A SOCIO-BIOLOGICAL STUDY OF THE AQUATIC RESOURCES AND THEIR UTILIZATION IN AN UNDERDEVELOPED RURAL REGION, THE MUTSHINDUDI RIVER CATCHMENT

VOLUME 2

REPORT TO THE WATER RESEARCH COMMISSION

by

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CHAPTER 10

A CHEMICAL PROFILE OF THE MUTSHINDUDI RIVER, NORTHERN PROVINCE

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10.1 INTRODUCTION

To understand the factors affecting the sustainable use of water, it is important to obtain a thorough knowledge of the nature and status of this resource (Department of Water Affairs, 1990). This project commenced in July 1995 to study the physico-chemical aspects that are the subject of this report.

Generally-used physical-chemical criteria of water quality (Kempster *et al.*, 1980; Shaw, 1988; Gordon, 1992) are electrical conductivity, pH, temperature, and suspended solids, while it may also be necessary to monitor the presence of toxic elements such as cadmium, cerium, copper, lead, lithium, mercury, arsenic, beryllium, and chromium. Water hardness is assessed by calcium and magnesium, and the presence of detergents may be assessed by means of surface tension. Solids form the most obvious visible component of water quality, and derive from organic and inorganic sources. Electrical conductivity depends on the presence of dissolved salts. Temperature is an important factor, mainly because of the effect of temperature *changes* on living organisms. Since oxygen is such an essential ingredient for the sustenance of life, dissolved oxygen plays an important part in the assessment of water quality; it also affects the taste of water.

10.2 METHODS

Representative water samples were collected regularly from the Mutshindudi and its tributaries over a two-year period. Using standard methods (van Loon, 1980; Shaw, 1988), these samples were analysed for a range of indicators. Analyses were executed initially mainly by atomic absorption spectroscopy, but other techniques (mainly Merck Spectraquant kits) were also employed as they became available. Twelve potential sampling sites were identified and after an exploratory round of sampling and analysis, this number was reduced to eight sites (Table 10.1).

10.3 RESULTS AND DISCUSSION

Three samplings were undertaken (15 October 1995, 11 March 1996, 8 May 1996). Representative results are summarised in Tables 10.2 to 10.10. Figures 10.1 and 10.2 are graphic examples of the distribution of certain parameters. To gain an insight into average concentrations the analyses were also plotted cumulatively.

Table 10. 1 Sampling sites. Distances are measured upstream from the confluence with the Luvuvhu. The actual full (midstream bed) distance from the confluence to Site No. 1 is estimated to be 75 km.

Site	Name	Coordinates	Distance/km
1	Thathe Vondo	30:20 E, 22:56 S	45,0
2	Phiphidi	30:23 E, 22:57 S	37,5
3	Sibasa	30:29 E, 22:55 S	25,8
4	Dzingahe	30:31 E, 22:55 S	23,0
5	Tshinane (Jail)	30:32 E, 22:54 S	
6	Matatshe	30:35 E, 22:54 S	15,6
7	Tshirunzini	30:38 E, 22:52 S	7,8
8	Mbwedi	30:40 E, 22:52 S	3,6

The heavy rains that commenced in November 1995 increased the flow, even throughout winter. The effect on the chemical profile is clearly shown in the graphs, with especially the suspended and dissolved solids increasing dramatically. A second noteworthy aspect is the contribution to constituents in the Mutshindudi made by the runoff from the densely populated Sibasa area (Sites 2 to 4) and the Tshinane River (Site 5). Even during periods of very low or very high volume flow, none of the measured chemical indicators of water quality (except Suspended Solids occasionally) exceeded acceptable levels (*cf* Table 10.7).

Table 10.2 Suspended Solids, $mg.dm^{-3}$.

Date | Site	1	2	3	4	5	6	7	8
15.10.95	3.0	2.0	2.0	3.1	5.3	7.5	7.7	7.9
11.03.96	3.0	16.4	13.5	12.6	33.7	55.6	53.4	43.1
08.05.96	3.6	7.2	112.8	91.7	2520.2	834.0	737.4	

Table 10.3 Total Dissolved Solids, $mg.dm^{-3}$.

Date | Site	1	2	3	4	5	6	7	8
15.10.95	300	300	200	200	200	500	100	100
11.03.96	42	11	62	59	40	96	128	166
08.05.96	39	10	5	32	26	12	16	

Table 10.4 Calcium concentration, $mg.dm^{-3}$.

Date | Site	1	2	3	4	5	6	7	8
15.10.95	0.4	1.0	2.6	4.5	3.2	4.9	5.4	4.5
11.03.96	0.3	0.2	0.6	0.4	0.7	0.7	0.7	0.6
08.05.96	1.5	5.3	8.9	12.6	4.3	12.6	10.5	

Table 10.5 Magnesium concentration, $mg.dm^{-3}$.

