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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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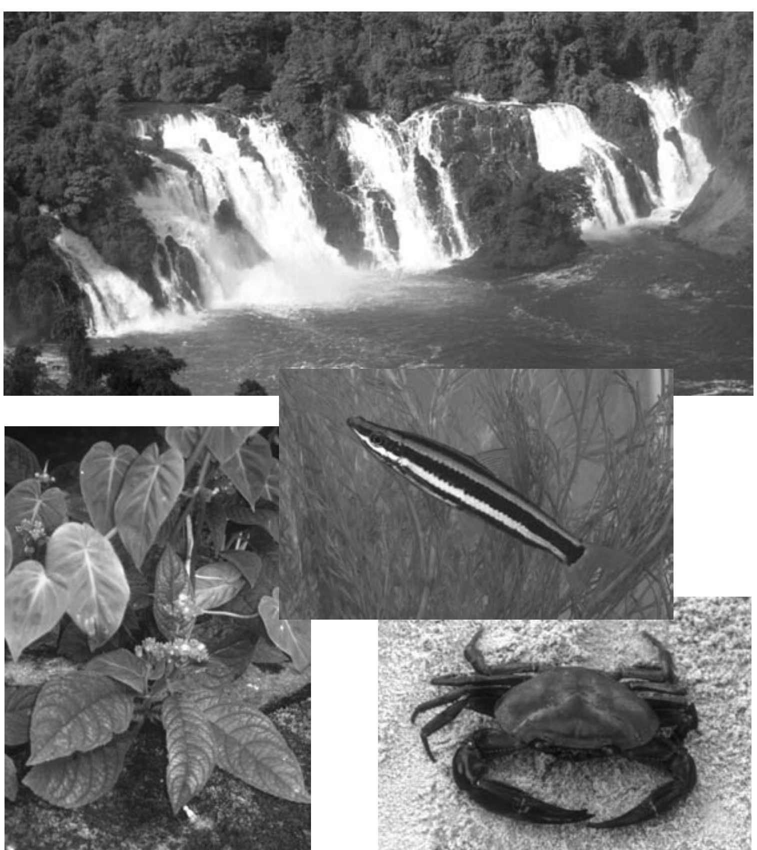
Editors/Editores
Barry Chernoff, Antonio Machado-Allison, Karen Riseng, and Jensen R. Montambault



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Instituto de Zoología Tropical, Universidad Central de Venezuela

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202-912-1000 telephone
202-912-0773 fax
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Editors: Barry Chernoff, Antonio Machado-Allison, Karen Riseng, and Jensen R. Montambault
Design/production: Kim Meek
Map: Mark Denil
Photos: Barry Chernoff, Antonio Machado-Allison, and Jensen R. Montambault
Translations: [Spanish] Antonio Machado-Allison and Ana Liz Flores, [Kuyujani] Alberto Rodriguez

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Chapter 8

The Distribution of Fishes and Patterns of Biodiversity in the Caura River Basin, Bolívar State, Venezuela

Barry Chernoff, Antonio Machado-Allison, Philip W. Willink, Francisco Provenzano-Rizzi, Paulo Petry, José Vicente García, Guido Pereira, Judith Rosales, Mariapia Bevilacqua and Wilmer Díaz

ABSTRACT

We test null hypotheses concerning random species distributions with respect to subregions and macrohabitats within the Caura River Basin with data from 97 species of benthic invertebrates, 399 species of riparian plants and 278 species of freshwater fishes. The analysis of the eight subregions split evenly above and below the falls indicated that invertebrates were randomly distributed with respect to subregion. Fishes and plants were not random, and the subregional effect in plants was more strongly patterned than that of fishes. Furthermore, fishes were less species rich in the Upper Caura than the Lower Caura. The converse was observed for plants while the invertebrates were almost equally rich. Non-random macrohabitat effects are found in each of the groups with certain commonalities. For example, species of Odonata and Ephemeroptera are found in high oxygen, swift water and rapids habitats and are associated with a large assemblage of fishes and dense stands of macrophytes, usually Podostemonaceae. Fish assemblages demonstrate smooth transitions along several macrohabitat gradients (e.g., sand to mud bottoms and shores). At least six macrohabitats are necessary to preserve 82% of the species of fishes.

INTRODUCTION

The Caura River watershed is a relatively large pristine region and is home to thousands of species of plants and animals. Of the aquatic and flood zone organisms surveyed during the AquaRAP expedition to the Caura River, more than 90 species of benthic invertebrates, 399 species of plants and 278 species of fishes were collected. In addition to the quantity of new information about species distributions, and new species occurrences, it is critical from a conservation perspective to test hypotheses about the distributions of animals and plants within the basin.

A pattern of heterogeneous flora and fauna distribution within the Caura River subregions and macrohabitats would have important ramifications for conservation recommendations. For example, if species were homogeneously distributed then a core conservation area could be established that might effectively protect the vast majority of the species. However, as the distribution of the species either among subregions or among macrohabitats becomes increasingly distinct and patchy, then a single core area, apart from the entire region, may not provide the desired level of protection. Chernoff and Willink (2000) and Chernoff et al. (1999, 2001a) demonstrated how we can use information on the relative heterogeneity of distributions among sub-regions or among macrohabitats to predict possible faunal changes in response to specific environmental threats and that such analyses can and should be carried out within the framework of a rapid assessment program.

This paper will begin with tests of two null hypotheses critical to freshwater fish conservation in the Caura River Basin as follows: that the fishes are randomly distributed among i) eight subregions; and ii) 20 macrohabitats. We will then compare the results from fishes to those for benthic invertebrates and the plants.

METHODS

The collections from the Caura River were divided into two principal regions—above (Upper Caura) and below Salto Pará (Lower Caura). Eight geographic subregions were then designated (Map). The four regions in the Upper Caura are: Kakada, Erebato, Entreríos-Cejiato, and Entreríos-Salto Pará. In the Lower Caura the four regions are: El Playón, Nichare, Cinco Mil, and Mato.

At each collecting locality a number of ecological variables, such as bottom type, shore type, habitat type, etc. described in Appendices 1 and 3 were recorded. We were able to categorize each station into a principal macrohabitat type. Twenty principal macrohabitat types were identified. There were no true lakes, water bodies with endorheic drainage basins; instead lakes refer to lagoons with either a small connection to a river or temporally isolated from the river. At each locality, we evaluated whether aquatic grasses were present, whether there was riparian forest and if there was flooded vegetation. Flooded vegetation included mats of vegetation that were attached to rocks in rapids (e.g., Podomostemacea) or floating (e.g., *Eichhornia*).

In order to determine if the number of collections per region or per macrohabitat was affecting the estimates of species richness, we calculated a linear regression, pooled among groups. The regression line is logically forced through the origin (e.g., Chernoff and Willink 2000). Because the analysis of variance (ANOVA) of the regression was significant, testing the slope against a null hypothesis of zero, an analysis of covariance (ANCOVA) was performed to see if other hypothesized effects (i.e., headwaters vs. lowlands) were significant. In ANCOVA, the qualitative group variable (i.e., elevational group) is entered as the independent variable, the number of species is the dependent variable and the number of collections serves as the covariate. If the F-statistic of the ANCOVA is significant, two further tests must be carried out to determine if the difference is attributable to mean differences of the independent variable. The first tests the null hypothesis that the within-group variances are equal. The second tests the null hypothesis of homogeneity of within-group slopes. If one fails to reject both null hypotheses, then the F-statistic significance is attributable to the differences indicated by the independent variable.

Chernoff et al. (1999, 2000) selected Simpson's Index of Similarity, S_s, as the most consistent with data collected during rapid inventories or with point source data. Simpson's Index uses the following table format to calculate the similarity between two lists or samples of species:

		Sample 1	
		1	0
Sample 2	1	*a*	*b*
	0	*c*	*d*

where, ***a*** is the number of positive matches or species present in both samples, ***b*** is the number of species present in sample 2 and absent from sample 1, ***c*** is the converse of ***b***, and ***d*** is the number of negative matches or species absent from both localities. Simpson's index of similarity, $S_s = a/(a+b)$, where $b < c$, or $S_s = a/n_s$ where n_s is the number of species present in the smaller of two lists. The denominator of the index eliminates interpretation of the negatives—absent species. The 0's in the matrices are really coding artifacts or place holders for missing data.

In order to interpret the observed similarity of two samples, both of which are drawn from a fixed larger universe (e.g., the set of all species captured in the Caura), we undertake a four-step procedure. In **step 1**, we calculate S_s by reducing via rarefaction the number of species in the larger sample to equal the number of species in the smaller sample, n_s. This rarefaction and calculation of S_s is iterated 500 times. From the 500 simulations a mean similarity, S'_s, is calculated and reported in tables of similarity. This procedure is repeated to calculate an S'_s for each pair of samples in the analysis.

Interpreting the significances of the mean similarities among the samples requires simulations across the range of number of species found in the samples of subregions, water classes, and macrohabitats. In **step 2**, we simulate 200 random pairs of samples by bootstrapping with replacement from the set of all species captured during the expedition with the constraint that each random sample contains a fixed number of species for a given point in this range. For each random pair of the 200 we calculate their Simpson's Similarity. These 200 random similarities approximate a normal distribution from which we calculate a mean and standard deviation due to random causes; henceforth called mean random similarity, S^*_n, where n refers to the number of species present in the sample.

Random similarity distributions were generated at intervals of 10 species in order to estimate S^*_n and its standard deviation for samples containing between 20 and 140 species. This range of random list-sizes encompasses the actual number of species observed in subregions and in macrohabitats. In **step 3**, the means and standard deviations are plotted against number of species present in a sample. As the number of species present in a sample increases the observed similarity due to random effects also increases but the variance decreases.

