several characteristics (Table A 4.2).

Eigenmannia sp. 2 is commonly identified as *E. virescens*, a species distributed throughout almost all of South America east of the Andes. It was described by Valenciennes in 1842 based on figures (Plate 13) in 'Voyage dans l'Amérique méridionale' by A. d'Orbigny. A reproduction of the *virescens* figure can be found on page 120 in Mago-Leccia (1994). No types are known, but d'Orbigny traveled from 1826-1833 through Argentina, Chili, Paraguay, Brasil, Bolivia, and Perú, so the type locality is probably somewhere within this area. Regardless of the exact location, it is a long distance from the Guayana Shield.

Because of the poor quality of the type figure, lack of type specimens, and indeterminate type locality, it is very difficult to know what is the accurate description of *Eigenmannia virescens*. For example, the eye is large and the three longitudinal lines are not evident in the reproduction in Mago-Leccia (1994). Geographic variation has been commented upon (e.g., Ellis 1913), and it is possible that this species is actually a complex of many species, with *E. virescens* restricted to southern South America.

In 1845, Müller and Troschel described *Sternopygus lineatus* from Lake Amucu, Guyana. This species was later synonymized with *Eigenmannia virescens*. Dependent upon the original description and type material (which is extant), it may be appropriate to resurrect the species *lineatus* and apply this name to Guayanan fishes.

However, the identification key in Albert (2001) claims that Sternopygidae (including *Eigenmannia*) does not have an urogenital papilla, whereas a urogenital papilla is present in *Eigenmannia* sp. 2. This species may be *E. virescens*, *Eigenmannia* (*Sternopygus*) *lineatus*, or a completely different species that may or may not even be in the genus *Eigenmannia*. This group is desperately in need of revision.

As seen in Table A 4.2, *Eigenmannia* sp. 1 differs in several characters from *Eigenmannia* sp. 2. Gymnotids are known to exhibit substantial allometric changes and sexual dimorphism (Albert 2001, Cox Fernandes et al. 2002). In our limited sample, *Eigenmannia* sp. 1 does tend to be larger

Table A 4.1. Species described by Linnaeus based on what is believed to be Surinamese material. Information from Wheeler (1958, 1989), Fernholm and Wheeler (1983), and Eschmeyer (2004). Abbreviations as follows: BMNH = British Museum (Natural History), NRM = Swedish Museum of Natural History, UUZM = Uppsala University Zoological Museum, ZMUC = Zoological Museum, University of Copenhagen.

Taxa	Museum with preserved specimens
Achirus (*Pleuronectes*) *achirus* (Linnaeus 1758)	No existing specimens known.
Ageneiosus (*Silurus*) *inermis* (Linnaeus 1766)	No existing specimens known.
Apteronotus (*Gymnotus*) *albifrons* (Linnaeus 1766)	No existing specimens known.
Astyanax (*Salmo*) *bimaculatus* (Linnaeus 1758) [1]	BMNH, NRM
Callichthys (*Silurus*) *callichthys* (Linnaeus 1758)	BMNH
Charax (*Salmo*) *gibbosus* (Linnaeus 1758)	BMNH
Cichlasoma (*Labrus*) *bimaculatum* (Linnaeus 1758) [2]	NRM
Crenicichla (*Sparus*) *saxatilis* (Linnaeus 1758)	BMNH, NRM
Doras (*Silurus*) *carinatus* (Linnaeus 1766)	No existing specimens known.
Electrophorus (*Gymnotus*) *electricus* (Linnaeus 1766)	No existing specimens known.
Gasteropelecus (*Clupea*) *sternicla* (Linnaeus 1758)	BMNH
Gymnotus carapo Linnaeus 1758	BMNH, NRM, UUZM
Hypostomus (*Acipenser*) *plecostomus* (Linnaeus 1758)	NRM, ZMUC
Loricaria cataphracta Linnaeus 1758	NRM, ZMUC
Polycentrus schombrugkii Müller & Traschel 1849 [3]	NRM
Pseudoplatystoma (*Silurus*) *fasciatum* (Linnaeus 1766)	No existing specimens known.
Pterengraulis (*Clupea*) *atherinoides* (Linnaeus 1766)	No existing specimens known.
Salmo notatus Linnaeus 1766 [4]	No existing specimens known.
Serrasalmus (*Salmo*) *rhombeus* (Linnaeus 1766)	No existing specimens known.

[1] Confusion about collection locality of all specimens.
[2] Specimen originally misidentified as *Labrus punctatus*. Current identification uncertain.
[3] Due to unusual circumstances, *Labrus punctatus* Linnaeus 1758 is a synonym.
[4] Unclear what this species is.

than *Eigenmannia* sp. 2, but some individuals from both species overlap in size. Also, males are present in both species, and the characters mentioned in Table A 4.2 can still be used to discriminate these specimens.

Ellis (1913) mentions that some *Eigenmannia virescens* in clear water have well developed longitudinal lines and a dusky fringe on the anal fin, whereas some of those in muddy water can be substantially paler, to the extent that the longitudinal lines and dusky fringe on the anal fin are absent. *Eigenmannia* sp. 1 has the anal fin with a dark fringe, but lacks the longitudinal lines, hence does not fit the color pattern variation described for *E. virescens*. *Eigenmannia* sp. 1 may be *Eigenmannia* (*Sternopygus*) *lineatus* (Müller and Troschel 1845), depending upon the species description. Or, *Eigenmannia* sp. 1 is a completely new species.

Other undescribed *Eigenmannia* species are in Venezuela (P.W. Willink, personal observation), and undoubtedly elsewhere. Once again, the genus *Eigenmannia* is in need of a careful systematic revision.

Hemiodus* cf. *quadrimaculatus

There are currently considered to be four species in the *Hemiodus quadrimaculatus*-group (Géry 1964, 1977, Langeani 1999). (Please note that some of these species were previously in the genus *Hemiodopsis*.) They are easily recognized by the four bold dark bands on the side of the body and caudal peduncle. According to Planquette et al. (1996), *H. quadrimaculatus* (*Hemiodopsis quadrimaculatus* or *Hemiodopsis quadrimaculatus quadrimaculatus* in Planquette et al. 1996, pages 100-101) is restricted to the eastern half of French Guiana. *Hemiodus huraulti* (*Hemiodopsis huraulti* in Planquette et al. 1996, pages 98-99) is restricted to western French Guiana and into Suriname. Somewhere further to the west in Suriname, *H. huraulti* is replaced by *Hemiodus vorderwinkleri* (or *Hemiodopsis quadrimaculatus vorderwinkleri*).

The specimens collected in the Coppename River have 41-43 perforated lateral line scales, if you count scales past the hypural plate and onto the tail. (This manner of counting scales seems to be the convention among hemiodontid workers. For an example, compare lateral scale counts for *Bivibranchia bimaculata* in Vari (1985) who counts scales to the hypural plate with Géry et al. (1991) who count scales past the hypural plate and onto the tail.) This identifies them as *Hemiodus quadrimacultus* or *H. vorderwinkleri* (42-45 perforated scales), because *H. huraulti* has 50 or more perforated scales (Géry 1964, Planquette et al. 1996). Furthermore, the specimens have 8 branched anal fin rays (a couple specimens did have 9), which is a characteristic of *H. vorderwinkleri* (*H. quadrimaculatus* has 9 branched anal fin rays) (Géry 1964). However, specimens between 55 and 85 mm standard length have 21 to 26 gill rakers on the lower arch. This character has a great deal of allometric variation, but Figure 3 in Géry et al. (1991) does a good job at presenting these changes, and the Coppename specimen values closely match *H. quadrimaculatus*. *Hemiodus vorderwinkleri* has 16-21 gill rakers (Géry 1964).

It is not clear to which species the Coppename specimens belong, but a closer look at the type localities may help. The type locality for *H. quadrimaculatus* is eastern French Guiana, and this is consistent with the distribution given by Planquette et al. (1996). The type locality for *H. huraulti* is western French Guiana, and this is also consistent with the distribution given by Planquette et al. (1996). The holotype locality for *H. vorderwinkleri* is the Brasilian-Colombian border near Leticia, with one paratype locality the same as the holotype and another paratype locality near Amatuk, Guyana (Géry 1964). These are a very long distance apart, and the official description is based on only five specimens from three localities (Géry 1964). More specimens

Table A 4.2. Comparison of two *Eigenmannia* species collected during the 2004 AquaRAP expedition to the Coppename River, Central Suriname Nature Reserve, Suriname.