Date | Site	1	2	3	4	5	6	7	8
15.10.95	1.2	1.5	2.8	3.4	3.5	3.4	3.4	3.7
11.03.96	0.5	0.5	1.0	0.8	1.0	0.9	0.9	0.9
08.05.96	0.3	0.3	0.5	0.5	0.4	0.4	0.5	

Table 10.6 Zinc concentration, $\mu g.dm^{-3}$.

Date | Site	1	2	3	4	5	6	7	8
15.10.95	22	15	0	0	7	22	0	0
11.03.96	38	0	127	12	18	0	0	0
08.05.96	56	28	86	16	19	105	28	

Table 10.7 Representative chemical indicators of water quality (Department of Water Affairs, 1990).

Criterion		Aesthetic quality				Chemical quality	
	pH	Iron, μgdm^{-3}	SS, $mgdm^{-3}$	TDS, $mgdm^{-3}$	Zn, μgdm^{-3}	Ca, $mgdm^{-3}$	Mg, $mgdm^{-3}$
Value	6,5-8,5	<300	<25	<1000	<30	<1000	<1500

Table 10. 8 First Collection, 15.10.95

Site	1	2	3	4	5	6	7	8
$SS/mgdm^{-3}$	3	2	2	3.1	5.3	7.5	7.7	9.7
$TDS/mgdm^{-3}$	300	300	200	200	200	500	100	100
Time	10:00	10:35	14:25	11:30	14:00	12:00	12:35	13:05
Temp/°C								
EC/mSm^{-1}								
PH								
DO_2 %								
$DO_2/mgdm^{-3}$								
$Ca/mgdm^{-3}$	0.4	1.0	2.6	4.5	3.2	4.9	5.4	4.5
$Mg/mgdm^{-3}$	1.2	1.5	2.8	3.4	3.5	3.4	3.4	3.7
$Fe/\mu gdm^{-3}$	0	0	0	0	0	0	0	0
$Zn/\mu gdm^{-3}$	22	15	0	0	7	22	0	0

Table 10.9 Second Collection, 11.3.96

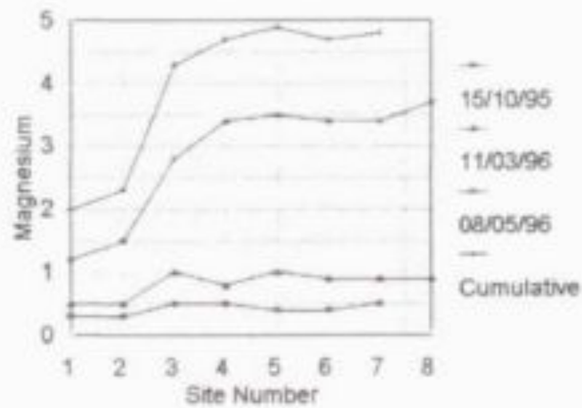
Site	1	2	3	4	5	6	7	8
SS/mgdm^{-3}	3.0	16.4	13.5	12.6	33.7	55.6	53.4	43.1
TDS/mgdm^{-3}	42	11	62	59	40	96	128	166
Time	9:20	10:00	14:05	10:35	13:35	11:30	12:00	12:35
Temp/°C	24.1	22.9	24.8	22.2	24.0	22.9	24.0	24.8
EC/mSm^{-1}	20	20	30	30	40	40	40	40
PH	5.9	6.3	7.3	6.5	7.7	6.9	7.1	7.3
DO_2 %	54	95	86	91	96	85	83	91
DO_2/mgdm^{-3}	4.6	7.7	6.5	7.6	7.6	7.2	6.8	7.2
Ca/mgdm^{-3}	0.3	0.23	0.59	0.44	0.67	0.67	0.67	0.59
Mg/mgdm^{-3}	0.5	0.47	0.95	0.8	1.02	0.89	0.93	0.89
Fe/μgdm^{-3}	80	270	120	195	210	540	400	365
Zn/μgdm^{-3}	38	0	127	12	18	0	0	0

Table 10.10 Third Collection, 8.5.96

Site	1	2	3	4	5	6	7	8
SS/mgdm^{-3}	3.6	7.2	112.8	91.7	2520.2	834.0	737.4	
TDS/mgdm^{-3}	39.0	10.0	5.0	32.0	26.0	12.0	16.0	
Time	10:50	11:15	12:00	14:50	14:40	13:00	13:30	
Temp/°C	19.6	18.9	19.4	19.8	19.2	18.9	19.4	
EC/mSm^{-1}	30	30	40	50	30	40	50	
PH	6.9	7.2	7.3	7.3	7.2	7.2	7.2	
DO_2/%	61	97	97	95	96	97	94	
DO_2/mgdm^{-3}	5.4	8.9	8.5	8.0	8.3	8.5	8.2	
Ca/mgdm^{-3}	1.5	5.3	8.9	12.6	4.3	12.6	10.5	
Mg/mgdm^{-3}	0.28	0.30	0.50	0.49	0.35	0.44	0.52	
Fe/μgdm^{-3}	21	12	0	21	7	5	14	
Zn/μgdm^{-3}	56	28	86	16	19	105	28	

10.4 CONCLUSIONS

Although water quality has not yet deteriorated significantly, the environmental overload resulting from population-related emissions into the Mutshindudi has been clearly shown, and should be monitored regularly in future. If the Mutshindudi catchment is representative of other catchments in rural areas, local authorities should take cognizance of the threat to South Africa's water resources.