In **step 4**, we compare the observed mean similarity, S'_s, calculated from rarefaction (step 1) to the predicted value of S^*_n and its standard deviation. Using a 2-tailed parametric approach, we calculate the probability of obtaining the observed similarity at random from the number of standard deviations that the observed similarity was either above or below the mean of the bootstrap random distribution. This probability was obtained by interpolation of the values presented in Rohlf and Sokal (1995: table A). The significance of the probability values was adjusted with the sequential Bonferoni technique (Rice 1989) because each sample is involved in multiple comparisons. The sequential Bonferoni procedure is conservative, making it harder to reject a null hypothesis. We selected the P=0.01 level as our criterion for rejection of a null hypothesis. The value, 0.01, was divided by the number of off-diagonal comparisons present in the upper or lower triangle of the matrix of observed similarities. This new result is used as the criterion to evaluate the null hypothesis that $S'_s = S^*_n$. For example, in the lower triangle of Table 8.1 there are 28 similarities. In order to reject the null hypothesis of this two-tailed test, S'_s must be more than 3.5 standard deviations above or below S^*_n so that P<0.0002.

If S'_s is found to be significantly different from S^*_n, then we reject the null hypothesis and conclude that the observed *similarity* is not due to random effects. However, if S'_s falls within the random effects, or if S'_s is greater than the random mean, we fail to reject the null hypothesis concerning the *samples*—that the two *samples* are equal. In the former case we conclude that the two lists are drawn homogeneously from a larger distribution. In the latter case, we conclude that the similarity is due to biological dependence or correlation, such as nested subsets. That is, one population forms the source population for another. If S'_s is significantly less than S^*_n , we reject the null hypotheses for equality of similarity and for equality of the samples. We can then search for biological or environmental reasons for the dissimilarities.

If we discover that similarities are not random, we can investigate whether the pattern of species presences in relation to environmental variables is non-random. The measure of matrix disorder as proposed by Atmar and Patterson (1993) calculates the entropy of a matrix as measured by temperature. Temperature measures the deviation from complete order (0°) to complete disorder (100°) in which the cells of a matrix are analogous to the positions of gas molecules in a rectangular container. After the container has been maximally packed to fill the upper left corner (by convention), the distribution of empty and filled cells determines the degree of disorder in the species distributions and corresponds to a temperature that would produce the degree of disorder (Atmar and Patterson 1993). To test whether the temperature could be obtained due to random effects, 500 Monte Carlo simulations of randomly determined matrices of the same geometry were calculated. The significance of observed temperatures is ascertained in relation to the variance of the simulated distributions. Because we are not using this procedure to test specifically whether a non-random pattern can be ascribed to either nested subsets or clinal turnover the modifications proposed by Brualdi and Sanderson (1999) are not required. Software to calculate matrix disorder is available from Atmar and Patterson at the following internet site: http://www.fieldmuseum.org

Relationships among regions and macrohabitats are summarized in branching diagrams. Two types of procedures were used both involving parsimony criteria. The first is a minimum "evolution" network calculated from a distance matrix as 1 minus the means of the rarefied Simpson's Index ($=1- S'_s$). The second method uses the presence of species as shared characters in A Camin-Sokal Parsimony Analysis (Sneath and Sokal 1973) does not permit reversals, hence, shared absences are not taken as characters. Paup* 4.0b was used for these analyses.

RESULTS

Regions

A total of 67 collecting stations were made during the expedition resulting in the capture of 278 presumptive fish species. A total of 31 collections within 14 georeference areas were made above the falls and 35 collections within 17 georeference areas were made below the falls.

The apparent species richness was much greater in the Lower Caura than the Upper Caura with 226 and 103 fish species captured, respectively. The species richness was not even among regions (Figure 8.1). The number of fish species per region ranged from 26 to 120. However, we found almost twice as many fish species per region in the lowlands (mean = 104.8) than we found above the falls (mean = 54.5). There is, however, a strong effect of collecting effort on the number of species captured (Figure 8.1). The pooled regression analysis demonstrates that species richness is a significant, linear function of the number of collections made for each georeference area with a non-zero slope ($F_{1,6}$= 26.2, P<.002). The results of ANCOVA correct for the effects of

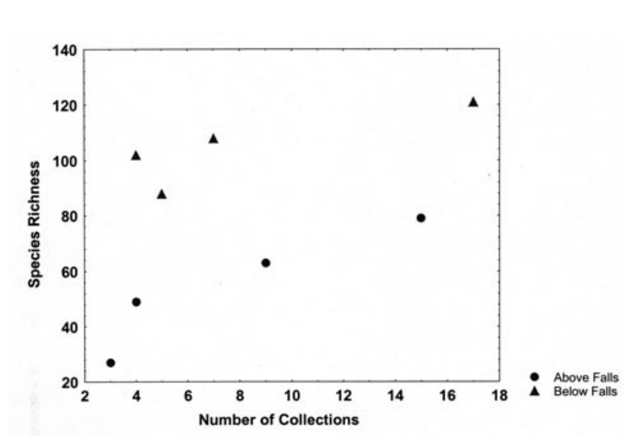

Figure 8.1. Species richness as a function of number of collections for subregions of the Caura River taken above (circles) and below (triangles) the Salto Pará.

collecting effort and reject the null hypothesis of equality of mean species richness above and below the falls ($F_{1,5}$=45.4, P<.002). The result reflects the differences in means because we could not reject null hypotheses of homogeneity of variances or of slopes (P>.24). Thus, for eight collections per region, the predicted and 95% confidence value in the Upper Caura is 55.4 ± 21 species as compared to 104.3 ± 20 species in the Lower Caura.

The disparity in fish species richness between headwaters and lowlands (n=157) is apparent from the total list of species (Appendix 8). As we proceed up river systems, above large falls and into the piedmont, we expect to find fewer species and many with more restricted ranges than species in the unimpeded lowlands (Lowe-McConnell 1987). Therefore, in the Upper Caura we predict that our samples should contain: i) species with broad elevational distributions, shared both by headwater and lowland species; and ii) species with narrower elevational preferences, not found in the lowlands, especially those with mud bottoms. The Lower Caura shares 52 fish species, from which we observe their similarity, S'_s, to be 50.5%. The Upper Caura is a higher gradient environment, with many rocks, rapids and sandy bottoms and narrower flooded margins (Machado et al. 2003). Of the 51 species captured only above the falls, many are representative of more widespread taxa (e.g., *Myleus asterias, Cyphocharax* cf. *festivus, Gymnotus carapo, Crenicichla alta, Plagioscion* cf. *auratus*). However, a large number of the species found uniquely in the upper section are characteristic of the environments described. For example, those characteristic of piedmont, rather than lowland habitats include: *Ancistrus* spp., *Cetopsorhamdia* cf. *picklei, Chaetostoma vasquezi, Hartia* sp., *Hypostomus* cf. *ventromaculatus, Rineloricaria fallax, Apareiodon* sp., *Leporinus arcus, L.* cf. *granti, Melanocharacidium melanopteron* and *Guianacara* sp. In addition there were a number of species usually associated with sandy bottoms that tend not to occur in the broad lowland, mud-bottom, flood plains of the Orinoco River: *Corydoras* spp., *Imparfinis* sp. B., *Characidium* spp., *Knodus* spp. and *Geophagus* sp.

We should also expect the true headwater species to have relatively narrow ranges because headwater regions are relatively isolated from one another, acting much like islands (Lowe-McConnell 1999). Of the 39 species collected only in the headwaters, only seven species were found to inhabit three or more of the four regions (Table 8.1). Although a few species appearing to have narrow or spotty distributions are artifactual (e.g., *Myleus* spp.*, Pimelodus* cf. *ornatus*), the majority are not. The result is that more than 80% of the species found only in the upper regions were captured in a single region. Although continued sampling would undoubtedly increase the distribution of the collected taxa (Alroy 1992; Chernoff and Willink 2000), as well as add more fish species to the known list, we doubt seriously whether the majority of the species will be ubiquitously distributed. From this we conclude that the regions above the falls contain a combination of species with broad elevation tolerances as well as those preferring more upland, headwater habitats.

The lowland fish fauna was very rich, containing 226 species. The fishes were not distributed as broadly in the Lower Caura as we would have expected (e.g., in the Pantanal; Chernoff and Willink 2000) only 26% were collected in three or four of the lowland regions. And only 28 species (12.5%) were collected in each of the four lowland regions. There were 174 fish species collected only in the lowlands. The lowland-only fauna contained species that are distributed in the Caura River, other Guayana Shield rivers, the Negro River (e.g., *Microschemobrycon* spp., *Leporinus brunneus*, *Ammocryptocharax elegans, Anostomus ternetzi, Serrasalmus* sp., *Crenicichla* cf. *lenticulata, C.* cf. *wallacei*) and those that are typical of the main flooded areas of the lower Orinoco River (e.g., *Anchoviella* spp., *Pellona castelneana*, *Pygocentrus cariba, Aphyocharax erythrurus, Triportheus albus, Sorubim lima, Pimelodus blochii, Bujurquina mariae, Achirus* sp.). Thirty-seven of the lowland only species (=16.8%) were distributed in three or four of the regions (Table 8.2) comprising an assemblage of many ornamental or diminutive species (e.g., *Anostomus ternetzi, Microschemobrycon callops, Ramirezella newboldi*, *Parvandellia* sp., *Apistogramma* cf. *indirae, Paravandellia* sp.). But there were also large species (> 200 mm SL, e.g., *Hydrolycus tatauaia* or *Hypostomus* cf. *plecostomus*) and a diverse set of trophic specialists, from mud-eating and herbivorous (e.g., *Curimata incompta*) to piscivorous (e.g., *Serrasalmus* sp.).

The pattern of similarities, S'_s (Table 8.3) demonstrates the effects of the Salto Pará on the structure of fish communities in the Caura River. Among the regions above the falls, the coefficients are significantly different from random and are positive. This means that the regions in the Upper Caura are positively correlated or biologically dependent upon each other (Chernoff et al. 1999; Chernoff and Willink 2000). Good evidence of this can be found in the number of species shared between regions relative to those that are found in only one region. Although the four regions above the falls share large percentages of their species overall, the numbers of species shared uniquely among these regions is exceptionally low—less than four and modally zero. This result indicates that species do not seem to be segregating or partitioning the areas above the falls differentially; there is no evidence of species turnover or transition boundaries. This result is consistent with the regions having nested subset relations to each other (see below).

