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A Biological Assessment of the Aquatic Ecosystems of the Caura River Basin, Bolívar State, Venezuela

Una Evaluación Rápida de los Ecosistemas Acuáticos de la Cuenca del Río Caura, Estado Bolívar, Venezuela

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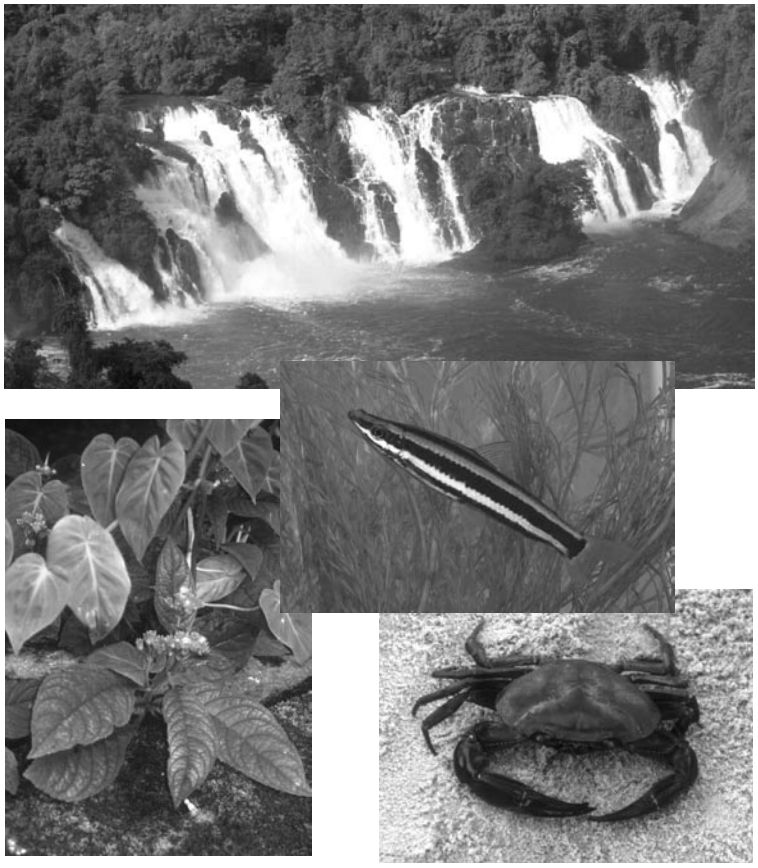

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28

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Chapter 1

Introduction to the Caura River Basin, Bolívar State, Venezuela

Antonio Machado-Allison, Barry Chernoff and Mariapia Bevilacqua

INTRODUCTION

The Neotropics still contain hundreds of thousands of square kilometers of pristine forested areas. Much of this pristine region exists in Brazil, Bolivia, Colombia, the Guyanas, Perú and Venezuela. These Neotropical wilderness areas harbor some of the greatest diversity of species and highest biomass of plants, wildlife and freshwater ecosystems on the planet. Today, however, increasing world consumptive demands and increasing human populations are accelerating the exploitation of this once immense reservoir of food, minerals, scenic beauty, energy and biogenetics (SISGRIL 1990; Bucher et al. 1993; Chernoff et al. 1996; Chernoff and Willink 1999; Machado-Allison 1999; Machado-Allison et al. 1999, 2000). Biodiversity studies in South America, especially in the Amazon and Orinoco Basins, are ever more important in order to link economic potential with biological sustainability as a way to reduce actual threats and adverse environmental changes (IUCN 1993; Aguilera and Silva 1997). It is encouraging, however, that recent studies have shown that Venezuela is among those countries possessing high levels of biological diversity (Mittermeier et al. 1997, 1998).

Due to the maintenance of a national conservation policy, Venezuela possesses numerous protected areas. Many receive special protection as National Parks, Forestry Reserves, Natural Monuments, etc. The protected areas are distributed around the country and include Andean highlands ("paramos"), savannas ("llanos"), littoral lagoons, cloud forests and tropical humid forests. All these areas were created following a vision or criteria developed to protect terrestrial habitats and/or wetlands. Few conservation areas are designed to protect river basins, aquatic ecosystems and their adjacent forests.