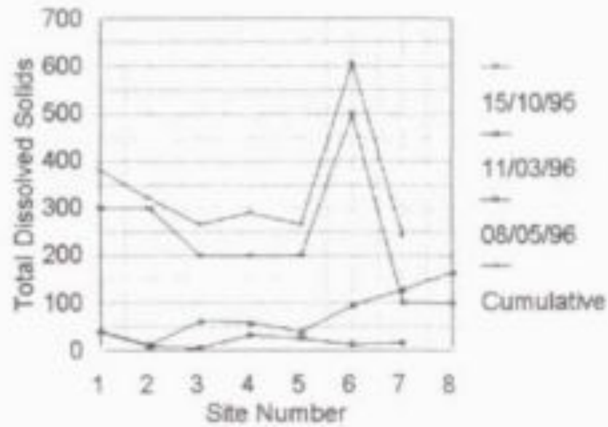


Figure 10.1 Magnesium concentration, mg.dm^{-3}. **Figure 10.2** Total Dissolved Solids, mg.dm

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CHAPTER 11

AN INVESTIGATION INTO THE PATHOGENIC MICROBIAL CONTAMINATION OF THE MUTSHINDUDI RIVER

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11.1. INTRODUCTION

Water-borne diseases is an important cause of mortality in most underdeveloped regions of the third world (OAU, 1992). Of these, diarrhoea is the single largest cause of infant mortality in rural areas of South Africa (Changing Health in SA, 1991). During the period 1994 to 1996 three clinics in the Mutshindudi River catchment reported between 10 and 58 cases of diarrhoea per month in children under 12 years of age. In all three years the incidence peaked in January, in April to May and again in August to September. The reason for this is not clear. Slightly fewer cases but with the same trend were reported for older children. It is unknown whether these cases were caused by unhygienic household conditions or by contact with contaminated river water.

This study evaluated bacterial contamination of the Mutshindudi River as a possible cause of human infection.

11.2. MATERIALS AND METHODS

11.2.1 Sample collection

Water samples were collected in sterile two-litre glass bottles with screw-caps, at seven different locations along the Mutshindudi River (Fig. 11.1) The samples were kept cool and analysed within 18 hours after collection.

11.2.2 Media used

Pathogenic bacteria were isolated and characterized according to Standard Methods, SABS Method 221-1990 second revision. *Salmonella* was isolated using Oxoid XLD at 37 °C for 24 hours as well as with Selenite F broth at 37 °C for 24 hours. *Shigella* and Vibrios were isolated using Oxoid TCBS at 37 °C for 48 hours as well as with SAIMR double strength Alkaline peptone water at 37 °C for 48 hours. *Streptococcus faecalis* was isolated using Biolab MacConkey W/O Crystal Violet with salt at 37 °C for 24hours as well as with Bile esculin at 37 °C for 24 hours. *E. coli* 0157 H was isolated using Oxoid Sorbitol MacConkey agar at 37 °C for 24 hours.

11.2.3 Bacterial counts

The density of faecal bacteria was determined with the membrane filtration technique on selective m-FC agar at 44°C for 18 to 24 hours. Coliphage V1 was counted using the double agar layer technique at 37° C for 6 to 18 hours. The *Clostridium perfringens* stereotype could not be ascertained.

11.3. RESULTS

11.3.1 Pathogenic bacteria isolated

Various pathogenic and opportunistic pathogenic bacterial strains were isolated and identified including: *Salmonella group C species; Aeromonas hydrophilia; E .coli 0157 H; C perfringens; Sreptococcus faecalis; Flavobacterium odoratum; Serratia oditera; Proteus vulgarus; Proteus mirabilis; Aeromonas sorbria; Citrobacter freundii; S. faecium; S. bovis; S. equinus; S. avis* and *Klepsiella* species.Table 11.1 shows that only one *Salmonella* group C species was detected at collecting site 4. This identification was confirmed with the help of Wellcolex colour agglutination, specifically for *Salmonella* and *Shigella* as well as API 20 E.

The genera *Klepsiella* and *Proteus* were detected in large numbers on plates. *Streptococcus faecalis* were found and identified with bile-esculine at collecting sites1,2,3,4,5 and 7. An *E. Coli* 0157 was found, but further confirmation is necessary. Lastly, a *Pseudomonas cepaciae* was detected at site 7, an *Aeromonas hydropilia* at site 6 and *Aeromonas sorbia* at site 4.

