

## EXECUTIVE SUMMARY

### 1. INTRODUCTION AND BACKGROUND.

There are vast differences in the importance of rivers in underdeveloped rural areas as opposed to developed areas. Low income rural communities, have a high level of dependence on a river and its catchment. River ecosystems not only supply water but also food, medicine, fuel, building material, and play an important role in social and cultural lives of these people. General awareness of their effect on rivers, needs of other users, and potential employment opportunities related to services provided by rivers are, however, almost non existent.

River management should include aquatic awareness as well as community participation. All these activities are knowledge based and specifically include knowledge of threshold values of the factors that sustain riverine biota. However, very little is known about this aspect and how it is influenced by anthropogenic activities. Consequently the effects on diversity are still unclear. In trying to understand loss of diversity it is important to examine and understand fine scale determinants of freshwater rheophilic assemblages. These determinants include available habitat and changes in the physico-chemical parameters that influence habitat preference, distribution, niche partitioning, assemblage structure as well as nutrient pathways and feeding adaptations.

In rivers the fast-flowing or rheophilic habitats are the most sensitive because of their dependence on flow. This project aimed to determine thresholds of probable concern by explaining and modelling the loss of aquatic diversity in rheophilic biotopes through an understanding of niche differentiation and habitat requirements of selected biota.

It was envisaged the products of the project would include the proposal of TPCs and a neural network that describes niche partitioning and habitat requirements in rheophilic biotopes as well as applies TPCs.

## **2. SITE SELECTION AND GENERAL APPROACH.**

Two rivers, the Luvuvhu and Mutale, were selected for study. The Luvuvhu River arises in the Soutpansberg Mountain complex and flows through a diverse landscape before it joins the Limpopo in the Kruger National Park. The Mutale River emerges as a "spring" below Lake Fundudzi and joins the Luvuvhu River in the Kruger National Park before its confluence with the Limpopo River.

The two rheophilic sites were selected to represent an anthropogenically "disturbed" and a "less-disturbed" reach. The "disturbed" site was in the Luvuvhu River close to Tshino village and is situated in what is regarded as Lowveld (ecoregion 5.04). The "less-disturbed" site was in the Mutale River and is situated in Central Highlands (ecoregion 2.01). Care was taken to ensure that the selected sites had the biotopes and habitats required by both fish and macro-invertebrates. Both sites are at similar altitudes which would imply that similar biota could be expected.

The sites were comprehensively sampled a total of nine times each in the period from August 2000 to May 2002. The microbiology team could not be present during all of these dates and sampled both sites on five separate occasions. Macro-invertebrate data generated in a separate survey during 1999 was also included.

The sampling protocol consisted of a grid of 4m<sup>2</sup> quadrats marked out with metal stakes at each corner. Fish, macro-invertebrates and detritus for microbiological investigation, were collected in each of the quadrats. After all the quadrats had been sampled, different biotopes, such as a rapid, a riffle and pools, were identified outside the grid area and fish were collected in each. The sampling team consisted of at least one fish expert and one invertebrate expert. The physico-chemical aspects of the water, the river profile and substrate determination were done for each of the eighteen site visits.

## **3. THE PHYSICO-CHEMICAL CHARACTERISTICS**

During each site visit pH, temperature, conductivity and dissolved oxygen were determined on site. A water sample was also collected for laboratory analyses.

In the laboratory the turbidity and the Total Suspended Solids (TSS) of the water were determined.

Maximum and minimum water depths, in flowing water, were recorded. Velocity was measured with a velocity meter at approximately 3 – 5cm above the substrate level and the maximum and minimum velocities for each site were recorded. Estimates of the dominant substrate types viz. boulders, cobble, gravel, sand and silt/clay in each block were noted.

#### **4. MICROBIOLOGICAL ASPECTS**

*E. coli* (45%) and *Salmonella* (45%) were isolated more frequently from the skin of the fish caught in the Mutale River while more *Staphylococcus aureus* (54%) were isolated from fish skin from the Luvuvhu River. No *Listeria* isolates were cultured from any of the skin or gut samples of the fish from both rivers. From the gut content of the fish, *Salmonella* (45%) was the most frequently isolated organism in fish from both rivers. In both rivers during the study period *E. Coli*, *Salmonella* spp, *S. aureus* and *Clostridium perfringens* were detected.