A significant fraction of Venezuelan ecosystems are currently threatened. The majority of these ecosystems, considered the last forest frontiers of the tropical world, are situated in regions where social and environmental needs conflict (Bevilacqua and Ochoa 2001). The Caura River Basin and other aquatic ecosystems located to the south of the Orinoco River are among these last frontiers.

The Caura watershed is located in the western sector of the Bolívar State, Venezuela. It is a vast expanse of forests and rivers and is a major tributary of the Orinoco River (Rosales and Huber 1996). The first organized expedition into the Caura was directed by Chaffanjon (1889), followed 20 years later by a joint Venezuelan and English expedition directed by André. However, results of the latter expedition were never formally published. In the past century, efforts to study the Caura have been led by scientists from Venezuelan universities and research institutions. Parallel efforts to develop a conservation plan for the Caura River Basin have been made by Venezuelan NGOs, such as ACOANA, Econatura, Fundación La Salle, Jardín Botanico del Orinoco and the Corporación Venezolana de Guyana (CVG). Results of these and other scientific projects in the Caura River Basin have been published in two volumes of *Scientia Guaianae* (Rosales and Huber 1996; Huber and Rosales 1997). Recent publications about the ichthyofauna of the Caura River Basin discuss species diversity, biogeography and conservation (Chernoff et al. 1991; Vari 1995; Balbas and Taphorn 1996; Lasso and Provenzano 1997; Bonilla-Rivero et al. 1999; Machado-Allison et al. 1999).

The Caura River Basin is largely pristine and comprises part of the homelands of the Ye'kuana people. Recent changes to Venezuela's constitution give the Ye'kuana and other indigenous groups rights of determination in their homelands. The very high environmental quality of this region, especially from the Raudal Cinco Mil to the headlands, is due in large measure to the excellent stewardship of the Ye'kuana, who are extremely careful in their management of and appreciation for their natural resources.

HYDROLOGY

The Caura River Basin is located in the middle region of the Venezuelan Guayana Shield (3°37'–7°47'N and 63°23'–65°35'W). The principal rivers contained within the basin are the Sipao, Nichare, Erebato and Merewari Rivers on the western margin and the Tigrera, Pablo, Yuruani, Chanaro and Waña Rivers on the eastern margin. The area of the basin is approximately 45,336 km^2 which is 20% of the total surface of Bolívar State, or 5% of Venezuela. These data place the Caura River Basin as the fourth largest basin in Venezuela, proceeded in size by the basins of the Apure, Caroní and Orinoco Rivers (Peña and Huber 1996).

The Caura River courses more than 700 km, originating in the highlands of the Guayana Shield at 2000 meters above mean sea level. The Caura River crosses several types of physiographic environments from the alluvial planes near the mouth of the Orinoco to the rocky complexes of the Guayana Shield to the south. Evergreen, flooded, gallery and savanna forests cover approximately 90% of the basin (Marín and Chaviel 1996).

The mean annual rainfall varies from 1200 mm toward the mouth of the Orinoco (northerly) to 3000–4000 mm toward the headwaters (southerly). The differences in rainfall correspond to dramatic differences in climatic seasonality between northern and southern portions of the basin. In the north the dry season extends from January through March with a rainy season extending from April through October. In the south there is a short dry season (January-February) and an extensive rainy season throughout the rest of the year. The Caura River contributes close to 3500 m^3/s of water to the Orinoco. This places the Caura River as the second most important affluent of the Guayana Shield margin of the Orinoco (Vargas and Rangel 1996).

Water quality of the Caura River is considered to be good (García 1996). The river has been classified traditionally as a blackwater river following Sioli (1965) due to its apparent brown or tea coloration as well as its low nutrients, low pH and high transparency. However, the river does not fit the true blackwater classification if factors such as certain carbon species and oxygen concentrations (García 1996) and water color after filtration are considered.