11.3.2 Pathogenic bacterial counts

Figure 11.2 shows relatively low counts of common pathogenic bacteria at all sites except for *E. coli* at site 4 and coliform as well as *E. coli* at site 7. Even at these two sites the counts are not exceptionally high.

11.3.3 The effect of runoff

Figure 11.3 shows a rapid increase in Faecal *E. coli* count due to runoff after a dry period in May 1996. Human faecal matter washed from surrounding areas could be the cause of this contamination.

11.4 DISCUSSION

Samples from the Mutshindudi River contained a number of potential pathogenic bacterial agents. The presence of pigmented bacteria such as *Flavobacterium* and *Serratia* is reason for concern. Although a high heterotrophic count does not necessarily constitute a health risk, it is a sign that a particular network is subject to biological disorders, which can protect pathogenic species (Piriou *et al* 1996). The presence of *Aeromonas* may be problematic because this organism is currently considered to cause gastro-enteritis (Graviel *et al.* 1996). Up to date no correlation could be found between the incidence of *Aeromonas* and total coliform or total heterotrophic plate counts. *Salmonella* species are mostly pathogenic and could in some instances be fatal to humans, causing enteric fevers, gastro-enteritis and septicaemia and could also affect animal species.

Although the coliform count of the Mutshindudi River is not exceptionally high, water from the river is not suitable for human consumption. This condition worsens after rains. According to the World Health Organisation (WHO) the guideline values for bacteriological drinking water quality of unpiped water supplies should not exceed more than 10 coliform organisms per 100 ml and no faecal coliform counts should be detected (Helmer *et al.* 1991). In South Africa the maximum allowable limit for total coliform is 5/100 ml and re-sampling is necessary if coliform is found and for faecal coliforms there should be none (Pieterse, 1989 and DWAF, 1993).

11.5. RECOMMENDATIONS.

The community should be made aware of the dangers of using untreated river water and of means of purifying water. Improvement of the water provision network, improvement of sanitation and upliftment of the community will also help to alleviate the problem.

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Standard Methods SA Bureau of Standards 221-1990 2nd revision.