Our rarefaction and simulation analyses of similarities demonstrate that out of 16 similarity coefficients for regions separated by the Salto Pará, only a single coefficient is significantly different from mean random similarity (Table 8.3). The species found above and below the falls come almost entirely from the set of species that are found in five or more of the eight regions (Table 8.4). That is, essentially those species that are ubiquitous. In one case, the similarity of Entreríos-Cejiato to the Mato River is significant (P<.01) and is negative—much lower than expected due to random processes. Negative relationships indicate displacement or strong regional sorting of taxa (Chernoff et al. 1999). Indeed the Mato River sample is the most downstream and includes many species from the Orinoco River that penetrate only partway up the Caura River (e.g., the piranha, *Pygocentrus cariba*, the catfish, *Xyliphius* cf. *melanopterus*).

In the Lower Caura, four of the six similarity coefficients are significantly different from random (P<.01) and are positive. The two random coefficients compare the Mato River with the Playón and Nichare subregions. These are the two subregions in the Lower Caura River that are most distant from the Mato River subregion; the Cinco Mil subregion is positively and significantly correlated with Mato River. The significant similarity between Mato River and Cinco Mil is due to the Orinoco River elements that largely characterize Mato River extending only as far upriver as the rapids at Cinco Mil.

The overall distribution matrix is marginally significantly different from random. The observed matrix temperature (49.93) was 1.82 standard deviations below the mean of 500 Monte Carlo simulations (P=.03). This is entirely due to the distribution of widely distributed taxa shared by the lowland regions. When we analyzed the subregions in the Upper Caura by themselves, highly significant results were obtained. The observed matrix temperature (24.09) was more than 3.38 standard deviations cooler than the mean of 500 Monte Carlo simulations (P<.0004). Given the data on similarities from above, the upper subregions are consistent with a pattern of nested subsets. The most interpretable patterns within the distributional data comprise the following: i) that there is a significant faunal turnover due to the Salto Pará; ii) the subregions of the Upper Caura are structured as nested subsets; and iii) in the Lower Caura there is more of a disjunction at the lower end due to the incursion of Orinoco River fauna. These conclusions are well summarized by the results of the tree structure using Camin-Sokal Parsimony (Figure 8.2). The retention index, which measures the amount of information due to shared taxa, is 0.706. With the exception of the Mato River being the most disparate of the lowland group, the pattern among Cinco Mil, Nichare

Table 8.1. Species of fishes found only in the Upper Caura River above the Salto Pará.

One or Two Regions (n=39)	
Acestrorhynchus	cf. *apurensis*
Aequidens	sp.
Ageneiosus	sp.
Ancistrus	sp. A
Ancistrus	sp. B
Anostomus	*anostomus*
Apareiodon	sp.
Brachychalcinus	*orbicularis*
Cetopsorhamdia	cf. *picklei*
Chaetostoma	*vasquezi*
Characidae	sp. A
Characinae	sp. A
Corydoras	cf. *osteocarus*
Creagrutus	sp.
Ctenobrycon	*spilurus?*
Cyphocharax	cf. *festivus*
Doras?	sp.
Farlowella	*oxyrryncha*
Geophagus	sp.
Guianacara	cf. *geayi*
Gymnotus	*carapo*
Harttia	sp.
Hemigrammus	sp. B

One or Two Regions (n=39) (continued)	
Hemiodus	cf. *unimaculatus*
Hemiodus	*goeldii*
Hypostomus	cf. *ventromaculatus*
Imparfinis	sp. B
Jupiaba	cf. *zonata*
Jupiaba	sp. B
Knodus	sp. C
Melanocharacidium	*melanopteron*
Moenkhausia	cf. *grandisquamis*
Moenkhausia	cf. *miangi*
Moenkhausia	sp. B
Myleus	*asterias*
Myleus	*torquatus*
Phenacogaster	sp. B
Pimelodus	cf. *ornatus*
Plagioscion	cf. *auratus*
Three or More Regions (n=7)	
Aphyocharax	sp.
Bryconops	sp. A
Corydoras	*boehlkei*
Crenicichla	*saxatilis*
Guianacara	*geayi*
Knodus	cf. *victoriae*
Rineloricaria	*fallax*

Table 8.2. Fishes captured only in three or four regions of the Lower Caura River, below the Salto Pará (n=37).

Ancistrus	sp. C
Anostomus	*ternetzi*
Aphyocharax	*alburnus*
Apistogramma	sp. A
Astyanax	sp.
Brycon	*pesu*
Bryconamericus	cf. *cismontanus*
Characidae	sp. B
Corydoras	cf. *bondi*
Creagrutus	cf. *maxillaris*
Curimata	*incompta*
Cyphocharax	*oenas*
Farlowella	*vittata*
Hemigrammus	cf. *tridens*
Hemiodus	*unimaculatus*
Hydrolycus	*tatauaia*
Hyphessobrycon	*minimus*
Hypostomus	cf. *plecostomus*
Ancistrus	sp. C
Anostomus	*ternetzi*
Jupiaba	*polylepis*
Knodus	sp. B
Leporinus	cf. *maculatus*
Microschemobrycon	*callops*
Microschemobrycon	*casiquiare*
Microschemobrycon	*melanotus*
Moenkhausia	cf. *lepidura* D
Moenkhausia	*copei*
Ochmacanthus	*alternus*
Paravandellia	sp.
Pimelodella	cf. *cruxenti*
Pimelodella	cf. *megalops*
Ramirezella	*newboldi*
Rineloricaria	sp.
Serrasalmus	sp. A
Steindachnerina	*pupula*
Tetragonopterus	*chalceus*
Triportheus	*albus*
Vandellia	*sanguinea*

Table 8.3. Number of species shared (upper triangle) and mean Simpson's similarity coefficients, S's (lower triangle) among regions within Caura River. Similarity coefficients shown in bold are significantly different from random similarity (P<0.001). The shaded cells are comparisons among regions below the falls. Abbreviations: Ent-Cejiato–Caura River between Entreríos and the Raudal Cejiato; Ent-SP–Caura River between Entreríos and Salto Pará; Cinco Mil–Raudal Cinco Mil; Mato–Río Mato; n–number of species; u–number of unique species; %u–percentage of unique species.

	Kakada	Erebato	Ent-Cejiato	Ent-SP	Playon	Nichare	Cinco Mil	Mato
Kakada	1	25	25	18	11	12	7	4
Erebato	**50.67**	1	39	36	21	22	16	9
Ent-Cejiato	**32.33**	**49.52**	1	43	27	27	21	12
Ent-SP	**28.61**	**57.16**	**54.47**	1	24	24	22	15
Playon	9.92	19.49	25.04	-22.18	1	66	57	38
Nichare	9.92	18.3	22.42	-19.88	**54.53**	1	61	45
Cinco Mil	-6.91	-15.82	-20.62	-21.66	**52.88**	**50.38**	1	43
Mato	-4.44	-10.27	**-13.65**	-17.03	35.23	37.3	**42.1**	1
n	27	49	79	63	108	121	102	88
u	0	1	19	6	21	27	22	30
%u	0	2.04	24.05	9.52	19.44	22.31	21.57	34.09

and Playón subregions was random and, therefore, is not to be interpreted. In the subregional group from Upper Caura there is a principal river grouping extending from just above the falls to Cejiato; the samples from the Erebato River and Kakada River share sequentially fewer species with the mainstem group. This pattern is confirmed by the results of the principal coordinates analysis (Figure 8.3), in which the first two principal coordinates (64% of the variance) array the subregions congruent with their geographical relationships—the groups separated by the falls, and the Mato River is most disparate.

Table 8.4. Species of freshwater fishes commonly found in the Caura River. Common is defined as having been captured in five or more of the eight regions.

Aequidens	cf. *chimantanus*
Astyanax	*integer*
Bryconops	cf. *colaroja*
Characidium	sp. A
Cyphocharax	*festivus*
Cyphocharax	sp.
Hoplias	*macrophthalmus*
Hypostomus	sp. B
Jupiaba	*atypindi*
Jupiaba	cf. *atypindi*
Jupiaba	cf. *polylepis*
Jupiaba	*zonata*
Moenkhausia	cf. *lepidura* A
Moenkhausia	cf. *lepidura* B
Moenkhausia	cf. *lepidura* C
Moenkhausia	cf. *lepidura* E
Moenkhausia	*collettii*
Moenkhausia	*grandisquamis*
Moenkhausia	*oligolepis*
Phenacogaster	sp. A
Pimelodella	sp. B
Pimelodella	sp. C
Poptella	*longipinnis*
Pseudocheirodon	sp.
Satanoperca	sp. A
Serrasalmus	*rhombeus*
Synbranchus	*marmoratus*
Tetragonopterus	sp.

Macrohabitats

The distribution of fish species was found to be non-randomly distributed with respect to the sample of 20 macrohabitats. All of the coefficients were significantly different from random ($P<.005$) and the matrix was significantly more ordered (cooler) than expected at random ($P<.0001$).

The non-random associations due to habitats are evident in the Camin-Sokal Parsimony analysis (Figure 8.4). The

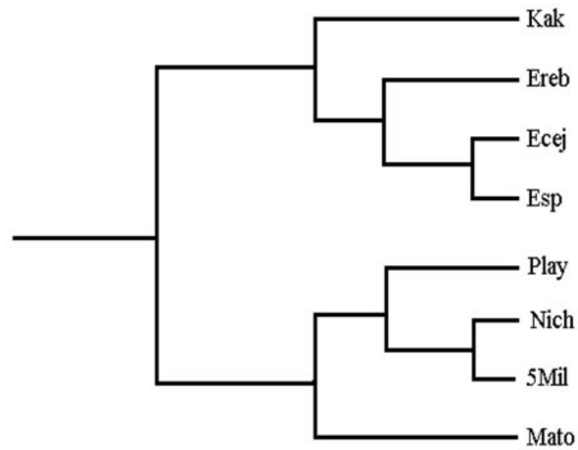

Figure 8.2. Camin-Sokal parsimony analysis of Simpson's similarities among subregions in the Caura River for fishes. Abbreviations: Kak–Kakada River; Ereb–Erebato River; Ecej–Caura River from Entrerios to Cejiato; Esp–Caura River from Entrerios to Salto Pará; Play–El Playón; Nich–Nichare River; 5Mil–Raudal Cinco Mil; and Mato–Mato River.