Character	*Eigenmannia* sp. 1	*Eigenmannia* sp. 2
Anus position	Posterior	Anterior
Presence of urogenital papilla	Absent	Present
Snout length	1-1.25 eye diameter	1-1.25 eye diameter
Maxilla length	0.75 eye diameter (maybe a little less)	0.75 eye diameter
Body depth	1.25 head length (maybe a little more)	1.1 head length
Color	Pigmentation darker dorsally and fading ventrally. Dark fringe on distal margin of anal fin. Lacks three dark lines on body.	Anal fin largely clear. Three dark lines on body: 1) adjacent to anal fin, 2) dorsal of first line but not on ‘body proper’, 3) middle of body. See picture of *Eigenmannia virescens* on page 387 of Planquette et al. (1996) for this color pattern.

have been collected since 1964, so *H. vorderwinkleri* needs to be redescribed. My suspicion is that *H. vorderwinkleri* as originally described is actually a mixture of two species, and that the name will be applied to a Brasilian-Colombian species because this is the holotype locality. The Guyana species is probably new. This would explain why the Suriname specimens partially fit the characters in the *H. vorderwinkleri* description, but more closely resemble *H. quadrimaculatus*. Another possibility is geographic variation with a clinal distribution of character values within a single species. The entire *H. quadrimaculatus* - group needs to be revised, with close attention to geographic variation.

Although the Coppename specimens are currently being called *Hemiodus* cf. *quadrimaculatus*, there is an older name. As pointed out by Géry (1964), Eigenmann (1912) recognized that the Guyana specimens did not exactly match the French Guiana *H. quadrimaculatus* specimens. On pages 275-276, Eigenmann uses the name *H. quadrimaculatus* and says "evidently closely related to, if not identical with, *Hemiodus quadrimaculatus* Pelligrin" before describing the Guyana specimens. But in a species list on page 91, he uses the name *Hemiodus pellegrini* without providing a species description, hence creating a nomen nudum. Eigenmann even designated a type series that resides at The Field Museum. Five lots of *H. quadrimaculatus* collected by Eigenmann in Guyana include small additional labels inside the jars. These labels say '*Hemiodus pellegrini* Eigenmann' and whether the specimen was to be a type or cotype (FMNH 7330 n=2 cotype; FMNH 53451 cotype; FMNH 53452 n=5 cotypes; FMNH 53583 cotype; FMNH 53584 n=2 type and cotype).

Another interesting note is that the Guyana specimen figured in Eigenmann (1912, Plate 36, Figure 2) and The Field Museum specimens have three dark vertical bands on the body and a blotch on the caudal peduncle. This is also how it is described on page 276. The *H. quadrimaculatus* figured in Planquette et al. (1996, page 101) has the same three dark vertical bands on the body, but a fourth band on the caudal peduncle instead of a blotch. It is difficult to discern the pigmentation pattern in the *H. vorderwinkleri* and *huaralti* illustrations in Géry (1964). The Coppename specimens most closely resemble the Eigenmann (1912) illustration. The pigmentation pattern on the caudal peduncle may be another useful character or simply individual variation.

Hoplias aimara **and** ***Hoplias malabaricus***

The *Hoplias* species are undoubtedly some of the most impressive fishes in Suriname. These predators routinely reach lengths in excess of a meter, and do not appear to fear any other living creature in the rivers. For years the taxonomy of the group was confused, but this seems to have been largely clarified in French Guiana and Suriname by the efforts of Géry et al. (1991). However, some additional work still needs to be done.The most useful characters for distinguishing *Hoplias aimara* from *H. malabaricus* are related to eye size and position, with *H. aimara* having a relatively larger eye that is oriented dorso-laterally. The eye of *H. malabaricus* is relatively smaller and oriented laterally. These characters are illustrated in Figures 1 and 2 on pages 162 and 163 of Planquette et al. (1996). Another useful character that is illustrated in the same figures is the anterior tip of the branchiostegal membrane. In *H. aimara* it is rounded, whereas in *H. malabaricus* it is pointed, forming an easy to remember 'M' for *malabaricus*. Géry et al. (1991) provide additional information on other measurements.

Color can be used to tell the two species apart. *Hoplias aimara* is dark dorsally and pale on the sides of the body and ventrally. Over this background coloration there are even darker lines on the head radiating from the eye and several darker mottled bands on the body that start just below the lateral line and extend postero-dorsally. On close inspection, *H. malabaricus* has a similar basic coloration pattern. However, the pale, dark, and darker areas are more evenly pigmented, giving it an overall slightly mottled, but dark, look. There are also small dark spots on the head. There is a significant amount of individual variation among members of both species.

One potential difficulty with the above characters is the notorious allometry associated with eyes. In general, smaller fishes have relatively larger eyes. As an individual grows, the body grows faster than the eye, hence larger fishes have relatively smaller eyes. *Hoplias* are no exception. Fortunately, Géry et al. (1991) realized this and presented the results in Figure 2 of their publication. Although the head size to eye size ratio changes with standard length, it is still possible to distinguish between *H. aimara* and *H. malabaricus*. Unfortunately, Figure 2 in Géry et al. (1991) only covers the size range of about 20 to 220 mm standard length. Specimens of *H. malabaricus* are known to reach 380 mm, and *H. aimara* can exceed 1000 mm (Planquette et al. 1996). It is generally believed that only *H. aimara* reaches these larger sizes.

The characters described above work well for *Hoplias* specimens up to 460 mm standard length from the Coppename River, although the larger *H. aimara* begin to resemble *H. malabaricus* in coloration. However, there is a problem with one large specimen. Our guides caught a fish about a meter long. They ate the body, but we were able to persuade them to let us have the head. It has the following measurements:

Eye diameter = 37.64 mm
Interorbital width = 74.17 mm
Head length = 265.08 mm
Head length / interorbital width = 3.6
Head length / eye diameter = 7.0
Eye diameter / interorbital width = 0.5

Furthermore, the eyes are situated laterally on the head. These characteristics resemble those reported for *Hoplias malabaricus*, even though only *H. aimara* are supposed to reach this size. Either the characters no longer work at a certain size of fish or large *Hoplias* are being misidentified. It is possible that the eyes of *H. aimara* rotate from a dorsolateral position to a lateral position during ontogeny, but this has not been documented. A careful study detailing the allometry over the entire size range of these two species is needed to clarify the situation.

Some illustrations in Planquette et al. (1996) further confuse the issue. I measured eye diameter, head length, and standard length of the *Hoplias* in the photos in the species accounts. This is certainly not the best way to take data for a number of reasons, but this is what I came up with:

Hoplias aimara, page 165:
Eye diameter = 3.04
Head length = 21.61
Standard length = 86.37
Head length / eye diameter = 7.1
Standard length / eye diameter = 28.4
Standard length / head length = 4.0

Hoplias malabaricus, page 167:
Eye diameter = 5.38
Head length = 29.47
Standard length = 90.25
Head length / eye diameter = 5.5
Standard length / eye diameter = 16.8
Standard length / head length = 3.1

According to Géry et al. (1991) and the identification key on page 162 in Planquette et al. (1996), both fishes are *Hoplias malabaricus*. As a matter of fact, the *H. aimara* has a relatively smaller eye then the *H. malibaricus*. The coloration of the *H. aimara* in the picture is more typical for *H. malabaricus*, and the coloration of the *H. malabaricus* in the picture is more typical for *H. aimara*. The *H. aimara* is probably a large specimen, so this is part of the problem. Once again, a more detailed analysis of characteristics over the entire size range of these species is needed.

Other interesting projects concern the ecologies of these two very similar species. Do they live in the same microhabitats? Do they shift niches during ontogeny? And what about their diets? The relatively larger eyes of *Hoplias aimara* may indicate that they are more nocturnal (because larger eyes are capable of gathering more light) or perhaps have a greater reliance on vision as opposed to other senses. The dorsolateral position of the eyes in *H. aimara* may indicate that their prey are higher in the water column or at the surface, whereas the lateral position of the eyes in *H. malabaricus* may indicate that their prey are directly in front of the them or at least on the same level in the water column. And if the eyes of *H. aimara* rotate from dorso-lateral to lateral during ontogeny, then does its feeding habits change as well?