Figure 11.1 A map of the Mutshindudi River system showing collecting sites

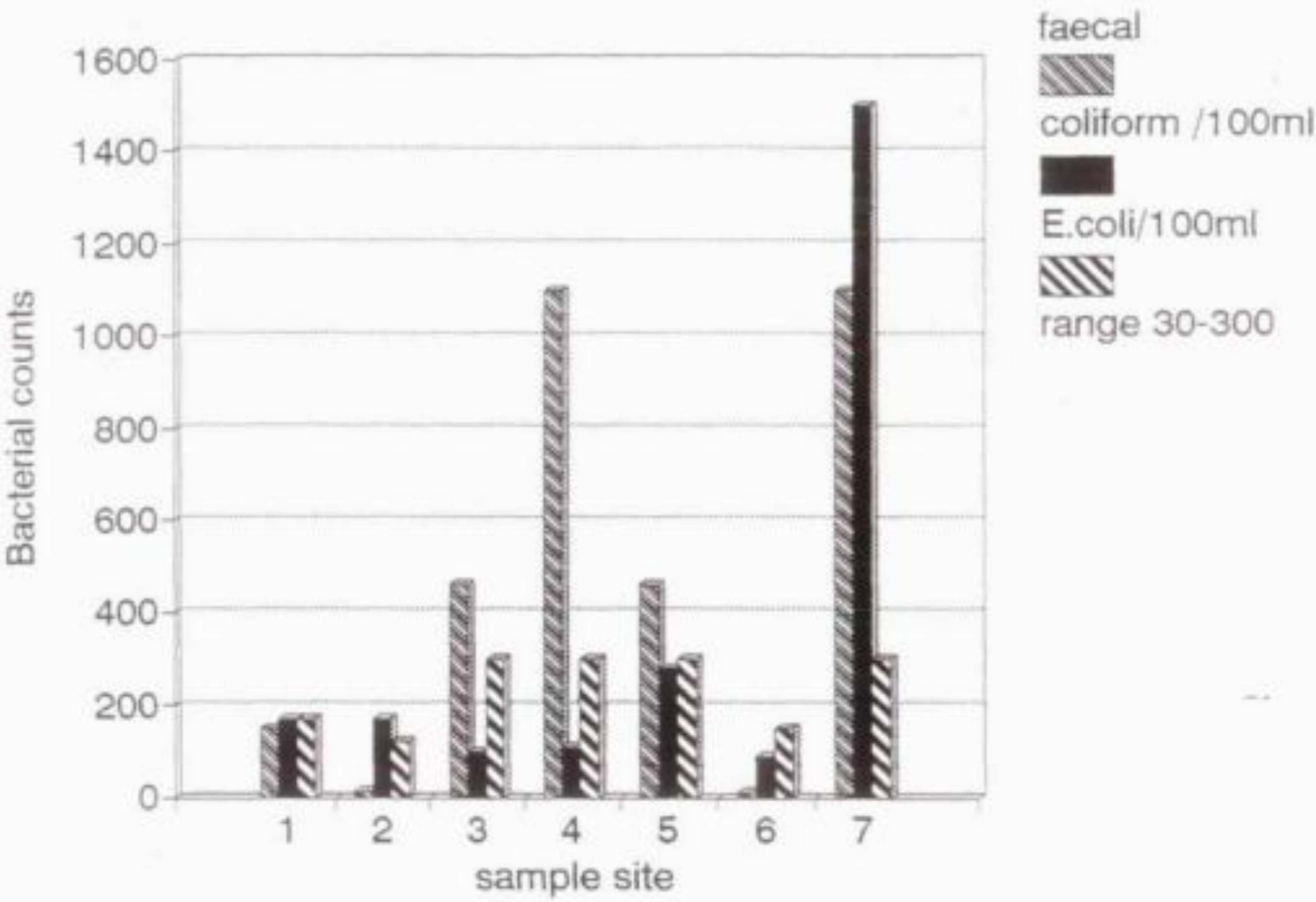

Figure 11.2 Average pathogenic bacterial counts at different localities in the Mutshindudi River