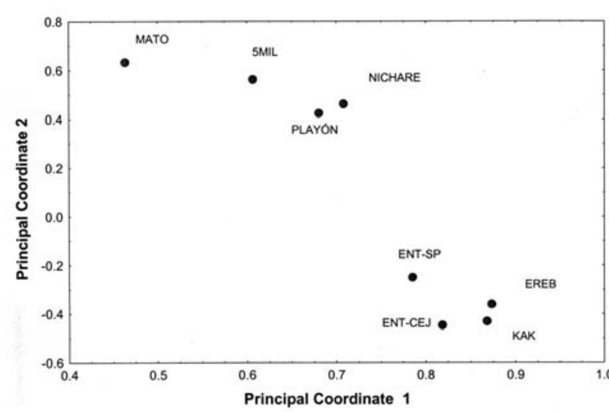

Figure 8.3. Principal coordinates analysis of Simpson's similarity matrix among subregions of the Caura River. Abbreviations: Kak–Kakada River; Ereb–Erebato River; Ent-Cej–Caura River from Entrerios to Cejiato; Ent–SP–Caura River from Entrerios to Salto Pará; Play–El Playón; Nichare–Nichare River; 5Mil–Raudal Cinco Mil; and Mato–Mato River.

retention index is 0.783. In the analysis, many like habitats are grouped together. For example, on the right hand side is a cluster containing muddy bottoms and shore, logs, leaves and detritus along with forested shores. A somewhat different community is found in big river habitats with sand, rocks, and beaches. The upper Caura River is well characterized by many island habitats that share many species in common with the main channel.

The assemblage of species inhabiting grasses, macrophytes and rapids is a major discovery of our expedition. In the upper Caura River, there are many rapids or areas with swift water over large boulders and rocks, including over the Salto Pará. In these swift water habitats we found up to seven species of the vascular plant family Podostemonaceae. There were 130 species of fishes living among the macrophytes overall, and 120 species in macrophytes and rapids.

The principal coordinates analysis (Figure 8.5) better demonstrates the transitions among habitat groups. For example, the transition between mud to sand in riverine communities occurs in the upper left side of the graph. There is also a smooth transition from sand bottoms and beaches through rocky substrates to islands, and rapids with macrophytes. From center to top right (Figure 8.5) represents a transition among lower velocity habitats (e.g., caños) to lakes and areas with still waters with floating vegetation.

Given the diversity of and non-random patterning of species among macrohabitats, we ask how many macrohabitats are required to protect the majority of the species. The accumulation curve of the percent of total species over the number of macrohabitats is shown in Figure 8.6. The curve was calculated from polynomial regression in which all coefficients are significantly different from zero. The equation of the regression is:

$$Y = 50.9 + 24.2X - 9.7X^2 + 1.8X^3 - 0.2X^4 + .004X^5 + e$$

where Y is the cumulative percentage of species, X is the number of macrohabitats and e is the error term. The greatest return of cumulative percentage to the number of macrohabitats is determined from the inflection point (setting the second derivative to zero). The inflection point is 6.0, which corresponds to 82% of the species (Figure 8.6). Thus, if adequate protection can be given to 6 macrohabitats,

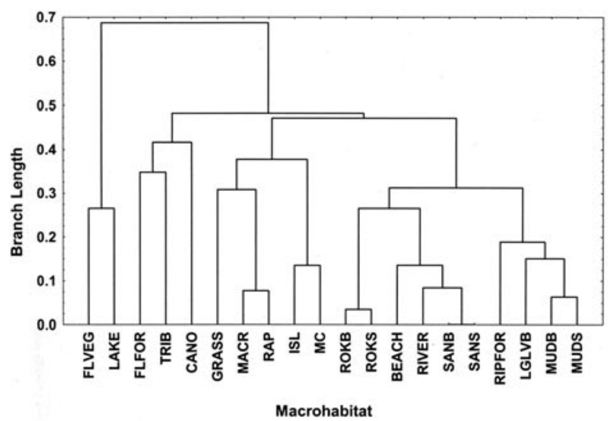

Figure 8.4. Camin-Sokal Parsimony analysis of 20 macrohabitats in the Caura River. Abbreviations: B–bottom; Flveg–floating vegetation; Flfor–flooded forest; Cano–caño; Isl–island; Lglv–logs and leaves; Macr–macrophytes; MC–main channel; Rap–rapids; Ripfor–riparian forest; Rok–rocky; San–sandy; S–shore; Trib–tributary.

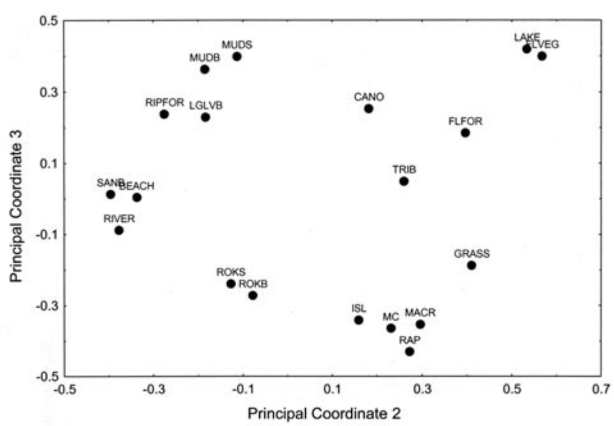

Figure 8.5. Principal coordinates analysis of Simpson's similarity coefficients among 20 macrohabitats in the Caura River. Abbreviations: B–bottom; Cano–caño; Flfor–flooded forest; Flveg–floating vegetation; Isl–island; Lglv–logs and leaves; Macr–marophytes; Rap–rapids; Rok–rocky; S–shore; San–sandy; Trib–tributary.

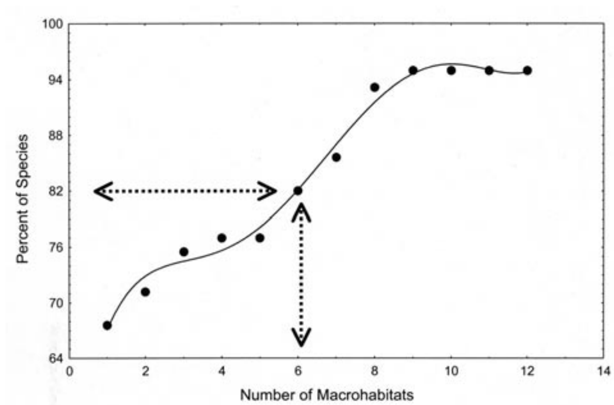

Figure 8.6. Cumulative percentage of species plotted against the number of macrohabitats. The actual values are shown as dots; the polynomial regression line is shown. The arrows indicate the point of inflection for the regression equation, indicating the maximum percentage of species that can be preserved with the fewest macrohabitats.

the large majority of species can be protected. This group includes 228 species with all of the commercially important species found in Appendix 2.1.

DISCUSSION

The distribution of fishes in the Caura River show strong subregional and macrohabitat effects, and are largely non-random and non-homogeneous. The subregional effects that are non-random are due to separation by the Salto Pará. These results accord well with our studies in the Tahuamanu-Manuripe rivers, Bolivia, the southern Pantanal, Brazil, and the Paraguay River in Paraguay, as well as the studies on the Jau River, Brazil (Forsberg et al. 2001), lowland Amazon floodplain (Cox Fernandes 1995; P. Petry, pers. comm.) and the Napo River, Ecuador (Ibarra and Stewart 1989). These studies disagree with the general statements of Lowe-McConnell (1987) and Goulding et al. (1988) who claim that distributions of freshwater fishes in lowland habitats are largely random. The non-random, non-homogeneous distribution have important implications for the conservation of the ichthyofauna.

The regions in the Upper Caura have significantly fewer species of fishes than the regions below the Salto Pará. This is because species from the Orinoco River penetrate the Caura River to varying degrees. The species richness of the plants overall is greater above the river than below (291 vs 185, respectively). However, there were more vascular aquatic macrophytes and grasses above the falls than below (Rosales et al. 2003a). This difference in species richness associated with elevational change in the fish and the plant data is congruent with the results reported from the southern Pantanal (Chernoff and Willink 2000). The benthic invertebrate data (Appendix 6) do not show an appreciable difference with 70 species in the Lower Caura and 75 species in the Upper Caura.

The distribution of benthic invertebrate species differs from those of the fishes in that the invertebrates do not show a geographic pattern of similarities among the subregions (Garcia and Pereira 2003). We have reanalyzed their data to correspond to the subregions presented herein and in the botanical analyses. The matrix correlation of subregional similarities between the fish and benthic invertebrate data sets is not significant ($r = 0.32$, $P>.05$). The results of Camin-Sokal Parsimony analysis and principal coordinates analysis (Figures 8.7, 8.8) show that although the below-falls (Salto Pará) samples from El Playón and the Mato River are outliers to the remaining subregions, Cinco Mil and Nichare share significant numbers of species with the above-fall subregions. This is in distinct contrast to the fish and botanical distributions. The fishes show a strong upstream-downstream component (Figures 8.2, 8.3) but are not well structured above the falls. The plants, on the other hand are well structured with regards to subregions (Rosales et al. 2003a,b). The plants show a marked discontinuity at the falls, but subregions such as the Kakada and Erebato also represent floral turnovers. The distribution of the fishes is intermediate between the unstructured invertebrate data and the well-structured plant distributions.