Physiographically, the Caura River Basin can be divided into three distinct sections: 1) Lower Caura River, from the confluence with the Orinoco River to the Salto Pará; 2) Middle Caura River, from the Salto Pará to the confluence with the Merewari River and Waña River; and 3) Upper Caura, from the confluence of the Merewari and the Waña Rivers to their headwaters in the Vasade mountain range. The subregions in this report are defined by the geological formation known as the Salto Pará waterfalls. Since we were unable to survey the physiographic Upper Caura due to logistics, in this report we refer to the entire zone above the Salto Pará as "Upper Caura River" and the area below the falls as "Lower Caura River."

GEOLOGY AND GEOMORPHOLOGY

The geology of the Caura River Basin is only partially known. While the mid-elevation and low areas (<1000 m) are well known, the regions corresponding to the Upper Caura are still unexplored from tectonic and petrographic perspectives (Colvee et al. 1990; Rincón and Estanga 1996). In the Caura Basin there are representations of four Geological Provinces (Imataca, Pastora, Cuchivero and Roraima), all belonging to the Guayana Shield formation. These geological provinces, which have been modified by a series of tectonic episodes, contain both Archeozoic and Proterozoic rocks. The first Province (Imataca) corresponds to an Achaean age and is located toward the east of the lower elevational portions of the basin. The Province is characterized by abundance of gneiss, amphibolites, granite intrusions and ferruginous quarzites. The second Province (Pastora) corresponds to the Proterozoic and is located on the center-west area, principally in the Icutú, Tudi and Erebato Rivers. An abundance of granite rocks associated with gneiss is common. The third Province (Cuchivero), formed 2,000–1,700 million years ago (MYA), is the most extensive in the basin. This Province comprises a mixture of complex formations from volcanic origin with acid-volcanic rocks and granite and is located toward the Middle Caura (Entreríos), Mato River, the Upper Caura highlands (Meseta de Jaua) and Merewari River. The fourth Province (Roraima) belongs to the Late Proterozoic and is volcanic with sedimentary volcaniclastic rocks including conglomerates and sandstones. This Province is located close to the Waña River, highlands of Jaua and the Sarizariñama Tepuy, among others. Sediments from pluvial-deltaic origin correspond to the Mesa Formation (Tertiary) that is located in the northern portion of the basin close to Maripa, Aripao and the mouth of the Caura. Finally, alluviums of residual sediments of recent ages (Quaternary) constitute the sediments of the flooded or gallery forests located in the lowlands of the Caura, Nichare and Tawadu Rivers (Colvee et al. 1990; Rincón and Estanga 1996).

The typical Guayana Shield landscapes resulted from the multiple geological and geomorphological processes occurring from the Precambric to the present. The igneous-metamorphic rocks of the Imataca, Pastora and Cuchivero Provinces are related to the development of mountains, plateau, slopes and peneplanes, while the sedimentary rocks of

the Roraima Province are more dominant in the high plains and tepuys. Approximately 70% of the area in the basin includes elevated landscapes and high slopes primarily in the south; the lowlands and plains are in the northern section of the basin.

BIODIVERSITY AND BIOLOGICAL VALUE

The biodiversity of the Caura River Basin is not uniformly known. While much of the terrestrial flora and fauna is fairly well studied (Rosales and Huber 1996; Huber and Rosales 1997), this is not true for the aquatic fauna (Machado-Allison et al. 1999). The wildlife of the region, mainly vertebrates, has been studied moderately and is known to contain at least 30 orders with approximately 475 species of birds, 168 species of mammals, 13 amphibian species and 23 species of reptiles (Bevilacqua and Ochoa 2001). These values represent 30% of the species registered for Venezuela and 51.3% of Guayanese species. The orders with greatest taxonomic richness are: birds (Passeriformes, Apodiformes, Falconiformes and Psittaciformes); mammals (Chiroptera, Rodentia and Carnivora); reptiles and amphibians (Squamata and Anura). Of the total terrestrial vertebrate species in the Caura River Basin, 5.2% are considered under threat in the national or international context (Bevilacqua and Ochoa 2001). The survival of these threatened species must be factored into future studies and conservation plans.