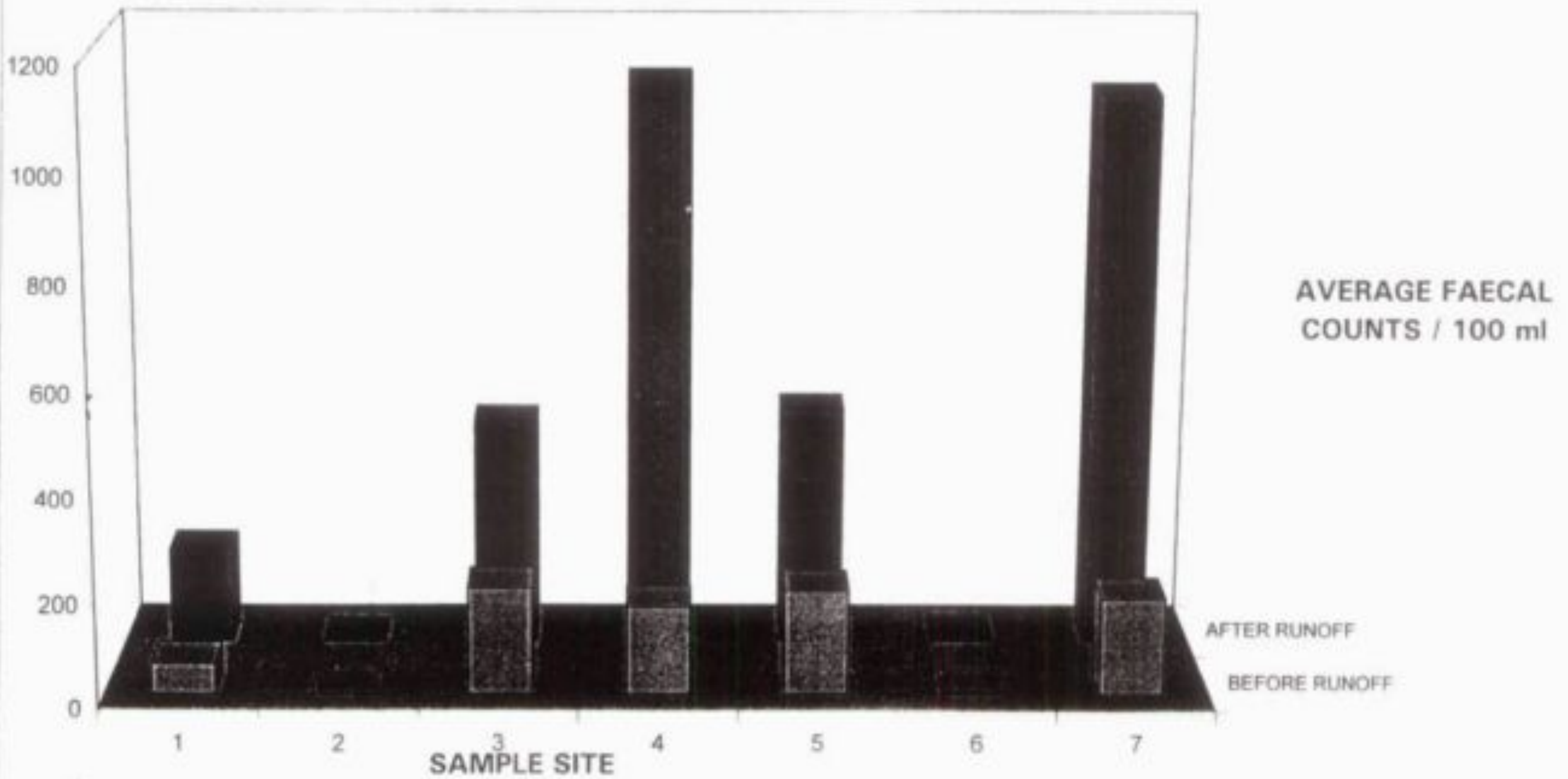

Figure 11.3 A comparison of faecal counts before and after runoff

CHAPTER 12

THE STRUCTURE AND COMPOSITION OF PLANT COMMUNITIES IN THE MUTSHINDUDI RIVER CATCHMENT

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12.1. INTRODUCTION

Vegetation research has been minimal in the Mutshindudi Catchment. A literature survey has shown that within the catchment, only the vegetation of the Phiphidi Reserve (Mushasha,1996) and Mbahe area (Phamphe, 1997) has been studied. Reports have been written on the Soutpansberg range describing vegetation types, but only at a broad regional scale (Acocks 1988, Butt *et al.* 1994, Erasmus & Geldenhuys 1993, Evans 1994, Everard *et al.* 1995). In view of the environmental problems developing as a consequence of the degradation of the catchment through human activities, studying the plant communities and establishing the current conservation status is urgent.

This study attempts to give basic information on the vegetation of the catchment as a descriptive record, and to provide botanical knowledge which may contribute to management decisions and restoration attempts in the future. Future research will also be facilitated by the broad picture given of the main communities within the catchment, which together with plant species lists and photographs provide base line data.

12.2. OBJECTIVES

The main objectives of the research part of this study were: (1) to identify and to describe the main plant communities in the Mutshindudi Catchment; (2) to compile a species list of plant species found in the plots sampled and (3) to establish the conservation status of the catchment.

12.3. MATERIALS AND METHODS

Fieldwork was initiated towards the end of 1995, and was completed by mid-1998. The exploratory phase was finalised during 1996. Data was collected and analysed from 1996 until early 1998. The research initially covered only the aquatic and semi-aquatic vegetation of the Mutshindudi River. However, in the early phases of data collection it became evident that this approach would yield insufficient information. The vegetation had been removed or had been severely reduced by the floodwaters which had followed the heavy rains of 1996. It was therefore decided to broaden the range of fieldwork to include the main plant communities within the catchment.

Sampling sites were selected in areas representative of communities identified through reconnaissance aided by aerial photographs. Tea plantations, cultivated fields and orchards were not included. The structure and floristics of the communities were studied using the semi-quantitative Braun-Blanquet Method (Braun-Blanquet 1932). Quantitative data of the woody component (trees and shrubs) of the forest at Matondoni was obtained using the Point-Centred Quarter Method (Cottam & Curtis, in Cox 1969). Photographs were taken as visual documentation. Mr S. Venter collaborated with us in the fieldwork and with plant identification.

For the purpose of this research, the study area was divided into three sections: (1) upper catchment: source to, and including, the Phiphidi Nature Reserve; (2) middle catchment: from Phiphidi Nature Reserve to the Sibasa-Hamakuya road bridge; and, (3) lower catchment: from the Sibasa-Hamakuya road to the confluence with the Luvuvhu River.

The communities were classified physiognomically into seven main categories: forest, afforestation, bushveld, secondary thicket, grassland, fallow fields, reed beds, marshes, littoral and aquatic vegetation. The communities were given names after the most dominant species present.

Descriptions of the plant communities are given, based on 80 plots. The descriptions include some information collected by post-graduate students (Mushasha 1996, Phamphe 1997). The structural information, where available, is presented in table form. The minimum and maximum values are given as an indication of the range that occurs within the plots used to describe each community type. Total plant cover of the plots is also given as a range.

Floating aquatic communities were very rare because most of these communities had disappeared after the 1996 floods, and had not yet recovered by the end of the sampling period.

12.4. RESULTS: OVERVIEW OF THE MAIN PLANT COMMUNITIES OF THE MUTSHINDUDI CATCHMENT

1. Forest Communities

- 1.1 *Syzygium cordatum - Bridelia micrantha* **Pristine Riverine Forest**
- 1.2 *Breonadia salicina - Syzygium guineense* **High Pristine Riverine Forest**

- 1.3 *Schefflera umbellifera - Aphloia theiformis* **Pristine Montane Forest**
- 1.4 *Pseudolachnostylis maprouneifolia - Xylophia parviflora* **Open Forest**
- 1.5 *Tarchonanthus trilobus - Coddia rudis* **Open Low Forest**

2. Afforestation

- 2.1 *Pinus* spp. **Afforestation**
- 2.2 *Eucalyptus* spp. **Afforestation**

3. Bushveld Communities

- 3.1 *Bridelia mollis - Euclea divinorum* **Bushveld**
- 3.2 *Bauhinia galpinii - Annona senegalensis* **Bushveld**

4. Secondary Thickets

- 4.1 *Dichrostachys cinerea - Panicum maximum* **Secondary Scrub**
- 4.2 *Caesalpinia decapetala - Lantana camara* **Secondary Thicket**