Macro-habitat effects are significant, non-random and critical to properly understanding the distributions of plants,

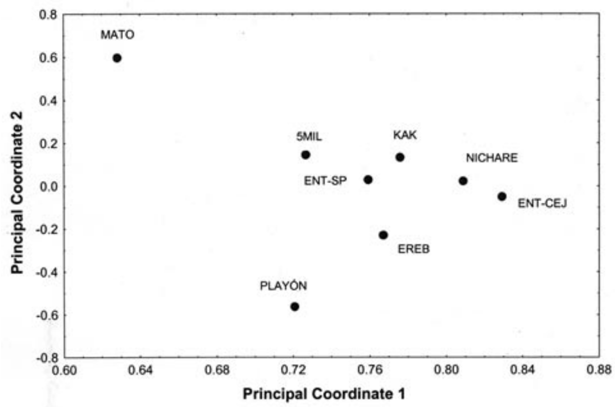

Figure 8.7. Principal coordinates analysis among Jaccard's similarity matrix for subregions of the Caura River for aquatic benthic invertbrates. Abbreviations: Ent-Cej–Caura River from Entrerios to Cejiato; Ent-SP–Caura River from Entrerios to Salto Pará; Ereb–Erebato River; Kak–Kakada River; Mato–Mato River; Nichare–Nichare River; Play–El Playón; 5Mil–Raudal Cinco Mil.

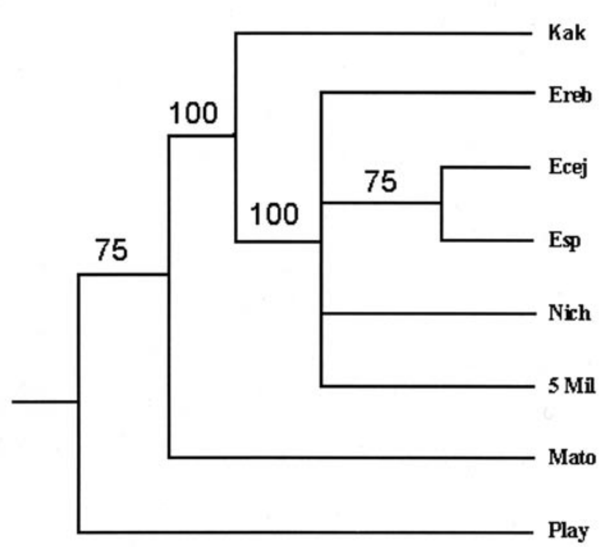

Figure 8.8. Majority rule consensus tree of Camin-Sokal Parsimony analysis of subregions in the Caura River for benthic aquatic invertebrates. Ecej–Caura River from Entrerios to Cejiato; Ereb–Erebato River; Esp–Caura River from Entrerios to Salto Pará; Kak–Kakada River; Mato–Mato River; Nich–Nichare River; Play– El Playón; 5Mil–Raudal Cinco Mil.

invertebrates and fishes within the Caura River watershed (see above, García and Pereira 2003; Rosales et al. 2003a.). It is difficult to precisely compare the macrohabitats among these groups. However, Garcia and Periera (2003) do demonstrate the correlations between physicochemical characteristics of habitats (such as dissolved oxygen) and that species of Odonata and Ephemeroptera, which were characteristic of swift water and rapids. The fishes are partitioning the environment relative to bottom type, forest structure, water current and the presence of macrophytes or other vegetation. Smooth transitions in faunal composition are evident (Figure 8.5) based upon these variables. Interestingly, many of the patterns of fish assemblages correspond to landscape changes in forests. As noted by Rosales et al. (2003a), the islands, particularly above the falls are unique habitats with characteristic assemblages of plants. These island habitats are unique for the fishes, as well, with rocky outcrops, lush stands of Podostemonaceae and rapids or swift currents.

Developing any conservation strategy for the Caura watershed must take into account both the subregional and macrohabitat effects upon species distributions. For example, 37 out of 278 species of fishes were found in three of four subregions, and only 28 species are found in five of the eight subregions and regarded as common. Different subregions and macrohabitats are critical as nursery areas or for particular life stages. Commercially important species, such as the palometa, *Myleus rubripinnis,* were found in backwater areas. Diminution of water quality through deforestation, runoff or pollution due to mining will kill off the aquatic macrophytes, invertebrates and ultimately the fishes—130 species of fishes were found closely associated with aquatic macrophytes. The effects of the number of macrohabitats on number of fish species (Figure 8.6) demonstrated that if six or more macrohabitats could be preserved in sufficient quantity, then more than 82% of the known fish fauna of the Caura River could be saved. It is particularly critical to incorporate the Lower Caura, especially from Raudal Cinco Mil downstream, because of the increasing effects of human pressures on the river.

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Glossary

Aquaculture—Raising fish in enclosed areas, usually with the intent of selling the fish.

Arboreal—Pertaining to trees.

Basin—See *watershed*.

Benthic—Of or pertaining to the bottom of a river, lake, or other body of water.

Biodiversity—Description of the number of species, their abundance, and the degree of difference among species.

Carnivorous—Organisms that feed on animals.

Caño—Tributary in which water can flow in both directions depending on whether the water is rising, due to rain or floods, or falling.

Cretaceous—A time period of the earth's history extending from about 145 million years ago to about 65 million years ago.

Dead arm—An arm of a river extending into the forest in an old river channel.

Endemic—Found only in a given area, and nowhere else.

Endorheic—Waters flowing into an enclosed watershed.

Erosion—The act of water washing away soil.

Floating meadows—Large aggregations of floating vegetation.

Fluvial—Pertaining to rivers or streams.

Herbivores—Organisms that feed on plants.

Heterogeneity—Degree of difference among items.

Hydrological—Pertaining to water.

Insectivores—Organisms that feed on insects.

Inundation—Flood.

Laguna—Lagoon.

Landscape—Pertaining to the structure of an area at a coarser level than that of site, at least at the level of a georeference area.

Lentic—Pertaining to still water, as in lakes and ponds. See *lotic*.

Liana—Vine.

Littoral—The aquatic zone extending from the beach to the maximum depth at which light can support the growth of plants.

Lotic—Pertaining to flowing water; as in rivers and streams. See *lentic*.

Macrophyte—A non-microscopic aquatic plant.

Madrevieja—Dead arm.

Miocene—A time period of the earth's history extending from about 25 million years ago to about 5 million years ago.

Omnivores—Organisms that feed on a variety of food types, both plant and animal.

Periphyton—Algae attached to rocks, logs, and other underwater substrates.

Physiognomy—The overall appearance or constituency of an area.

Piscivores—Organisms that feed on fishes.

Pleistocene—A time period of the earth's history extending from about 2 million years ago to about 100,000 years ago.

Precambrian—A time period of the earth's history extending from the origin of the earth to about 580 million years ago.

Quaternary—A time period of the earth's history extending from about 2 million years ago to the present.

Riachuelo—Small stream, forest stream.

Río—River.

Riparian—Found along the edge of a river. Often used in the context of vegetation.

Savanna—Grasslands.

Seine—A mesh net, often used to catch fish and other larger aquatic organisms.

Siltation—The deposition of fine sediment (know as silt), oftentimes covering existing structures.

Stagnant—Still water (that is often foul).

Substrate—The soil found between the roots of plants or at the bottom of lakes and rivers.

Watershed—A region drained by a particular river and its associated streams. Also known as a basin.

Tuna Medewadi, Wenesuweda de´wö

TAMEDÖ YEICHÜ

Tuna Medewadi na shi weja´katojo dü´se wodiwa nonoodü de´wö yeichü, Wenesuweda, annawööne Escudo Guayanés de´wö(3°37'–7°47'N y 63°23'–65°35'W). Na ajo´jo chuuta tumakudojunu yeichüüdö tunakomo maja yaawö dinñaku´kwaka yekenkajöötüdü (Rosales y Huber 1996). Edo chuuta na tüwü seneedö yeichü, tukunnö´ato maja, woi aiño maja naadenha yaawö chü´tadü 90% je medeewadi nonoodü de´wö (Marin y Chaviel 1996). Edö naadü na yaawö ye´kwana nonoodü weichü,sotto eda´chönnamo tünwanno iyö nono de´wö naadü. Inñataje naadü tüwü chuuta medewadi nonoodü de´wö, muuda soodü jokonno yujuudaka tüdüjoone, tünwanno ye´kwanaakomo kenñe.

Medewadi motadükoomo ajo´jokoomo na yaawö Sipawo, Wünküyaadi, Dedewatö, Medewadi maja shi womontojo dü´se, yotonno yaawö Tikededa, Jadde, Yuduwani, Sawaadu, Wanña maja shi weja´katoojo dü´se. Medewadi na 700 kilimetros je, neja´ka yaawö Escudo Guayanés kawö yeichü de´wö, 2000 metudu je dama jonno kajunñadödö: nija´dö´a önnene nono weichü de´kökö, önnene tooja´jano jonno yujuudawö akanajaato tooja´jemjünü dinña tüdüjoone dinñaku´kwaka yeekekadünña. Medewadi nonoodü na yaawö yü´seeto´jüdü 45.336 Km2 je, 20% je Wodiwa nonoodü jökö yeichü, 5% je tameedöödö wenesuweda nonoodü jökö yeichü; edö tuna nonoodü ajo´jo yeichü na aaköcheinña tooje Apuude, Kadooni, Dinñaku´jeje yeichü (Peña y Huber 1996).

ÖNNEENE MEDEWAADI NONOODÜ DE´WONKOMO YEICHÜ

Önnene Medewadi nonoodü de´wö naadü ajichajeene owaanökö´da na. Ooje woowanoma´jö yeichame chuuta jökö chuutakankomo jökö maja (Rosales y Huber 1996, 1997), na´kwakankomo jökömmaane yööje wö´duto´me´dana (Machado-Allison et al. 1999).