The vegetation of the Caura River Basin is very diverse. Approximately 88% of all Guayana endemic genera are present in the Caura River Basin, and there is a high level of endemism in highland or Tepuy communities (Berry et al. 1995; Huber et al. 1997; Bevilacqua and Ochoa 2001). The flora is characteristic of humid nutrient-poor forest ecosystems that have been structured through prolonged erosional processes (Rosales and Huber 1996). The extraordinary biological diversity has been attributed to the combination of erosional landscape, the convergence of four Geological Provinces and the marked altitudinal gradient (40-2,350 m) (Bevilacqua and Ochoa 2001). The existing data reveal that inland forests cover approximately 90% of the watershed while the remaining 10% consists of flooded forests and other non-forest vegetation (CVG-TECMIN 1994; Huber 1996; Marín and Chaviel 1996; Rosales 1996; Aymard et al. 1997; Dezzeo and Briceño 1997; Bevilacqua and Ochoa 2001).

The use of plants by the indigenous communities is high. A total of 358 lowland forest species are known to be used by indigenous peoples (Knab-Vispo et al. 1997) indicating the critical role that these ecosystems play in traditional cultures (Bevilacqua and Ochoa 2001).

Despite what seems to be a reasonable knowledge of the biodiversity of the Caura River Basin, our knowledge has been far from sufficient to manage and protect the natural resources. Using fishes as an example, Mago-Leccia (1970) reported approximately 500 freshwater species from Venezuela mostly found in the Orinoco River Basin, whereas Taphorn et al. (1997) increased that number to almost 1,000. In the Caura River, Balbas and Taphorn (1996) reported 135 species, which was then increased to 191 (Machado-Allison et al. 1999). In this report we raise the total to 278. Despite increasing knowledge, there is no hint that the rate of increase is leveling off as a result of collecting efforts, especially for remote regions (Chernoff and Machado-Allison 1990; Royero et al. 1992; Machado-Allison 1993). Mago-Leccia (1978), Chernoff et al. (1991) and Machado-Allison (1993) have suggested that only 30% of the aquatic flora and fauna of Venezuela is known with certainty.

Our knowledge of the Caura River mirrors that of the Orinoco River. Much recent information has come to light primarily because of numerous collections, expeditions and field efforts commensurate with national and international efforts towards biodiversity and conservation, e.g., in the Atabapo River, in the Orinoco River, at Neblina Tepuy and in the Caura River (Brewer-Carías 1988; Rosales and Huber 1996; Royero et al. 1992; Huber and Rosales 1997; Machado-Allison et al. 2000).

ECONOMY AND SOCIAL STRUCTURE

The economic and social structures of the human populations in the Caura River Basin are complex and diverse. In the areas above Salto Pará, indigenous cultures such as the Ye'kuana and Sanema (Yanomami) maintain their historic traditions. Seed planting of yucca and plantain on small farms or "conucos," hunting, fishing and gathering are fundamental to their domestic and economic activities, such that each member of the population has particular responsibilities according to age and sex (Silva-Monterrey 1997). In the lower part of the basin where population densities are higher, traditional indigenous elements mix with those of occidental cultures brought by non-indigenous Venezuelans or "criollos." In this lower region, the economy incorporates forestry, agriculture, ranching and fisheries, as well as tourist and artisanal activities. The economic relationships in the lower part of the Caura River Basin are more complex than in the upper region.

Given the conservation objectives of this volume, we are interested in cataloguing activities or enterprises that pose potential risks and threats to the ecosystem and biodiversity of the Caura River Basin (e.g. forest exploitation or extraction, pollution of soils and waters and intense fisheries). Most of these activities are concentrated in the lowland floodplains in the northern part of the basin, close to the Orinoco River. Agriculture (tubers, maize and fruit plants) and ranching are major economic activities in the area and have caused loss of forest cover and increased forest fragmentation, pollution of soils and waters by insecticides and erosion near Maripa.

Documenting sustainable activities and enterprises that protect the flora and fauna throughout the basin (Chernoff et al. 1996) is critical. As an example, the Ye'kuana traditions have historical prohibitions to impede over-exploitation of natural resources, in part by utilizing a large variety of food items (Silva-Monterrey 1997). They believe that their food gathering activities must sustain human life while contributing to the maintenance of the natural environment (Silva-Monterrey 1997). Their practice also includes periods of fasting in order to permit resources to be shared among members of the entire community (Silva-Monterrey 1997).