***Peckoltia* sp.**

A single specimen of an interesting fish was collected at Tonckens Vallen during the Coppename AquaRAP. It is a tan-brown suckermouthed armored catfish (Loricariidae) with several thin pale bands on the body and tail. Taxonomic keys identify it as being in the genus *Peckoltia* or *Hemiancistrus* (Eigenmann 1912, Le Bail et al. 2000, Armbruster 2004a). These two genera are polyphyletic (Armbruster 2004c), hence there are currently no known characters diagnosing these taxa (Cardoso and Lucinda 2003, Armbruster 2004c). The individual is arbitrarily placed in the genus *Peckoltia* because most currently recognize *Hemiancistrus* are spotted, whereas most *Peckoltia* are banded (Schaefer 1986, Burgess 1989, Cardoso and Lucinda 2003, Armbruster 2003). This unfortunate state of affairs will remain until a more comprehensive revision is completed.

At least seven species of *Peckoltia* / *Hemiancistrus* are known from the Guayana Shield, and there are undoubtedly more undescribed species. *Hemiancistrus medians*, *H. megacephalus*, *H. macrops* (possibly a synonym of *H. megacephalus*) and *P. sabaji* are spotted (Le Bail et al. 2000, Cardoso and Lucinda 2003, Armbruster 2003). *Peckoltia braueri* and *P.* (*H.*) aff. *braueri* are mottled / speckled with at least some scattered ossified plates on the abdomen (Eigenmann 1912, Le Bail et al. 2000). *Peckoltia yaravi* apparently has at least some scattered ossified plates on the abdomen (Armbruster 2004b), but this should be verified.

Peckoltia sp. lacks ossified plates on the abdomen and has a coloration pattern in which the bands originate at the dorsal midline then extend postero-ventrally. These characters do not match any of the currently described taxa. The 'Tonckens Vallen Peckoltia' is almost certainly a new species. Additional specimens need to be collected and studied before publishing an official scientific species description.

Comments by B.L. Sidlauskas:

ANOSTOMID SPECIES FROM THE 2004 SURINAME AQUARAP

***Anostomus anostomus* (Linnaeus 1758)**

Anostomus anostomus is the earliest described anostomid fish, and as is typical of Linnaeus' species the type locality is uncertain. The type (ZMUC 89) was part of the personal collection of Gronovius (Wheeler 1989), and other Neotropical material from that collection has a confirmed origin in Suriname (e.g., the type of *Charax gibbosus*, BMNH 1853.11.12.35) (Wheeler 1958, 1989). Therefore the type of *A. anostomus* was probably collected somewhere in Suriname.

Several lots of fishes from the Coppename material appear to match the photograph of the *Anostomus anostomus* type in Wheeler (1989). Given the probable Surinamese origin of that type, the Coppename material can be confidently assigned that species. However, the affinity of the Coppename material with specimens of *A. anostomus* from outside of Suriname is debatable. The life coloration of the Coppename *A. anostomus* differs from those found in other parts of South America in that the brilliant red coloration of the caudal fin extends well onto the caudal peduncle. In specimens from Venezuela and Guyana, the red coloration of the caudal fin is mostly confined to the rays proper and their associated membranes (B. Chernoff, pers. comm. 2004). Given that other well known species in the subfamily Anostominae have been split taxonomically in recent years (Winterbottom 1980, Sidlauskas and Santos 2004) it is possible that *A. anostomus* actually represents a species complex including one or several undescribed forms. A detailed morphometric, osteological and/or genetic study of the species across its range, which includes the Orinoco, the Caribbean-facing drainages of the Guyana Shield and the upper Amazon (Winterbottom 1980), would clarify the situation. Such a study could also test the validity of *Anostomus brevior*, a deep bodied but clearly related form known only from French Guiana, and *Anostomus anostomus longus*, an elongate form described from the Nucuray River in the Peruvian Amazon.

***Leporinus* cf. *cylindriformis* Borodin 1929**

The *Leporinus* specimen in Figure A 4.1could not be identified to species. Its unusually elongate body proportions match those of the poorly known *Leporinus cylindriformis* (Table A 4.3). However, the original illustration of the holotype (Borodin 1929) shows only three black markings along the lateral line. The Coppename specimen has an additional lateral marking at the anterior end of the lateral line, and all four of these spots are nearly circular in form. The markings on the *L. cylindriformis* holotype are longitudinally elongate. The Coppename specimen also has two small spots below the lateral line and a series of dark bars along the dorsum, none of which appear in the *L. cylindrformis* illustration (Borodin 1929). The Coppename specimen's markings closely resemble those found in *Leporinus gossei* from French Guiana (Géry et al. 1991). However, the squamation and body proportions of the Coppename specimen do not fall within the known range for *L. gossei* (Table A 4.3). Furthermore, the Coppename specimen has a distinctly subterminal mouth with the premaxillary teeth greatly overhanging those of the dentary. In *L. cylindriformis* and *L. gossei* the mouth is more or less terminal.

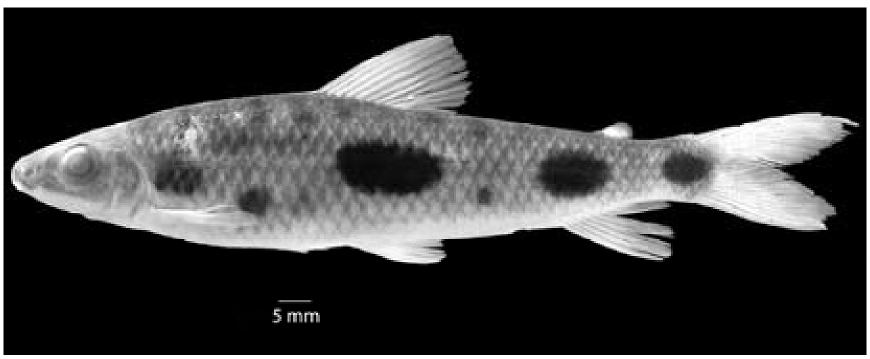


Figure A 4.1. *Leporinus* cf. *cylindriformis*, 115.6 mm SL, station S2004-F-32. Photo by M. Littmann

Table A 4.3. Meristic and morphometric comparison of *Leporinus* cf. *cylindriformis* (from the Coppename), the holotype of *Leporinus cylindriformi*s MCZ 20430 (from Porto de Moz, Pará, Brazil), and the type series of *Leporinus gossei* (from French Guiana). Head length and body depth are expressed as percentages of standard length. Eye diameter and snout length are expressed as percentages of head length.

	Leporinus cf. *cylindriformis*	*Leporinus cylindriformis*	*Leporinus gossei*
Lateral line scales	41	44	36-37
Scales above lateral line	6	6	4-5
Scales below lateral line	4.5	7	4.5
Head length	23.4	22.2	25.6-29.0
Body depth	21.3	21.1	29.9-33.7
Eye diameter	31.5	25.0	20.5-28.6
Snout length	41.2	40.0	36.7-40.7
Dorsal fin-rays	ii, 10	12	ii, 10
Anal fin-rays	ii, 8	10	ii, 8
Pelvic fin-rays	9	9	i, 8
Upper teeth	4	4	4
Lower teeth	4?	4	4

It is quite possible that this enigmatic specimen from the Coppename represents an undescribed species. However, given the taxonomic confusion that surrounds *Leporinus* and the disjunct distributions of many Neotropical fishes, it is possible that this species has been described, perhaps from a geographically distant locality. Until more specimens are available, I prefer to place the nomenclatural issue in abeyance.

***Leporinus fasciatus* (Bloch 1794)**

The type locality of *Leporinus fasciatus* is an unknown locality in Suriname, and thus the yellow- and black-banded *Leporinus* with all bands of similar width encountered in the Coppename is almost certainly the true *L. fasciatus*. The name is also commonly applied to individuals collected throughout the Amazon river drainage.