Medewadi nonoodü de´wö na önnene chuuta, 1180 e´joye chuuta yeichü edantaajö. Jajeeda jökö ajoijajö na chuuta 90% na Medewadi nonoodü omomjünü de´wö, 10% kene yaawö chuuta tukunnö´ato yö´jejemaja chuuta ya´wakukaajö (CVG-TECMIN 1994; Huber 1996; Marin y Chaviel 1996; Rosales 1996; Aard et al 1997; Dezzeo y Briceño 1997; Bevilacqua y Ochoa 2001).

Chuutakankomo Medewaadinñankomo töne nato 475 je tadinñaamo, 168 je odookoja´komo, 13 kütooja´komo, 23 je makasana okoyuja´komo yeichomjökö (Bevilacqua y Ochoa 2001). Edo nadü yawö na 30% je chuutakankomo edanta´komo Wenesuweda de'wö yeichü yotonno yaawö 51% je Guayana de´wö yeichü. Tameedöödö ye´jö´ja´komo weichü Medewaadinña naatoodü, 5% je naato amonche´da yaatamedükomo eetö Wenesuweda de´wö aneja nono de´wö maja yaawö (Bevilacqua y Ochoa 2000). Edö AquaRap küntöjö´a´todawö küneedantoicho 113 je eduwa´komo, 10 je eduwa´komo ju´jokomo weichü, mödö aka naato na´kwakankomo weichö tuna saayu´jemjünü akankomo naato yaawö yojodüa´komo 278 je. 92 je se´jömjünükomo naatodü 12 je yaawö wayakani ja´komo mödööna yaawö awa´deenato mödööwa´kö yeeja´kaajö.

Chuuta chutakankomo maja Medewaadi nonoodü de´wö naatodü na yaawö Jaada soodü e´nei na yöökamooajö Medewadinña naatoodü. Jaada soodü de´wonno maadödö na yaawö inñankomo jooje inñawoono we´yeje´da, mödö nene´ju´jö´a yaawö chuuta ke, tüwü na yaawö yü´seeto 88% je Guayana de´wono denha na yöötö mödö töneejeene na yaawö ojejene jüü de´kökö (Berry et al. 1995; Huber et al. 1997; Bevilacqua y Ochoa 2001). Yööjemmaja ö´düjai weiño nadenña yaawö chuuta, se´jömjünükomo na´kwakankomo kudaada maja u´joye naatodenha Escudo Guayanés yotonno Amazonas de´wonkomo denha tünwanno, anejanaadö´ja nadenha jü´waye, dinñaku´kwakaano yotonno yanonñano maja tüweiye.

ÖNNENE SOTTO WEICHÜKOMO YEICHO´KOMO MAJA

Sotto weicho'komo yeicho´komo maja Medewadinñankomo, na ooje önnene. Medewadi ü´joye ju´wayeedö maja jaada de´wö naato ye´kwaanakomo Ye´kwana Sanama maja, tünwanno nato yaawö yöötödö nadöato tüwotunnoichomo. Kiyeede yotonno jaduudu ñaatü´tödü, wesenünnö, o´tödü, chööjüdüdü amukudu na chadawajuichomo yeicho´komo maja. Mödööje yaawö chööwaadönñe ñanno sotto tadawajuichomo na yaawö inchomoodü woije yanwaje yeichü o wodije yeichü woije (Silva-Monterrey 1997).

Sotto chaadawajoichomo jökö yeichü Medewaadi jü´waye na önnene. Inña na yaawö wanna´köjeene sotto iyö yaawö ye´kwana weichü noojodüa yaawö yadanawi weichü akö. Mödööje yaawö chadawaajuichomo nadenha yaawö iye akötödü, natü ñaatü´tödü, oküünü inñejenkadü, o´tödü, Waademanö jökö wetadawa´kajoonö, yotonno yaawö tükaajüdü o akaajötüdü jeiñemma.

Ye´kwanakomo najöiyaato tümenka´da kudaka yö´jöje yawö anejakomo na´kwakankomo totükomooje. Yaane yööje´da yaawö ye´kwanakomo weichükomo nünhe´da, yadanawi kudaka najöiya sotto otükomooje tümenka inñatakomoodenña: kachamas *(Colossoma macropomum),* kajaadu *(Phractocephalus hemiliopterus),* ya´koto *(Prochilodus mariae)*, Akujja *(Plagioscion squamossissimus)*, Laulaos yotonno muukudi (*Brachyplatystoma* spp.), muudu (*Piaractus brachypomus*), jadumeeta (*Mylossoma* spp.), kudidi (*Pseudoplatystoma* spp.), sajuwaada (*Semaprochilodus laticeps*), yotonno sadidinata (*Pellona castelneana*) (Machado-Allison et al. 1999; Novoa 1990).

Oje kudaka nato yaawö tujunna´komo ökünüje tüdüüamo (yadanawi wö) mödö na yaawö tadawajuje eijaicho tajoojodenha tüwü yaawö ye´kwanakomo tadawajuije tüwatamemjünüje eijaicho mane tüwü yaawö. Kanno ñanno yaawö kudaka okünüje tüdüüamo medewaadinña edanta´komo: tetras (*Astyanax, Hemigramus, Hyphessobrycon, Jupiaba, Moenkhausia*), jadumeta o silver dollars (*Metynnis, Myleus, Mylossoma*), cichlids (*Aequidens, Apistogramma, Bujurquina, Mesonauta*), Ka´shai (*Pygocentrus, Serrasalmus*) yö´jöje yaawö headstanders (*Anostomus, Leporinus*).

Jata weicho´komoje na yaawö medewadinñankomo, dinñaku´kwaichomo maja yaawö, aónmakudö´da naato yaawö tünna´kwadükomo´kwai ñonoodu de´wö naadü maja yaawö. Iye nako´aato ye´kwanaakomo tüweicho´komooje, 358 je iye weichü owanökö na yaawö ye´kwanaakomo tünaakö´e yeichü (Knap-Vispo 1998). AquaRap nedantödü´kene yaawö chuuta tünnadüüato na´kwakankomo weicho´komo maja yaawö tuna e´jichokono na yaawö önnene kudaka wennejenkato´komooje naadünane jadumeta (*Myleus rubripinnis*). Enmenkaajo na yaawö akene ke´ja aneja´kwaichomo kudaka wüta´komo medewaadi´chai ni´ya´ta yaawö yü´seto´jüdü 75,000 tonedada métrica je Madijanña Kaikadaña maja ajöiya´komo.

MEDEWAADI MAKUDÖNEI WEEJÜDÜ YAAWÖ

Escudo Guayanés wenesuweda de´wö na tünkone´madü yeichame jata tü´tajötüdü tüwennejenkato´me, amode´notojo, na´kwakano ajöichü o wesenünnö inñammödö chü´tammeküdü´jo´da tüdüdü nejoodüjoodü. Uudu, widiki, Bauxita u´kadü yoojodüajö yaawö tuna a´dudu jadö nejodüja yaawö: 1) Chuutakankomo yotonno chuuta wö´jajoodü ooje kadoninña yotonno yaawö kuyuweninña maja (Machado-Allison et al. 2000); 2) Tuna yemmadü, chuuta, ose, sotto maja yaawö asoke ke; 3) Nossaje tuna wööyemmadü tumuuke; 4) Tuna inñatadü tönhemmü´je´da yö´düdü yaawö (Machado-Allison 1994, 1999; Miranda et al. 1998).

Medewaadi kone´manei weejüdü na yaawö uudu, widiki u´kadü ke, inñammödö na´kwakano ajoichü jajeda´je´da tüweichame, tuna inña´düdü maja yaawö. Uudu, widiki u´kadü na oojeje tünonñato yaawö, jadawa akö amonche´da ööjökö yeijökö medewaadi, inña ooje uudu widikimaja u´kadü na (Machado-Allison et al. 2000). Yotonno yaawö, nöneadenha yaawö ömje´sato oje kudaka´je´da yeichü eduwa medewaadi jü´waye ye´kwanakomo nonoodü de´wö ajöichü töjemajomuje yeijököjenñema inñammödö jajedaje´da tüweichame.

Naadenha yaawö aku´sana tü´tajöötüdü Medewaadi inña´dudu jökö 75% tuna adudu jökönchödö Medewaadi jonno Jadawa´kwaka kadoninña tüdüjone, yotonno yaawö Jaada inña´düdü. Mödoö aku´sana tü´tajöötüdü naadü tuna medewaadi se´kö yödüdümma jünü na yaawö, tuna waawüyümüdü nichone´madenha yaawö. Sotto jataadükomo, na´kwakankomo, chuuta, tunajakokonkomo weichü naato yaawö tuwoije tuna wawüyümudüke. Yotonno nadenha yaawo, Jaada jonno ju´wakaadö wö´kaaje´da ooje´kömma no´düa wönwenaanö jökö wetadawa´kajoonö, o´tödü enno´janködö, tumjune´da natü ñaatü´tödü maja yaawö, mödööna yaawö jojejeene Muuda sodünwawonno jü´wakaadö. Edö tadawaju naadü yaawö wowanoomanö eijaiña yaawö ajichajeene wetadawakajoono wetö nono de´wö.