5. Grassland Communities

- 5.1 *Eragrostis curvula - Themeda triandra* **Montane Grassland**
- 5.2 *Panicum natalense - Loudetia flavida* **Montane Grassland**
- 5.3 *Heteropogon contortus - Chloris virgata* **Secondary Grassland**

6. Vegetation on abandoned fields

- 6.1 *Vernonia poskeana - Perotis patens* **Community**

7. Reeds, sedge marshes, littoral and aquatic communities

- 7.1 *Phragmites mauritianus* **Reed Community**
- 7.2 *Typha capensis* **Reed Community**
- 7.2 *Setaria sphacelata - Juncus lomatophyllus* **Littoral Community**
- 7.3 *Nymphoides* sp. - *Isolepis fluitans* **Littoral Community**

12.5. DESCRIPTION OF PLANT COMMUNITIES

12.5.1. Forest Communities

- 1.1 *Syzygium cordatum - Bridelia micrantha* Pristine Riverine Forest

This forest type was sampled in the upper catchment, about one kilometre upstream of Thathe Vondo Dam. It occurs as a fringe along the river, and hence, occupies a small area within the catchment. The substrate is quarzite and the soil a reddish clay.

The following structural values were obtained:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - (0,25)0,3	5 - 20	70 - 80
Sub-canopy	(0,25)0,3 - (1,5)3,0	5 - 25	
Canopy	(1,5)3,0 - (8,0)12,0	50 - 70	

Floristics

The dominant canopy species was *Syzygium cordatum*. Other canopy and subcanopy species were *Ficus sur*, *Anthocleista grandiflora*, *Maesa lanceolata*, *Keetia gueinzii*, *Aphloia theiformis* and *Nuxia floribunda*. A special sub-canopy species was *Todea barbara*, which is a rare fern. Common species of the field layer were the grasses *Oplismenus hirtellus*, *Leersia hexandra*, and on one site, *Juncus lomatophyllus*. There was no sign of human interference, no noxious invasive species recorded nor bank erosion noted.

- 1.2 *Breonadia salicina - Syzygium guineense* High Pristine Riverine Forest

This forest type was sampled in the Phiphidi Nature Reserve and in the lower reaches of the Mutshindudi River. It contained magnificent examples of what probably was the vegetation along the Mutshindudi River before human disturbance occurred. The forest forms a tall band of trees along the river (Figure 12.1).

The following structural data was recorded:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - (0,6)1,5	15 - 30	40 - 80
Sub-canopy	(0,6)1,5 - (2,0)5,0	20 - 35	
Canopy	(2,0)5,0 - (7,0)18,0	20 - 60	

Floristics

The canopy and sub-canopy was dominated by *Breonadia salicina* and *Syzygium guineense*. Other canopy species were *Rothmania globosa* and *Englerophytum natalense*. *Keetia gueinzii* was a common climber. The field layer was covered by *Dicliptera clinopodia*, and in one plot, also by *Dietes iridioides*.

- **1.3** ***Schefflera umbellifera - Aphloia theiformis*** **Montane Forest**

These were forested areas on the slopes of the mountains in the upper catchment, usually on rocky ridges where they were protected from fire (Figure 12.2). The soil was a shallow, brown humus-rich, sandy-loam. The slope was between 10 and 25 degrees. The community physiognomy was that of a mesic forest, with the canopy having the highest cover value. There was a relatively inconspicuous subcanopy and a sparse field layer.

The following structural values were estimated:

	Height(m)	Cover (%)	Total cover (%)
Field layer	0 - 0,3	15 - 25	80-85
Sub-canopy	0,3 - (2,0)5,0	5 - 20	
Canopy	(2,0)5,0 - (8,0)10,0	70 - 75	
Emergent	14,0	5	

Floristics

The canopy was dominated by *Schefflera umbellifera*, *Nuxia floribunda*, *Aphloia theiformis*, *Englerophytum magalismontanum*, *Eugenia woodii* and *Syzygium gerrardii*. The sub-canopy was formed by *Ochna arborea*, *Maytenus acuminata*, *Pterocelastrus echinatus* and *Englerophytum magalismontanum*. The field layer consisted mainly of *Oplismenus hirtellus*.

A quantitative study of a Montane Forest in the Matondoni area

The woody element of this community was studied in the Matondoni area, in the upper catchment. There, the taller trees achieved a height of up to 18 m, with an estimated crown diameter which ranged from 8-14 m. This type of forest was studied using the point-centered quarter method. The results are given in tables 12.1 and 12.2.

Floristics

The number of species in the sub-canopy layer exceeded the number of species in the canopy. Thirty plant species were recorded in the sub-canopy layer, whereas only 16 species were recorded in the canopy layer. Table 12.1 shows that *Schefflera umbellifera* was dominant, followed by *Bridelia micrantha* and *Cussonia spicata*. Table 12.2 indicates that in the sub-canopy, *Psychotria capensis* had the highest importance value, followed by *Combretum kraussii* and *Xymalos monospora*.