The local indigenous groups use a wide variety of fishes and other aquatic resources for their subsistence. Beyond the indigenous practices, however, commercial fisheries for human consumption use a much narrower range of species, principally: "cachamas" (*Colossoma macropomum*), "cajaros" (*Phractocephalus hemiliopterus*), "coporos" (*Prochilodus mariae*), "curbinatas" (*Plagioscion squamossissimus*), "laulaos" and "valentones" (*Brachyplatystoma* spp.), "morocotos" (*Piaractus brachypomus*), "Palometas" (*Mylossoma* spp.), "rayaos" (*Pseudoplatystoma* spp.), "sapoaras" (*Semaprochilodus laticeps*) and "sardinatas" (*Pellona castelneana*) (Novoa 1990; Machado-Allison et al. 1999). Numerous other species of fishes have potential value as ornamental species, an alternative that is not yet employed but that has the potential to develop into a sustainable industry for indigenous populations in the area. The following species are found in the Caura and are important and commonly known in the world aquarium trade: "tetras" (*Astyanax, Hemigrammus, Hyphessobrycon*, *Jupiaba*, *Moenkhausia*), "palometas" or "silver dollars" (*Metynnis, Myleus, Mylossoma*), "cichlids" (*Aequidens, Apistogramma, Bujurquina, Mesonauta*), "piranhas" (*Pygocentrus* and *Serrasalmus*) and "headstanders" (*Anostomus* and *Leporinus*).

Future plans for development of the basin include additional deforestation, alteration of the Caura River for development of hydroelectric power facilities, mining and tourism. Unfortunately, implementation of these proposed development activities will neither enhance regional economies nor increase the quality of life. Data from such projects implemented in other countries or in other parts of Venezuela have shown little or no success (Miranda et al. 1998; Machado-Allison 1999; Machado-Allison et al. 1999, 2000; Bevilacqua and Ochoa 2001).

THREATS

The Guayana Shield region of Venezuela has endured much environmental alteration from development projects, industry and unregulated fisheries and hunting. The exploitation of strategic minerals such as gold, diamonds and bauxite, coupled with development and construction of one of the largest hydroelectric dam complexes of the world has produced: 1) biodegradation and destruction of extensive green areas in the Caroní and Cuyuní River Basins; 2) mercury pollution of rivers, forests, wildlife and humans; 3) diminished water quality due to increased sedimentation; and 4) loss of large quantities of potable water for domestic uses (Machado-Allison 1994, 1999; Miranda et al. 1998).

The Caura River Basin is threatened by mining, illegal fishing practices and a proposed hydroelectric project. In the Caura River Basin, several hundred kilometers are now being heavily logged close to the Paragua River Basin. Some mining activities have also been introduced into headwater areas of the Caura River Basin. At the moment, mining activities are minor in comparison to neighboring basins such as the Caroní and Cuyuní (Machado-Allison et al. 2000: fig. 1). A dramatic decrease in fisheries resources in the Lower Caura River is thought to be due to illegal commercial fishing in indigenous territory. The most important major threat to the Caura River Basin is a plan to construct a new hydroelectric dam and divert as much as 75% of the water from the Caura River into the Paragua-Caroní River system. This will not only drastically deplete the amount of water in the Caura River, but also severely alter the hydrologic cycle. The health and maintenance of human communities and aquatic and riparian flora and fauna are completely dependent upon the natural hydrologic cycle.

OVERALL CONCLUSIONS

The Caura River Basin is a large pristine wilderness area representing an important opportunity to preserve a unique region. The community composition of animals and plants in the Caura River Basin occurs nowhere else in Venezuela or on the Guayana Shield. It is a high diversity area with many endemic forms and unique communities, such as aquatic plant communities (Podostemonaceae) in rapids and the mid-river rocky-island floras. Protection through education programs, community outreach and long-term monitoring are highly recommended. Monitoring and establishment of fisheries regulation in the basin is essential to achieve sustainability for its inhabitants.

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