***Leporinus friderici* (Bloch 1794)**

Considerable confusion surrounds the nomenclature of *Leporinus friderici* and a host of similar forms. *Leporinus friderici* is commonly applied as a catch-all name to specimens with a terminal mouth, approximately 36 or 37 pored scales in the complete lateral line, and a series of three black spots along the lateral line: one beneath the dorsal fin, one above the anal fin, and one on the caudal peduncle. A color pattern of three lateral spots is extremely common among *Leporinus* species, and dozens of names have been applied to species exhibiting this color pattern or variations thereof. It is not at all clear which names might be in the synonymy of *L. friderici* and which represent distinct species. There are no satisfactory keys to the group, and Géry's notable attempt (1977) is significantly out of date.

For the present purposes, it is sufficient to know that only one species in this group was captured in the Coppename. Because Suriname is the type locality for *Leporinus friderici*, I am reasonably confident that the Coppename specimens represent the true *L. friderici*. However, I have not seen the types or original description of *L. friderici*, as Bloch's volumes are unfortunately quite rare.

Valenciennes had access to Bloch's types, and an intriguing passage from his supplementary description of *L. friderici* (Cuvier and Valenciennes 1849), may provide an additional clue:

> "L'anale a une tache noiré oblongue, est quelquefois le bord est coloré. Cette tache ne disparaît pas plus que celle des flancs, et est caractéristique dans ce poissons.
> Je la retrouve dans les huit exemplaires que j'ai examines. Elle n'avait pas échappé advantage à M. d'Orbingny, qui l'avait représentée dans les croquis de cette espèce, faits à Monte-Video. On voit aussi qu'il en restait quelques traces sur les individus de Bloch; il seulement donné à cette tache de l'anale une teinte bleuâtre."

This passage translates as follows:

> "The anal has an oblong black spot and sometimes the edge is colored. This spot does not disappear more than those on the flanks and is characteristic in these fish.
> I recovered it in the eight examples that I examined. It had not escaped the notice of Mr. d'Orbigny, who represented it in the sketches of this species made at Montevideo. One sees also that a few traces of it remain on Bloch's individuals; it gives only a bluish tint to this spot of the anal fin."

In preservative, the Coppename specimens have dusky anal fins with hyaline distal margins. Though there is no distinct spot with clear borders on the anal fins in these specimens, the anal fin is noticeably darker than the dorsal fin and paired fins. This coloration agrees with Valenciennes' notes on Bloch's types and suggests that the Coppename specimens represent the true *Leporinus friderici*.

Suriname is also the type locality for *Leporinus lebaili*, a species which closely resembles *L. friderici*. Juveniles and adults of *L. lebaili* are diagnosed by a fourth faint spot centered on the lateral line anterior to dorsal fin insertion and an additional black bar bordering the branchial opening dorsal to the pectoral fin (Géry and Planquette 1983). The fourth spot and branchial bar are not present in the Coppename material

***Leporinus maculatus* Müller and Troschel 1844**

When Géry et al. (1988) translated Müller and Troschel's original description of *Leporinus maculatus* and examined its type in Berlin, they discovered that despite common application to various species of *Leporinus* with circular spots covering most of the body, the name correctly applies to a species of *Leporinus* from Guyana with alternating wide and narrow dark vertical bars. The confusion apparently stems from Valenciennes' incorrect referral of a *Leporinus* with spots along, above and below the lateral line to *L. maculatus* (Cuvier and Valenciennes 1849). Though Valenciennes's error is understandable given the extreme brevity of Müller and Troschel's Latin description, the mistake has been perpetuated and the name is currently applied to a variety of multiply spotted leporins throughout South America including *Leporinus granti*, *Leporinus nijsseni*, *Leporinus megalepis* and *Leporinus ortomaculatus*.

Géry et al's work appears to have been largely overlooked, perhaps because they published in French, a language not immediately accessible to English-, Spanish- and Portuguese-speaking scientists. Below I have paraphrased the crux of their argument for applying the name *Leporinus maculatus* to the Guyanese species with alternating wide and narrow dark bars.

Müller and Troschel's original description (1844) reads: "Maculis nigris magnis in lateribus. D.13. A.11. An Varietas

L. novemfasciati, quocum dimensionibus convenit. Squamae in linea laterali 38. Hab. In fluviis Guianae," which translates roughly as: "Large black spots along the sides. 13 dorsal rays and 11 anal rays. Or variety of *Leporinus novemfasciati*, whether(?) measurements agree. Scales in lateral line 38. Lives in Guyanese rivers."

From this description, it is clear that Müller and Troschel considered *Leporinus maculatus* and *Leporinus novemfasciati* (=*Leporinus novemfasciatus* Spix and Agassiz) to be sufficiently similar that *L. maculatus* might be a "variety" of *L. novemfasciatus*. *Leporinus novemfasciatus* is currently in the synonymy of *L. fasciatus* (Garavello and Britski 2003) and possesses dark vertical bands with regular widths. Müller and Troschel's association of *L. maculatus* with *L. novemfaciatus* but not *Leporinus nigrotaeniatus* (with a partial stripe along the lateral line) or *Leporinus friderici* (with three spots along the lateral line) suggests that the markings in the true *L. maculatus* resemble the vertical bands in *L. fasciatus* and not the multiply spotted forms commonly called *L. maculatus*.

To my and Géry et al.'s knowledge, the only two species of Guyanese *Leporinus* with dark vertical black bars are the well known *Leporinus fasciatus*, and the species with alternating wide and narrow vertical bands pictured in Figure A 4.2. Three other names have been applied to this alternately banded leporin: *Leporinus pellegrini* Steindachner *Leporinus alternus* Eigenmann, and *Leporinus paralternus* Fowler. Géry et al. place all three of these names in the synonymy of *Leporinus maculatus*, but then discuss slight differences in coloration and morphometrics and raise the possibility that *L. pellegrini* and *L. alternus* together represent a distinct sub-

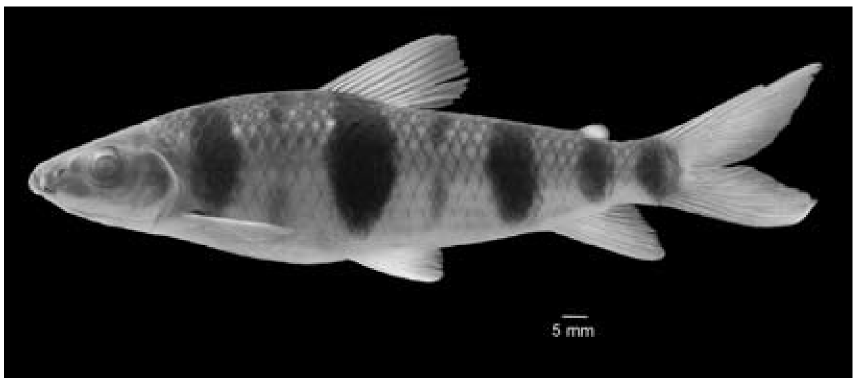


Figure A 4.2. *Leporinus maculatus*, station S2004-F-32. Photo by M. Littmann.