SOOMATOJO EIJAICHO

Medewaadi nonoodü na yaawö ajo´jo chuuta ye´wö. Chuuta wekone´maduke jata tadawajui wennejenkadüüke nortenñano wadödoö Escudo Guayanés de´wö yeichü (Kadoninña Kuyuwininña maja), edö Medewaadi na yaawö tüsomamje yaadödö yeijökö inñatajeedö. Chuutakankomo Chuuta maja yaawö Medewaadi de´wono naato yaawö a´ke aninñaja eetö wenesuweda de´wö yeichü a´ke maja yaawö Escudo Guayana de´wö. Na yaawö tüwü onnene ye´wonkomo, yotonkomo tötü tünwanno, kanno na´kwakankomo (podostemonaceae) soodü jökö yeichukomo tünwanno yotonno chuuta yantadü de´wonomma tüwü. Modooje yeijökö yaawö tüdüdü eijanña wowanomanö ñanno yöötö jata nadükomo, mödö yaawö Medewaadi eda´choto´me ma tuweiyemüje. Yojemmaja yaawö na´kwakano ajöchü aje´kadü tujunne nadenha chonekadö maja yaawö iyö yeichojo ataame´da yeichükomo wetö yotonkomo weichojoje

AQUARAP WÜTÖJÖTÖ´JÜDÜ

Aku´sana tu´tajötüdü watannö´nö jökö Medewaadinña, tuna adöödü medewaadi jadawa wadödö, iye akötödü, sotto wejamüdükomo, yotonno yaawö aneja kone´manei weejüdü ekwojötüdü jokonchödö, künojodücho tawanojo´na´komo wanna aninñajankomo jadö kuntonto yaawö tuna enmenka tamjö´ne (AquaRap), edö tüdü jökönchödö yaawö: 1) Ekammajotüdü jökönchödö na´kwakankomo weichükomo yeichü´komo awiyakoko nadü maja yaawö iyö de´wö natoodü tumjune´da ñaakudödü owajo; 2) Eneedü, na´kwakankomo eijaicha naicho iyö yeicho´komo choone´ma´jökö.

Küntöjö´a´to yaawö 25 noviembre yeichü 12 diciembre jona tüdüjoone 2000 wedu yeichü, mödö künnücho yaawö sejiyato sodü jonno matu kankoi tüdüjoone. Ashicha enmenkadü jökönchödö, künö´datokajötüi yaawö aaduwawö amojato´kwakö töneemü: 1) Ka´kada; Dedewatö; 3) Medewaadi dedewatö kanonno sejiyato sodü jonane; 4) Medewaadi dedewato kanonno jaada sodü jonane; 5) Jaadanwakökö; 6) Wünküyade; Muuda sodüchökö; Matu maja. Künötömmenkai yaawö chuuta weichü mawoono nakwakano maja, tuna weichü yakaano maja yaawö, tunanwakonño, se´jömjünükomo na´kwakankomo yotonno yaawö kudaka maja. Edö tüdüajo yaawö, kone´manei weejüdü yeijökö, no´dua´de yaawö medewadi somato´me wowanomatojojene eijaiña aneedawö ke wö´dütojoje.

Programa suramerica wadödö AquaRap tüwü na yaawö iyö nono de´wono aninñajano akö aatantai tawanojo´na´komo maja yaawö soomatojo e´se´totoojo edantödü jökö maja yeichü tüwü ataame´da na´kwakankomo öse chuuta maja yeichükomo wetö ta´kwiti´yemjünü kwaka naatodü America Latina de´wö. AquaRap tadaawajui na yaawö oneejadü iyö tuna´kwawö naatodü yeicho´komo soomatojo maja, tamjö´ne ñe´ku´tödukomoai, ekammajotudu weto yawo kajichanakomowo, jajeeda chonekannamowo, eda´chödüjökö nichü´tajö´aatodü wönñe , científico komowö, jüdata u´namowo maja edo nunhato jokono. AquaRap na yaawö we´wa´tönö jokono ne´se´ta yaawö Coservación Internacional yotonno Field Museum.

AquaRap aka na yaawö tüweiye comité internacional mödö niju´jö´ta yaawö científicokomo eda´chö´sa´komo aköamojato´to´kwakö nono de´wö (Blivia, Brasil, Ecuador, Paraguya, Perú, Venezuela yotonno yaawö Estados Unidos). Edö comité nadü nemmenka yaawö jajeda tamjö´ne ö´düjai yeichü tujunne yeichü maja yaawö enmenkadü jökö yeichü. AquaRap wütöjötüdawö chöjadönñe ichödükomo na yaawö yeichü iyö nonode´wonkomo científicokomo jadö, towanokomo ekammajö´anködö ñanno aninñajankomo we´a´komojadö iyö wadadödö wowanomatojoje eijaicho mödödenha. Yööje wütöjö´nawö yötunnöi watamu´kajö sotto owanökönñe nö´döa yaawö jajeda (Boletin de evaluación Biológica) Conservación Internacional nüdüdü, iyö chonekajö na yaawö kajichanakomo, poditikokomo, eda´sö´cha´komo wadodonoje, tüdüjai natodü eda´chödü jökö yeichü yotonno jüdata iyöjokono tüdüdü jökönchödö yaawö.

Edö nono naadü wenesuweda de´wono chönünhejene owanökö´dana, joduje nö´düa yaawö enmenkadü iyö tuna nonodü de´wonkomo (biodiversidad) choone´madü owajo . Chuuta, tadinñamo, odookoja´komo jökönñe woowanoma´jö tüweiye yeichame, tujunne na yaawö ooje´köjeene iyö nono jökö chönünhejene e´se´tödü wetö yaawö.

CHÖWADÖNÑE SA´DIMINCHAJÖ´AJÖ

Chuuta weichü mawoono na´kwakaano maja

Medewaadinña küntöjö´a´todawö künajoicho yaawö 443 je töneejomü öönünhatojünü yeicho´komo awoono. Iyö töneemü ajöiyajö aka 302 je chuuta weichü, tamedödö tüwü yaawö 1180 je chötükomo ajoijaajö owanökö naadü medewaadinñano aka yeeja´kajö tüwü.

Iyö wowanoma´jö kümja´kai yaawö önneene chuuta weichü, tuna´janonñano nono de´wono nunhedenña nono yaawö chuuta ewanshiñü´je´da. Önnene chuutakomo weichü tunajakökö ooje yo´kadüke tuna jedü. Öönunhe´da ta´ne yeichü jejechö kawö nono weichüke (40–2350 m) mödöje yeichü mödö tamedödö ni´ya´tadenha yaawö önnene na yaawö medewaadi nonodü de´wö.

Nono akanajaato tünnadüato maja de´wö nato yaawö se´kö aatantawö yeichükomo yootonkomo. Yöötö na jooje yaawö wasai, waju ja´komo: *Euterpe precatoria, Attalea maripa, Socratea exhorriza, Genoma baculifera,* yotonno yaawö *Bactris brongniartii.* Ooje´kö önnene yeichü na yaawö Amazoníanñano chutakankomo Guyananñano maja e´joye´kö iyönünhato denha yeichame chuuta weichü. Tüwomonhato nono dedewatö´kwainño na yaawö ooje na yaawö *Oenocarpus,* medewadi´chai´chene yaawö, oojena *Mauritiella,* mödö na yaawö aninñajano tuna´kwainño Escudo Guayana de´wono. Önnene chuuta ejüüdü na yaawö yantadukomo de´wö dedewatö´kwai yotonno yaawö medewaadi´chai jaada to´na tüdüjone. Iyö yantadukomo na yaawö chuuta tüweiye mawoono na´kwakano maja yaawö, anedawö ooje yaawö Podostemonaceae soodü jakökö yeichü tüwü yaawö.

Inñataje tuna weichü

43 je chööwütu künatammüi tuna töneemüje makiñaai ü´joyeno yootonno jü´wayeno maja yaawö. Medewaadi ü´joye na yaawö yaadödö tümaakudö´da, inña na yaawö ooje´kö tuna ñootadukomo yootonno yaawö tuna weichü woije tüwü na yaawö jü´wayeno nünhe´da, mödööje yaawö ooje inñadü´dana yaawö chuuta. Ajo´jo yeichüna yaawö tuna medewaadi weichü ooje awansi´je´da yaka iyö tuna kunötömmenkai edö jökö yeichü: Ta´ne o tukuna´se yeichü, tukuna´sato o ta´nato tünado yeichü, sü´je yeichü, tumuuke yeichü maja yotonno anejakomo maja yaawö.

Ajo´jo yeichü, iyö tuna na yaawo tüda´yeiche (ácida), se´kö ta´nato o tukuna´sato tünadö yeichü tüwü na yaawö. Yeichü mödöjena yaawö tuna konojojato weejüdü. Edö wowanoma´jö weja´kaajö na yaawö awa´deeto wowanoma´jö nünhe maja yeeja´kaajö mödöje na yaawö chü´tadü jena´do´jö nono madono yeijökö. Önünhe küneja´kai yaawö u´joyaano akö jü´wayeeno, yaane, yantai ñootadükomo anijanadö´ja yaawö.

Tumuuke yeichü jököödö´ja, inñataje küneeja´kai tamedödö ajöiyajö küna´ja´dü. Jü´waye tumuuke´kö küneeja´kai u´joyaano e´joye´kö, tuna jedü tükone´ma yeijökööjenñemma kunnöjö awö taku´ne´kö na yaawö, mödö nichamjiyakaja yaawö na´kwakankomo weicho´komo.

Se´jömjünüükomo tunanwakonchomo

25 je jaatadü künootonejai yaawö ñanno se´jömjünükomo tunanwakoichomo önnene yeichükomo. Ñanno weichükomo küneeja´kai yaawö wanna memuuja´komo, mutuuja´komo, diichö, suuduja´komo, ködödöi, wayakanija´komo, ojemma yotonno yaawö. Kanno wechükomo yeichü mödö yaawö tümakudööjünü nossajemjünü tuna aka yeichükomo tünwanno. Künödantöi yaawö tamedöiche tuna wadadödö nato tünwanno se´jömjünükomo tunanwakonchomo. Öönünhe´da önnene yeichükomo tunanwakonchomo na yaawö chü´tadü okisijeno woije tumuuke tuna weichü woijemmaja jenñemma. Mödööje yöödantödü yeichü tujunne na yaawö ne´kö´se ke´ja tuna weichü chamjiyaka´jökö jayeedömma, chuuta akö´a´jökö, o uudu u´kwadüje wetadawakajonö tüdüüa´jökö aneja nüta yaawö tuna aka, chamjiyakajoone yaawö ñanno tunanwakonchomo weicho´komo.