#### **5. MACROINVERTEBRATES**

A total of 30 macroinvertebrate families and 4551 individuals were collected, three families were singletons and two families were doubletons. Statistically there were no significant differences between the assemblages of Tshino and Mutale. Functional feeding group analyses suggest that collectors dominated both sites while shredders were completely absent. Predators and scrapers comprised a small percentage of the total individuals caught and at Tshino (post 2000 floods) there was a moderate but probably not significant, increase in scrapers. The significant temporal seriation in the community assemblage of the macroinvertebrates structure suggests a successional recovery in communities after the floods of 2000. Habitat substrate, i.e. the presence of boulders, cobbles, bedrock and mud, played the most important part in invertebrate assemblages structuring at the micro scale. At macro-scale the abundance of one family, Leptophlebiidae, was significantly correlated with a combination of serial environmental factors.

## 6. FISH

Both sites were dominated by three rheophilic fish species, namely *Chiloglanis pretoriae*, *Labeo cylindricus* and *Amphilius uranoscopus* and one semi-rheophilic species, *Labeobarbus marequensis*. Some limnophilic species that are generally not found in rheophilic habitats were also collected. This included *Barbus trimaculatus*, *Petrocephalus wesselsii*, *Marcusenius macrolepidotus* and *Mesobola brevianalis*. The Tshino site appears to have a larger fish population that is completely dominated by *C. pretoriae*. The Mutale site has a higher fish diversity, which could be linked to the higher habitat integrity of the lesser-impacted Mutale River. During the study period continuous increase in fish numbers occurred at Tshino, caused mainly by the increase of *C. pretoriae*. The opposite is evident at Mutale where the total number of fish collected decreased. This difference was ascribed to recovery of the sites after the 2000 floods. Flood damage at the Mutale site was less severe, probably due to the buffering effect of Lake Fundudzi. As a whole there was a decrease in fish diversity, predominantly because of a significant decrease in evenness over the period. The absence of seasonal effects on fish abundance or composition indicates dynamic fish communities that are possibly not stable and still adjusting from the effects of the February 2000 flood.

The analyses of the stomach contents illustrated the differences between feeding types and trophic niches. In the case of the insectivores these differences were underpinned by the stomach morphology.

The results indicated that both *C. pretoriae* and *L. cylindricus* are distinctly rheophilic with the former more frequently observed in shallow water and the latter in water deeper than 0,5 m. *L. marequensis* showed no clear preference and is regarded as semi-rheophilic.

While the majority of *A. uranoscopus* were collected in fast flowing habitats at both sites their preference for shallow or deep water differed between the two sites. The species can however be classified as a true rheophilic species.

Monitoring projects can be used to outline the biotic integrity but little is still known about the factors and interaction of factors responsible for the decline in ecological integrity. Both fish and invertebrates have been used in monitoring but there still no agreement about which group is the most efficient.

Comparisons between the analyses of fish and macroinvertebrate data sets suggest that fish are better predictors of water quality, but no real seasonality was evidenced in assemblage structure and water quality variables were the best predictors of their composition. Macroinvertebrate assemblages seemed to be seasonal and respond more to characteristics of the habitat structure than to water quality variables.

Fish assemblages as a whole respond to water quality variables to a larger extent than invertebrates. However, when focusing on responses at finer taxonomic level, the macroinvertebrate family, Leptophlebiidae, was the best indicator of the environmental conditions measured in this study.

#### **7. A PREDICTIVE MODEL OF ANTHROPOGENIC INFLUENCES.**

A simplified conceptual model was developed in an attempt to abstract important anthropogenic influences at increasing levels of detail. This model provides the essential framework for the understanding of the various influences on the river, as it captures those concepts that are important for the maintenance of biodiversity. A synthetic dataset was used to train a feed-forward back-propagation neural network consisting of one intermediate layer of 10 neurons, which was successful in classifying the dataset into six distinct groups. These preliminary results demonstrated that neural network modelling can be used as a diagnostic or classification tool. From this initial investigation it would appear that neural network analysis of river data will shed some light on river health and is an approach well worth pursuing. The preliminary model classified sites correctly and enabled the identification of sites impacted by anthropogenic influences. This kind of model needs to be investigated more fully and used for the examination of complex, multivariable water quality systems.