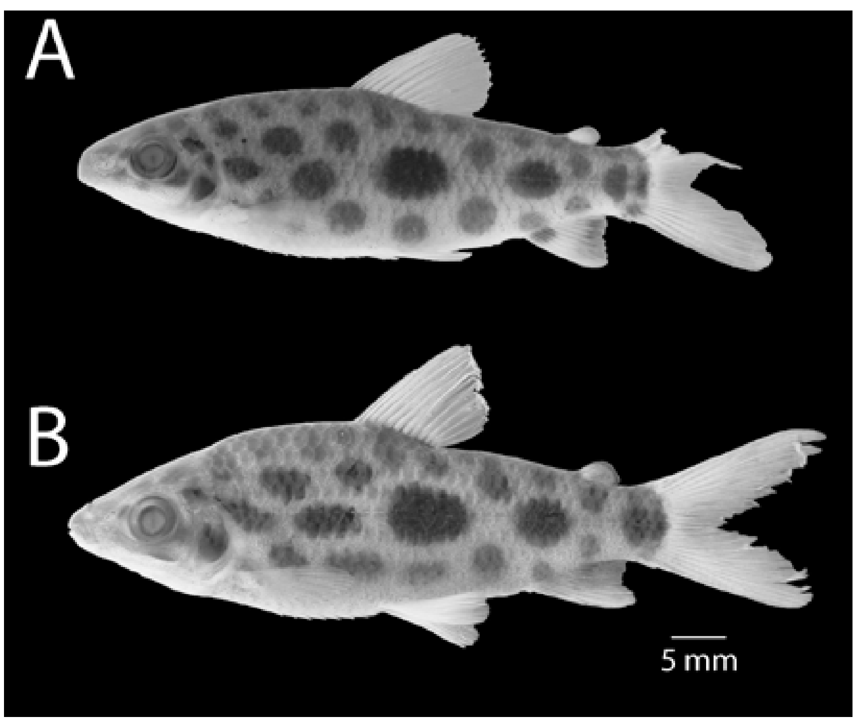


Figure A 4.3. A) *Leporinus megalepis*, 45.9 mm SL, station S2004-F-17 and B) *Leporinus nijsseni*, 47.4 mm SL, station S2004-F-21. Photos by B. Sidlauskas.

species. A new revision of this species group with osteological comparisons and measurements of genetic similarity will be necessary to determine whether any of the three junior synonyms merit continued taxonomic recognition.

Several *Leporinus* with alternating wide and narrow dark vertical bands were collected in the Coppename (Figure A 4.2). Though I have not seen the type of *Leporinus maculatus* in Berlin, based on the redescription in Géry et al. (1988) and the proximity of the Coppename to the type locality (the Rupununi River), I am confident that these specimens represent the true *L. maculatus*.

***Leporinus megalepis* Günther 1863**

Günther's original description of *Leporinus megalepis* is too brief to be useful: "D. 12, A. 12. L. lat 33. L. trans 5/5. Body with large blackish spots, arranged in two or three series; fins red." Even more problematically, the three syntypes of *L. megalepis* each represent a distinct species. According to Géry et al. (1988), the largest specimen has only a single series of spots and 36 lateral line scales. It can be confidently assigned to the *Leporinus friderici* group. The two smaller syntypes have multiple series of spots but differ in the position of the mouth and in the pattern of spotting. One has a terminal mouth and matches the types of *Leporinus granti* Eigenmann. The other has a subterminal mouth and matches no other described species. Géry et al. (1988) designated the specimen with the subterminal mouth (BMNH 1864.1.21: 45) as the lectotype for *L. megalepis* and redescribed the species.

Several specimens matching the redescription of *Leporinus megalepis* were collected in the Coppename (Figure A 4.3). This species was collected frequently alongside the superficially similar *Leporinus nijsseni*. Both species exhibit multiple series of black spots along their flanks, but side by side comparison reveals numerous differences (Figure A 4.3A,B). *Leporinus megalepis* is distinguished from *L. nijsseni* in possession of a subterminal mouth (vs. terminal), 16 circumpeduncular scales (vs. 12) and 3 teeth on each dentary and premaxilla (vs. 4). The pattern of spots on the anal fins is also diagnostic of these two species. The anal fin in *L. megalepis* has a distinct spot at the anterior extreme immediately ventral to a similar spot on the body. The anal fin in *L. megalepis* also has a dark posterior margin. In *L. nijsseni* the anal fin has a diffuse dark bar along the middle of the fin rays but lacks the anterior spot and the dark margin. *Leporinus nijsseni* also possesses a dark horizontal bar below the eye and along the ventral margin of the third infraorbital. This dark bar is absent in *L. megalepis*.

***Leporinus nijsseni* Garavello 1990**

The species of heavily spotted *Leporinus* with a terminal mouth encountered in the Coppename is *Leporinus nijsseni* (Figure A 4.3B). This species is very similar to *Leporinus granti* from Guyana, but can be distinguished by possession of 12 circumpeduncular scales (vs. 16) and absence of a dark bar linking the anteriormost spot of the lateral line to the row of spots immediately ventral (vs. such a bar present). *Leporinus granti* was not encountered among the Coppename specimens.

Leporinus megalepis is superficially similar to *Leporinus nijsseni* and both were collected together in the Coppename. Several characters which may be used to separate these species are listed in the note on *L. megalepis* above.

LITERATURE CITED

Albert, J.S. 2001. Species diversity and phylogenetic systematics of American kifefishes (Gymnotiformes, Teleostei). Miscellaneous Publications, Museum of Zoology, University of Michigan 190: 1-127.

Armbruster, J.W. 2003. *Peckoltia sabaji*, a new species from the Guyana Shield (Siluriformes: Loricariidae). Zootaxa 344: 1-12.

Armbruster, J.W. 2004a. A key to the genera of Loricariidae. Web site: http://george.cosam.auburn.edu/usr/key_to_loricariidae/key.html (accessed 2004 September 24).

Armbruster, J.W. 2004b. *Peckoltia* A. Miranda Ribeiro, 1912. Web site: http://george.cosam.auburn.edu/usr/key_to_loricariidae/Peckol/Peckol.html (accessed 2004 September 24).

Armbruster, J.W. 2004c. Phylogenetic relationships of the suckermouth armoured catfishes (Loricariidae) with emphasis on the Hypostominae and Ancistinae. Zoological Journal of the Linnean Society 141: 1-80.

Artedii, P. 1738. Ichthyologia, sive opera omnia piscibus scilicet: bibliotheca ichthyologica. philosophia ichthyologica. genera piscium. synonymia specierum. descriptiones specierum. omnia in hoc genere perfectiora, quam antea ulla. posthuma vindicavit, recognovit, coaptavit et edidit Carolus Linnaeus, Med. Doct. et Ac. Imper. N.C. Leiden.

Borodin, N.A. 1929. Notes on some species and subspecies of the genus *Leporinus* Spix. Memoirs of the Museum of Comparative Zoology 50: 269-290.

Burgess, W.E. 1989. An atlas of freshwater and marine catfishes: a preliminary survey of the Siluriformes. Neptune City, New Jersey: T.F.H. Publications.

Cardoso, A.R. and P.H.F. Lucinda. 2003. Three new species of *Hemiancistrus* (Teleostei: Siluriformes: Loricariidae) from the rio Tocantins basin with comments on the genus. Ichthyological Exploration of Freshwaters 14: 73-84.

Cox Fernandes, C., J.G. Lundberg, and C. Riginos. 2002. Largest of all electric-fish snouts: hypermorphic facial growth in male *Apteronotus hasemani* and the identity of *Apteronotus anas* (Gymnotiformes: Apteronotidae). Copeia 2002: 52-61.

Cuvier, G. 1995(1828). Historical portrait of the progress of ichthyology, from its origins to our own time. Originally published in 1828. Republished with annotations by T.W. Pietsch (ed.) in 1995. Baltimore, Maryland: The Johns Hopkins University Press.

Cuvier, G. and A. Valenciennes. 1849. Histoire naturelle des poissons. Tome vingt-deuxième. Suite du livre vingt-deuxième. Suite de la famille des Salmonoïdes.

Dean, B. 1923. A bibliography of fishes. Volume 3. New York, New York: The American Museum of Natural History.

Eigenmann, C.H. 1912. The freshwater fishes of British Guiana, including a study of the ecological grouping of species and the relation of the fauna of the plateau to that of the lowlands. Memoirs Carnegie Museum 5: 1-578.

Ellis, M.M. 1913. The gymnotid eels of tropical America. Memoirs of the Carnegie Museum 6: 109-195.

Eschmeyer, W. 2004. CAS - Ichthyology - Catalog of Fishes, California Academy of Sciences, San Francisco, CA, USA. Web site: http://www.calacademy.org/research/ichthyology/catalog/fishcatsearch.html (accessed 2004 September 23).

Fernholm, B. and A. Wheeler. 1983. Linnaean fish specimens in the Swedish Museum of Natural History, Stockholm. Zoological Journal of the Linnean Society 78: 199-286.

Garavello, J.C. and H.A. Britski. 2003. Family Anostomidae *In*: Reis, R.E., S.O. Kullander, and C.J. Ferraris Jr. (eds.). Check list of the freshwater fishes of South and Central America. Porto Alegre, Brazil: EDIPUCRS. Pp. 71-84.