Wayaakani ja´komo

10 je künödantoicho yaawö wayaakani weichukomo enmenka´jüdü dü´tö medewadinña: Toniamojato je suudu weichükomo (Palaemonidae), toni yaawö wayaakani weichü (Pseudothelphusidae), aduwawö yaawö wayakanijato maja (Trichodactylidae). Medewadi ü´joye na yaawö ooje´damma kanno weichükomo jaatodenhamma, jü´waye´kene yaawö ooje´kö aduwawö amojatoto´kwakö. Inñano töötüjanñone aninñaja a´ke tüwü yaawö na suudu, wayaakanija´komo´kene tüweiye natodenha yaawö Llanonña yotonno yaawö Amazonanña. Kanno weichükomo künödantoichu yaawö yeichükomo mödö Escudo de Guayana yotonno yaawö Amazonico de´wö tuna naadü´kwawonkomo kanno. Suudu jadasideedu küna´jaakö yaawö ojejene yöödantödü enmenkadaawö. Kanno natodü yaawö eduwa ajicha nato tünwanno mödöjedenña naato´de tükone´ma´da medewaadi weichü´kö wadaadödö.

Kudaka

65 je jaatadü künö´düi ajoicho´komo sejiyato soodü jonno ka´kadanña tüdüjoone yotonno yaawö muuda soodü jona tüdüjoone jü´waye. Tamedödö yojodüüa´komo yaawö 278 je kudaka weichükomo künödantöi yaawö medewaadi´chawonkomo. Carasiformes weichükomo (orden) küneeja´kaicho yaawö 158 je, 74 je siluriformes, 27 je Perciformes, 9 je Gymnotiformes, 3 je Clupeiformes, 1 je yaawö Beloniformes, Pleuronectiformes, Synbranchiformes. Characidae weichükomo (familia) 113 je. Künödantoicho yaawö owaano de´wö yeichü jonno 45 je Characiformes weichükomo (orden) yootonno yaawö 31 je Characidae. Anejakomo´kene yaawö Siluriformes 49 je küna´ja´to owaano 74 je na eduuwa, Perciformes 12 je yeichü jonno 27 je eduuwa. Tamedöödö yoojodüajö na yaawö eduuwa´komo yöödanta´komo medewadi´chawonkomo 110 je. Tuweiye naato yaawö tönööamoje tüweiyamo ökünüje tüweiyamommaja.

Tunajakokono Chuuta

Medewadinñano chuuta tunajakokono enmenka´jüdü chuuta weichü, yootonoojünü chuuta, iyö nunhato chuuta weichü tuna wadadödö, nono weichü ene´ju´nei maja yaawö küneeja´kai yaawö tujunne eda´chödü nonojoya´komo chuuta tunajakokonkomo. Mödöje yeichü edantotojo yaawö Ingeae weichü jökö nonoweichü woijato wa´tadü tüwüüyeijökö. Chone´nadiyü´janojanñone na yaawö jaadanwawonno ju´wakadö.

Kudaka wöökamodükomo

Kudaka wöökamoa´komo künotonejai yaawö 97 je se´jömjünükomo tunanwakonchomo weichü weja´kajöke, 303 je tunajakokono chuuta yotonno yaawö 278 je kudaka weichükomo tuna ta´kwiti´yemjünü´kwakankomo. 8 jaatadü tömmenkamü künö´datokai öönünhe jaada de´wonno maadödö jaadanwawonno jü´wakadö maja mödö künekammai yaawö: 1) se´jömjünükomo nato chöwadadödömma, yööje´da´kene yaawö kudaka chuutammaja yaawö yööje´da yöökamoa´komo; 2) nono weichü e´nei töneejene küna´jaakö yaawö chuuta jökö; 3) medewaadi ü´joye oojejene´da kudaka weichükomo küneeja´kai yaawö jü´wayeenoje´da, chuuta´kene yaawö yööje´da, se´jömjünükomo´kene yaawö önünhe.

EDÖÖJE YEICHOJONA YAAWÖ EDA´CHOTOJO YOTONNO WOWANOMATOJOJE MAJA

Eda´chotojo eijaicho yaawö yotonno wowanomatojoje edö yennajö jökö yeeja´kajö; edö jonno yö´mennajö nadü tujunnejeene´da na yaawö.

- **Edennamjüdü tamedöödö aku´sana tü´tajötüdü tüwoije tuna medewaadi weichü wawüyümüdü chamjiyakajai naadü, inña´dudu, aneja´kwaka tuna adöödü, tuna wütotojo chamjiyakadü.** Tuna inña´dudu aneja´kwaka adöödümmaja yaawö anijana dö´ja tüdüjai na yaawö tuna wawüyümüdü konojo jökö yeichü. Chuuta weichü yotonno yaawö yöötöödö ichödükomo yeichükomo maja yaawö iyö de´wö nudöiñe naatodü naato yaawö yöötöödö tuna wawüyümüdü tüwoije yeichüke.

- **Tüdüdü wetadawa´kajotojo kudaka wütödükomo ene´mato´komo.** Kudaka wütödükomo nomonhato medewaadi´chaka yotonno yaawö chuuta chunnö´ajö nüdüato yaawö tüwe´moichato´komoje. Yeicho´komo ekone´majaicho jaada de´wonno ü´jonaadö inñawonno jü´wakaado maja ötödantöjai na yaawö o´jajo´da yeichükomo wetö yaawö.

- **Tüdüüdü wetadawa´kajootojo aduwaawö wedu to´kwa´kö kudaka ajoicho´komo choonekatojo jökö jaadanwawonno yeichü.** Töneena yaawö takade´da o´tödü ye´kwanakomo nonoodü de´wö yotonno yaawö oojedeja kudaka ajöchükomo na Jaadanwawonno jüwakaadö. Kudaka ajöichü sadö tujunnena yaawö towadöödö adöödü eneedü wetö yaawö ö´düjai yeichü e´se´totoojo (ö´wasa´kö ajöichü, ö´wasa´koto yaawö jaji) mödööje yaawö ataame´da yeichü wetö kudaka ajöichü.

- **Tüdüüdü wetadawa´kajootojo medewaadi ene´matoojo yotonno yaawö yaimaja tüdüüdü tuna weichü e´nmenkatoojo dedewatö kanö.** Iyö eijaiña yaawö científicokomo wütooto´komooje ajichaajene owanomaiyeto yaawö medewaadi jökö yeichü yotonno tüdüyeto yaawö yötunnöi jo´wadö edö chuutakano tuna weichü. Edööje yeijökö yaawö weichojooje nadü tükoone´ma´dadenña wökaaje´da ne´a choone´madü se´kö na yaawö tükoone´majüünü medewaadi nünhato, mödööje yeijökö yaawö eda´chödü tujunnena yaawö.

- **Tüdüüdü chuuta kunnö´ajö eda´chotoojo.** Medewaadi na ötöda´chöjaicho yöötö nadü yöötödö yeicho´me.

- **Tü´tajö´nö tüdüüdü chu´nakaadü jökö yöötö naatodü eda´choto´menñe.** Jaada de´wonno ü´jonaadödö yootonno inñawonno jüwakaadödö na yaawö chuuta yootonno kudaka maja öönünhe´da naato. Tooni amoojato na na´kwakankomo weicho´komo (soodü, yantadükomo, tuna onkwe´danaadü, ojemma yaawö) mödöökomo tujunnena yaawö 82%je na´kwakankomo weichükoomo eda´choto´menñe, tönööamoje naatodü jadönñe´jüdüüdö töjeemajaamommaja yaawö. Chü´tammeküüdü tujunnena ö´wasa´kö eijaiñai yaawö töda´chöömü 80% je e´joye chuuta yootonno yaawö chuutankomo na´kwakankomo maja weicho´komoje naadü medewaadinña.

- **Woowanomatoojo tüdüüdü tujunne na yaawö na´kwaankomo weichojo eda´chödüjökö.** Edö ö´düjaiña yaawö ye´kwanakomo nonoodü´naköi. Ye´kwanakomo nonoodü jonno jü´wakadödö choone´madü mödö yaawö tukunnö´ato chuuta jataadü. Jü´wayenkomo sotto naato medewaadi´kwawono kedenña, mödöjejene owanomake´jünüche naato yaawö yootonkomo medewaadi eda´chödüüjökö, ataame´da yöötödö eijaicho yeicho´komooje.

- **Amo´chödü yaawö kudaka aninñajankomo amonno´jodü.** Chööwa´kö naato kudaka yeicho´komommaja yaawö medewaadinña aninñajano ötööne´ja´cha yaawö. Na´kwakankomo medewaadinñankomo ñannomma kanno wenesuweda de´wö yeichü yööje yaawö töda´chömje naato. Tüweiye na yaawö ekammajo´tojo aninñajaano kudaka eneejüdü tünkone´ma yeichü ñanno yotonkomo kudaka yeicho´komo maja yaawö.

- **Jenaadö ye´jüdü nünhemmaja tüdüüdü chuuta tunajakokono muuda soodünwawonno jüwakaadödö.** Edö yeichojo tükoone´mana, yaatameeajö mödö yootonkomo (biodiversidad) yootonno yaawö yeichükomo maja (estructura comunitaria). Edö choone´madü otonejajanña yaawö ooje kudaka, suudu, wayakani maja ataajöcha yeichüke jenaadö yei´jüdü nünhe´da. Tüweiye na yaawö chuuta ñaatü´totoojo mödööje iñammaja chuuta weichü ö´düjai na yootonno ooje´kö kudaka eijai natoodenha yaawö.

- **Edöökomo iye ako´tojo tü´tajö´nö e´se´totoojo tüdüüdü ataame´da yeichü wetö:** Ocotea cymbarum, Vochysia venezuelana (kudiyada tüdüemü), Acosmium nitens, Geonoma deversa (ma amotojo) yootonno yaawö Heteropsis flexuosa (wüwa tüka´emü, ma amotojo maja). Mödöje choneka´jökö i´ya´töjaina wö´kaaje´da tadawaju weichü ataame´da medewadinña, mödööjemmaja yaawö jata we´wa´tödü eduwa yöötö nadü komo.

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Tabla de Contenidos

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

APÉNDICES