Géry, J. 1964. New species of hemiodin characoid fishes forming the *Hemiodopsis quadrimaculatus*-group. Tropical Fish Hobbyist, November: 11,13-15,69-72,73.

Géry, J. 1977. Characoids of the world. Neptune City, New Jersey: T.F.H. Publications.

Géry, J., and P. Planquette. 1983. Une nouvelle espèce de *Leporinus* (Poissons characoïdes, Anostomidés) de la Guyane et du Surinam: *Leporinus lebaili* n.sp. Revue Française d'Aquariologie, Herpâetologie 10: 65-70.

Géry, J., P. Planquette, and P.-Y. Le Bail. 1988. Nomenclature des espèces du groupe *Leporinus maculatus* et formes affines des Guyanes (Pisces, Characoidei, Anostomidae). Revue Suisse de Zoologie 95: 699-713.

Géry, J., P. Planquette, and P.-Y. LeBail. 1991. Faune characoide (poissons ostariophysaires) de L'Oyapock, L'Approuague et la Riviere de Kaw (Guyane Française). Cybium 15(supplement): 1-69.

Gronovius, L.T. 1754-1756. Museum ichthyologicum, sistens piscium indigenorum et quorumdam exoticorum, qui in museo Laurentii Theodori Gronovii, J.U.D. adservantur, descriptiones ordine systematico. accedunt nonnullorum exoticorum piscium icones aeri incisae. Leiden.

Kullander, S.O. and H. Nijssen. 1989. The cichlids of Surinam. Leiden: E.J. Brill.

Langeani, F. 1999. New species of *Hemiodus* (Ostariophysi, Characiformes, Hemiodontidae) from the Rio Tocantins, Brazil, with comments on color patterns and tooth shapes within the species and genus. Copeia 1999: 718-722.

Le Bail, P.-Y., P. Keith, and P. Planquette. 2000. Atlas des poissons d'eau douce de Guyane. Tome 2 – fascicule II. Siluriformes. Paris: Museum National d'Histoire Naturelle.

Linnaeus, C. 1754. Museum S:ae R:ae M:tis Adolphi Friderici…in quo animalia rariora imprimis, et exotica: quadrupedia, aves, amphibia, pisces, insecta, vermes describuntur et determinantur, Latine et Svetice, cum iconibus, jussu Sac. Reg. Maj:tis a Car. Linnaeo, Equ. Stockholm.

Linnaeus, C. 1764. Museum S:ae R:ae M:tis Adolphi Friderici…in quo animalia rariora imprimis, et exotica: quadrupedia, aves, amphibia, pisces, insecta, vermes describuntur et determinantur, Latine et Svetice, cum iconibus, jussu Sac. Reg. Maj:tis a Car. Linnaeo, Equ. Tomi secundi prodromus. Stockholm.

Linnaeus, C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. 10th edition. Stockholm.

Linnaeus, C. 1766. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. 12th edition. Stockholm.

Mago-Leccia, F. 1994. Electric fishes of the continental waters of America: classification and catalogue of the electric fishes of the order Gymnotiformes (Teleostei: Ostariophysi), with descriptions of new genera and species. Caracas: Fundacion para el Desarrollo de las Ciencias Fisicas, Matematicas y Naturales.

Müller, J. and F.H. Troschel. 1844. Synopsis generum et specierum familae Characinorum. (Prodromus descriptionis novorum generum et specierum). Archiv fur Naturgeschichte 10: 81-99.

Müller, J. and F. H. Troschel. 1845. Horae Ichthyologicae. Beschreibung und Abbildung neuer Fische. Die Familie der Characinen. Erstes und Zweites Heft. Berlin. Horae Ichthyologicae Nos. 1 & 2: 1-40, Plates 1-11.

Planquette, P., P. Keith, and P.-Y. Le Bail. 1996. Atlas des poissons d'eau douce de Guyane. Tome 1. Paris: Museum National d'Histoire Naturelle.

Schaefer, S.A. 1986. Historical biology of the loricariid catfishes: phylogenetics and functional morphology. Unpublished Ph.D. thesis. Chicago, Illinois: University of Chicago.

Sidlauskas, B. and G. Santos. 2004. *Pseudanos winterbottomi*, a new anostomine species (Teleostei: Characiformes: Anostomidae) from Venezuela and Brazil, and comments on its phylogenetic relationships. Copeia. in press.

Valenciennes, A. 1834-42. Poissons [plates]. *In:* d'Orbigny, A. Voyage dans l'Amérique méridionale. Poissons Amérique Méridionale. Plates 1-16. [Text published in

1847. Plates 1-10 published between 1834-36, 11-16 before 1842; Plate 3 is 1835.]

Vari, R.P. 1985. A new species of *Bivibranchia* (Pisces: Characiformes) from Surinam, with comments on the genus. Proceedings of the Biological Society of Washington 98: 511-522.

Wheeler, A. 1958. The Gronovius fish collection: a catalogue and historical account. Bulletin of the British Museum (Natural History), Historical Series 1: 185-249.

Wheeler, A. 1989. Further notes on the fishes from the collection of Laurens Theodore Gronovius (1730-1777). Zoological Journal of the Linnean Society 95: 205-218.

Winterbottom, R. 1980. Systematics, osteology and phylogenetic relationships of fishes of the ostariophysan subfamily Anostominae (Characoidei, Anostomidae). Life Sciences Contributions: Royal Ontario Museum 123: 1-112.

Appendix 5

Collectors of freshwater fishes in Suriname

Jan H. Mol

CORANTIJN RIVER

Richard Schomburgk, Corantijn River, 1840-1844?
K.M. Hulk, Corantijn and Lucie rivers, 1910-1911 (Corantijn Expedition)
H.P. Pijpers, Sipaliwini River, 1961
H.P. Pijpers, Lucie River, 1963
G.F. Mees, Kabalebo River, 1965
G.F. Mees, Sipaliwini River, 1966
M.S. Hoogmoed, Lucie and Coeroeni rivers, 1968, 1975
M. Boeseman and D.C. Geijskes, Kabalebo River and Kaboeri Creek, 1971
M.S. Hoogmoed, Zuid River, 1975
R.P. Vari, Corantijn and Kabalebo rivers and Kaboeri Creek, 1979-1980

NICKERIE RIVER

D.C. Geijskes, Nanni Creek, 1941
H. Nijssen, Nickerie River, 1967
M. Boeseman and D.C. Geijskes, Nickerie and Maratakka rivers, 1971

COPPENAME RIVER

H.A. Boon, 1901 (Coppename Expedition)
D.C. Geijskes, 1943-1944, 1957, 1958
H. Nijssen, 1967
G.F. Mees, 1972

SARAMACCA RIVER

P.J. de Kock, upper Saramacca River, 1902-1903 (Saramacca Expedition)
W.C. van Heurn, lower Saramacca River at Groningen, 1911
M. Boeseman, 1964
H. Nijssen, 1967, Kleine Saramacca River
J.H. Mol and P.E. Ouboter, Mindrineti and Kleine Saramacca rivers, 1996-1996

SURINAME RIVER

H.H. Dieperink, lower Suriname River at Paramaribo, 1816-1836
W.C. van Heurn, lower Suriname River at Paramaribo, 1911
D.C. Geijskes, middle Suriname River at Kabelstation, 1938
D.C. Geijskes, lower and middle Suriname River, 1942-1947
J. van de Kamp, Para River and lower Suriname River, 1956
M. Boeseman, 1963-1964
G.F. Mees, 1965-1966
H. Nijssen, 1966-1967
M.S. Hoogmoed, Para River, 1974
C.J.J. Richter, Lake Brokopondo, 1978

COMMEWIJNE RIVER

P.H. Creutzberg, Lai Creek, Moengotapoe, 1948
W. Vervoort, Ricanau Creek, 1966
H. Nijssen, Ricanau Creek, 1966
M.S. Hoogmoed, Wane Creek, 1975
J.H. Mol and P.E. Ouboter, Mapane Creek, 1997

MAROWIJNE RIVER

A. Kappler, 1846-1879
G.M. Versteeg, Gonini and Tapanahoni rivers, 1903-1904 (Gonini Expedition)
E.C. Stol, lower Marowijne River, 1951
D.C. Geijskes, Litanie River (1939), Marowijne River (1952, 1953, 1954)
J. Géry, Litani, 1957
J.P. Gosse, Lawa, Tapanahoni/Paloemeu, Oelemari rivers, 1966 and 1969
G.F. Mees, Tapanahoni River, 1965-1966
H. Nijssen, Tapanahoni and Marowijne rivers, 1967
P. Planquette and P.Y. Le Bail, Marowijne River, 1978-1995
P.E. Ouboter, Oelemari River, 1994(?)

Appendix 6

Fishes and the drainage they were collected in during the 2004 AquaRAP expedition to the Coppename River, Central Suriname Nature Reserve, Suriname

Jan H. Mol, Phillip Willink, Barry Chernoff, and Michael Cooperman

	Drainage					Number of specimens
Taxa	Rechter	Linker	Midden	Coppename	Adampada	
Rajiformes						
Potamotrygonidae						
Potamotrygon orbignyi	-	-	-	-	●	1
Characiformes						
Anostomidae						
Anostomus anostomus	●	●	●	●	●	13
Leporinus cf. *cylindriformis*	-	-	-	●	-	1
Leporinus fasciatus	-	-	-	●	-	2
Leporinus friderici	●	-	-	-	-	5
Leporinus maculatus	-	-	-	●	●	9
Leporinus megalepis	●	●	●	●	●	44
Leporinus nijsseni	●	-	●	●	●	25
Characidae						
Acestrorhynchus falcatus	●	-	-	-	-	1
Acestrorhynchus microlepis	●	●	-	●	-	8
Aphyocharacidium melandetum	●	-	-	-	-	1
Astyanax bimaculatus	●	-	-	-	●	5
Brachychalcinus orbicularis	-	●	-	●	●	28
Brycon falcatus	●	-	-	●	-	4
Bryconops affinis	●	●	-	●	●	48
Bryconops cf. *caudomaculatus*	●	●	●	●	●	63
Bryconops melanurus	●	●	-	●	●	163
Chalceus macrolepidotus	-	-	-	●	●	10
Charax pauciradiatus	-	●	-	-	-	2
Hemigrammus guyanensis	-	●	-	-	-	5
Hyphessobrycon cf. *minimus*	●	●	●	●	●	29
Hyphessobrycon copelandi	●	●	●	●	-	22
Hyphessobrycon rosaceus	●	●	●	●	-	39
Jupiaba abramoides	●	-	-	-	-	2
Jupiaba meunieri	●	●	●	●	●	145
Jupiaba pinnata	●	●	●	●	●	120

Taxa	Drainage					Number of specimens
	Rechter	Linker	Midden	Coppename	Adampada	
Jupiaba polylepis	●	●	●	●	●	223
Knodus sp. 1	●	●	-	●	-	75
Moenkhausia browni	-	-	●	●	-	4
Moenkhausia collettii	●	●	●	●	●	228
Moenkhausia georgiae	●	●	●	●	●	402
Moenkhausia hemigrammoides	●	●	●	●	●	37
Moenkhausia lepidura	●	●	●	●	●	314
Moenkhausia oligolepis	●	●	●	●	●	192
Moenkhausia surinamensis	●	●	●	●	●	119
Phenacogaster sp. 1	-	●	●	●	-	37
Phenacogaster sp. 2	-	-	-	●	●	5
Poptella brevispina	●	●	●	●	●	51
Tetragonopterus chalceus	●	-	-	-	-	1
Triportheus rotundatus	●	-	-	-	-	1
Crenuchidae						
Characidium zebra	-	●	-	●	●	8
Melanocharacidium cf. *melanopteron*	-	-	●	-	-	1
Melanocharacidium dispilomma	●	-	-	●	●	3
Microcharacidium eleotrioides	-	●	-	●	-	2
Ctenoluciidae						
Ctenoluciidae sp.	●	-	-	-	-	1
Curimatidae						
Cyphocharax helleri	●	●	●	●	-	49
Cyphocharax spilurus	●	●	-	●	●	68
Erythrinidae						
Erythrinus erythrinus	●	-	-	-	-	1
Hoplerythrinus unitaeniatus	-	-	●	-	-	1
Hoplias aimara	●	●	●	●	●	10
Hoplias malabaricus	●	●	●	●	●	28
Hoplias sp. [1]	-	-	-	●	-	1
Gasteropelecidae						
Gasteropelecus sternicla	●	●	●	●	●	47
Hemiodontidae						
Bivibranchia simulata	●	●	●	●	●	240
Hemiodus cf. *quadrimaculatus*	-	●	-	●	●	39
Hemiodus unimaculatus	-	●	-	-	●	2
Lebiasinidae						
Pyrrhulina filamentosa	●	●	●	●	-	11
Pyrrhulina stoli	●	●	-	-	-	4
Parodontidae						
Parodon guyanensis	●	●	●	●	●	75

	Drainage					Number of specimens
Taxa	Rechter	Linker	Midden	Coppename	Adampada	
Prochilodontidae						
Prochilodus rubrotaeniatus	●	-	-	-	-	2
Serrasalmidae						
Myleus rhomboidalis	●	●	●	●	●	42
Myleus rubripinnis	●					10
Myleus sp. 1?	-	-	-	-	●	1
Myleus ternetzi	●	-	-	●	-	8
Serrasalmus eigenmanni	-	-	-	●	-	1
Serrasalmus rhombeus	●	-	-	●	-	13
Serrasalmus sp. [1]	-	-	-	●	-	2
Siluriformes						
Ageneiosidae						
Ageneiosus inermis	●	-	-	●	-	4
Callichthyidae						
Callichthys callichthys	-	-	●	-	-	2
Corydoras cf. *guianensis*	●	-	-	●	-	3
Corydoras coppenamensis	●	●	-	-	-	56
Corydoras heteromorphus	●	●	-	-	●	13
Corydoras surinamensis	●	●	-	●	-	37
Megalechis thoracata	-	-	●	-	-	2
Loricariidae						
Ancistrus hoplogenys	●	-	-	-	-	1
Ctenilोricaria maculata	●	-	●	-	●	10
Guyanancistrus brevispinis	-	●	●	-	●	5
Harttia surinamensis	-	●	●	●	●	53
Hypostomus coppenamensis	●	●	-	●	●	7
Hypostomus saramaccensis	●	●	●	●	-	20
Hypostomus sp. [1]	●	-	-	●	-	4
Lithoxus lithoides	-	-	-	-	●	1
Lithoxus surinamensis	●	●	-	●	●	46
Metaloricaria nijsseni	-	●	-	-	-	2
Metaloricaria paucidens	●	●	-	●	-	8
Metaloricaria sp. [1]	●	-	-	●	-	2
Parotocinclus britskii	●	-	-	-	-	28
Peckoltia sp. 1	-	-	-	●	-	1
Pseudancistrus barbatus	-	-	●	●	-	2
Pseudancistrus depressus	●	-	-	●	-	2
Rineloricaria stewarti	●	●	-	●	●	14
Pimelodidae						
Chasmocranus longior	●	-	-	-	-	1
Microglanis poecilus	●	-	●	●	-	4

Taxa	Drainage					Number of specimens
	Rechter	Linker	Midden	Coppename	Adampada	
Pimelodella cristata	●	-	●	-	-	3
Pimelodidae sp. [1]	-	-	●	-	-	1
Pseudoplatystoma fasciatum	-	●	-	-	-	1
Rhamdia quelen	●	-	-	-	-	1
Trichomycteridae						
Ituglanis amazonicus	●	●	-	●	-	6
Ochmacanthus cf. *flabelliferus*	●	●	-	●	-	6
Gymnotiformes						
Gymnotidae						
Electrophorus electricus	●	-	-	-	-	1
Gymnotus carapo	●	●	●	-	-	5
Gymnotus coropinae	●	-	-	-	-	1
Hypopomidae						
Brachyhypopomus beebei	-	●	-	-	-	1
Hypopomus artedi	-	●	-	-	-	1
Rhamphichthyidae						
Gymnorhamphichthys rondoni	●	●	-	●	-	7
Sternopygidae						
Eigenmannia sp. 1	-	●	-	-	-	5
Eigenmannia sp. 2	●	●	-	-	-	15
Cyprinodontiformes						
Rivulidae						
Rivulus lungi	●	●	●	-	●	12
Synbranchiformes						
Synbranchidae						
Synbranchus marmoratus	●	-	●	●	●	4
Perciformes						
Cichlidae						
Apistogramma steindachneri	●	●	●	●	-	35
Cichla ocellaris	-	-	-	●	-	5
Crenicichla coppenamensis	●	●	-	●	●	18
Geophagus surinamensis	●	●	-	●	●	92
Guianacara owroewefi	●	●	●	●	●	1946
Krobia guianensis	●	●	●	●	-	31
Nannacara anomala	●	-	-	-	-	1
Sciaenidae						
Pachypops fourcroi	-	●	-	●	-	6
Total = 117 (112)[2] species	**80**	**65**	**45**	**73**	**47**	**5686**

[1] Juveniles or damaged specimens; probably representatives of taxa listed elsewhere in Appendix 6.
[2] If juveniles and damaged specimens excluded, then 112 species. See footnote [1].

Additional Published Reports of the Rapid Assessment Program

All reports are available in pdf format at www.biodiversity.science.org

South America

* Bolivia: Alto Madidi Region. Parker, T.A. III and B. Bailey (eds.). 1991. A Biological Assessment of the Alto Madidi Region and Adjacent Areas of Northwest Bolivia May 18 - June 15, 1990. RAP Working Papers 1. Conservation International, Washington, DC.

* Bolivia: Lowland Dry Forests of Santa Cruz. Parker, T.A. III, R.B. Foster, L.H. Emmons and B. Bailey (eds.). 1993. The Lowland Dry Forests of Santa Cruz, Bolivia: A Global Conservation Priority. RAP Working Papers 4. Conservation International, Washington, DC.

† Bolivia/Perú: Pando, Alto Madidi/Pampas del Heath. Montambault, J.R. (ed.). 2002. Informes de las evaluaciones biológicas de Pampas del Heath, Perú, Alto Madidi, Bolivia, y Pando, Bolivia. RAP Bulletin of Biological Assessment 24. Conservation International, Washington, DC.

* Bolivia: South Central Chuquisaca Schulenberg, T.S. and K. Awbrey (eds.). 1997. A Rapid Assessment of the Humid Forests of South Central Chuquisaca, Bolivia. RAP Working Papers 8. Conservation International, Washington, DC.

* Bolivia: Noel Kempff Mercado National Park. Killeen, T.J. and T.S. Schulenberg (eds.). 1998. A biological assessment of Parque Nacional Noel Kempff Mercado, Bolivia. RAP Working Papers 10. Conservation International, Washington, DC.

* Bolivia: Río Orthon Basin, Pando. Chernoff, B. and P.W. Willink (eds.). 1999. A Biological Assessment of Aquatic Ecosystems of the Upper Río Orthon Basin, Pando, Bolivia. RAP Bulletin of Biological Assessment 15. Conservation International, Washington, DC.

* Brazil: Rio Negro and Headwaters. Willink, P.W., B. Chernoff, L.E. Alonso, J.R. Montambault and R. Lourival (eds.). 2000. A Biological Assessment of the Aquatic Ecosystems of the Pantanal, Mato Grosso do Sul, Brasil. RAP Bulletin of Biological Assessment 18. Conservation International, Washington, DC.

§ Ecuador: Cordillera de la Costa. Parker, T.A. III and J.L. Carr (eds.). 1992. Status of Forest Remnants in the Cordillera de la Costa and Adjacent Areas of Southwestern Ecuador. RAP Working Papers 2. Conservation International, Washington, DC.

* Ecuador/Perú: Cordillera del Condor. Schulenberg, T.S. and K. Awbrey (eds.). 1997. The Cordillera del Condor of Ecuador and Peru: A Biological Assessment. RAP Working Papers 7. Conservation International, Washington, DC.

* Ecuador/Perú: Pastaza River Basin. Willink, P.W., B. Chernoff and J. McCullough (eds.). 2005. A Rapid Biological Assessment of the Aquatic Ecosystems of the Pastaza River Basin, Ecuador and Perú. RAP Bulletin of Biological Assessment 33. Conservation International, Washington, DC.

§ Guyana: Kanuku Mountain Region. Parker, T.A. III and A.B. Forsyth (eds.). 1993. A Biological Assessment of the Kanuku Mountain Region of Southwestern Guyana. RAP Working Papers 5. Conservation International, Washington, DC.

* Guyana: Eastern Kanuku Mountains. Montambault, J.R. and O. Missa (eds.). 2002. A Biodiversity Assessment of the Eastern Kanuku Mountains, Lower Kwitaro River, Guyana. RAP Bulletin of Biological Assessment 26. Conservation International, Washington, DC.

* Paraguay: Río Paraguay Basin. Chernoff, B., P.W. Willink and J. R. Montambault (eds.). 2001. A biological assessment of the Río Paraguay Basin, Alto Paraguay, Paraguay. RAP Bulletin of Biological Assessment 19. Conservation International, Washington, DC.

* Perú: Tambopata-Candamo Reserved Zone. Foster, R.B., J.L. Carr and A.B. Forsyth (eds.). 1994. The Tambopata-Candamo Reserved Zone of southeastern Perú: A Biological Assessment. RAP Working Papers 6. Conservation International, Washington, DC.

* Perú: Cordillera de Vilcabamba. Alonso, L.E., A. Alonso, T. S. Schulenberg and F. Dallmeier (eds.). 2001. Biological and Social Assessments of the Cordillera de Vilcabamba, Peru. RAP Working Papers 12 and SI/MAB Series 6. Conservation International, Washington, DC.

* Venezuela: Caura River Basin. Chernoff, B., A. Machado-Allison, K. Riseng and J.R. Montambault (eds.). 2003. A Biological Assessment of the Aquatic Ecosystems of the Caura River Basin, Bolívar State, Venezuela. RAP Bulletin of Biological Assessment 28. Conservation International, Washington, DC.

* Venezuela: Orinoco Delta and Gulf of Paria. Lasso, C.A., L.E. Alonso, A.L. Flores and G. Love (eds.). 2004. Rapid assessment of the biodiversity and social aspects of the aquatic ecosystems of the Orinoco Delta and the Gulf of Paria, Venezuela. RAP Bulletin of Biological Assessment 37. Conservation International, Washington, DC.

* Venezuela: Ventuari and Orinoco Rivers. C. Lasso, J.C. Señarìs, L.E. Alonso, and A.L. Flores (eds.). 2006. Evaluación Rápida de la Biodiversidad de los Ecosistemas Acuáticos en la Confluencia de los ríos Orinoco y Ventuari, Estado Amazonas (Venezuela). Boletín RAP de Evaluación Biológica 30. Conservation International. Washington DC, USA.

Central America

§ Belize: Columbia River Forest Reserve. Parker, T.A. III. (ed.). 1993. A Biological Assessment of the Columbia River Forest Reserve, Toledo District, Belize. RAP Working Papers 3. Conservation International, Washington, DC.

* Guatemala: Laguna del Tigre National Park. Bestelmeyer, B. and L.E. Alonso (eds.). 2000. A Biological Assessment of Laguna del Tigre National Park, Petén, Guatemala. RAP Bulletin of Biological Assessment 16. Conservation International, Washington, DC.

Asia-Pacific

* Indonesia: Wapoga River Area. Mack, A.L. and L.E. Alonso (eds.). 2000. A Biological Assessment of the Wapoga River Area of Northwestern Irian Jaya, Indonesia. RAP Bulletin of Biological Assessment 14. Conservation International, Washington, DC.

* Indonesia: Togean and Banggai Islands. Allen, G.R., and S.A. McKenna (eds.). 2001. A Marine Rapid Assessment of the Togean and Banggai Islands, Sulawesi, Indonesia. RAP Bulletin of Biological Assessment 20. Conservation International, Washington, DC.

* Indonesia: Raja Ampat Islands. McKenna, S.A., G.R. Allen and S. Suryadi (eds.). 2002. A Marine Rapid Assessment of the Raja Ampat Islands, Papua Province, Indonesia. RAP Bulletin of Biological Assessment 22. Conservation International, Washington, DC.