Table 12. 1. The species sampled in the top canopy of the forest along the valley slope, arranged according to decreasing Importance Value.RF = Relative frequency, RD = Relative density, RDom = Relative dominance and I.V. = Importance Value.

SPECIES NAME	RF	RD	Rdom	I.V.
Schefflera umbellifera	0.111	0.143	17.256	17.510
Bridelia micrantha	0.067	0.054	17.099	17.219
Cussonia spicata	0.022	0.036	9.795	9.853
Albizia adiantifolia	0.089	0.071	8.527	8.687
Brachylaena discolor	0.089	0.107	7.652	7.848
Combretum molle	0.067	0.071	6.669	6.807
Croton sylvaticus	0.111	0.125	6.394	6.630
Parinari curatellifolia	0.111	0.080	6.097	6.298
Mimusops obovata	0.044	0.036	6.059	6.139
Combretum kraussii	0.067	0.054	5.002	5.123
Nuxia floribunda	0.089	0.090	3.460	3.639
Aphloia theiformis	0.044	0.054	2.020	2.118
Homalium dentatum	0.022	0.018	1.324	1.364
Rhus chirindensis	0.022	0.018	1.324	1.364
Syzygium cordatum	0.022	0.018	0.847	0.887
Ochna arborea var. arborea	0.022	0.018	0.477	0.517

Table 12.2. Sub-canopy species according to decreasing importance value. RF = Relative frequency, RD = Relative density, RDom = Relative dominance and IV = Importance Value.

SPECIES NAME	RF	RD	Rdom	I.V.
Psychotria capensis	0.081	0.100	12.919	13.11
Combretum kraussii	0.021	0.038	11.787	11.856
Xymalos monospora	0.075	0.088	11.626	11.789
Monanthotaxis caffra	0.031	0.025	9.405	9.461
Mimusops obovata	0.610	0.050	7.797	7.907
Vangueria infausta	0.045	0.050	7.411	7.506
Albizia adiantifolia	0.310	0.025	6.764	6.819
Rothmannia globosa	0.090	0.100	6.147	6.337
Rapanea melanophloeos	0.045	0.063	4.476	4.584
Aphloia theiformis	0.045	0.050	3.630	3.725
Peddiea africana	0.045	0.050	3.380	3.475
Combretum molle	0.045	0.050	2.909	3.004
Ochna arborea var. *arborea*	0.031	0.025	1.815	1.871
Tarenna zimbabwensis	0.031	0.025	1.803	1.859
Ekebergia pterophylla	0.031	0.025	1.442	1.498
Maytenus peduncularis	0.031	0.025	1.243	1.299
Canthium inerme	0.015	0.013	1.243	1.271
Olinia emarginata	0.015	0.013	1.243	1.271
Syzygium guineense	0.045	0.038	1.007	1.080
Scolopia zeyheri	0.015	0.013	0.448	0.476
Trimeria grandiflora	0.030	0.025	0.312	0.367
Clutia pulchella var. *obtusata*	0.015	0.013	0.311	0.339
Croton sylvaticus	0.015	0.013	0.311	0.339
Myrsine africana	0.015	0.013	0.210	0.228
Brachylaena discolor	0.015	0.013	0.144	0.172
Carissa bispinosa	0.015	0.013	0.112	0.140
Bersama transvaalensis	0.015	0.013	0.084	0.112
Englerophytum natalense	0.015	0.013	0.024	0.052
Eugenia natalitia	0.015	0.013	0.008	0.036
Eugenia woodii	0.015	0.013	0.009	0.027

- 1.4 ***Pseudolachnostylis maprouneifolia* - *Xylophia parviflora* Midslope Open Forest**

This forest type was sampled on the southern exposed rocky outcrops on the Makonde mountain range, above and near, the Georgenholz Mission Station in the lower catchment. Over 40% of the substrate was exposed stone. Many species of the field layer had established in the fisures.

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,35	(7)25	(45)60
Shrub layer	0,35 - 2,0	(30)40	
Tree layer	2,0 - (5,0)7,0	(10)20	

Floristics

Common trees were *Pteleopsis myrtifolia, Peudolachnostylis maprouneifolia, Hymenocardia ulmoides* and *Xylophia parviflora*. The woody species recorded with the highest cover-abundance values were *Hymenocardia ulmoides* and *Rothmannia capensis*. A *Cyperus* species was dominant in the fieldlayer. The grasses *Digitaria eriantha, Setaria megaphylla* and *Melinus repens* were also recorded. The ferns *Cheilanthes viridis, Asplenium aethiopicum* and *Pellaea pectiniformis* were present.

- 1.5 ***Tarchonanthus trilobus* - *Coddia rudis* Open Low Forest**

This is an open forest with a medium to dense shrub layer, on sandy lithosoils, on the mountain top of the Makonde mountain range (Fig. 12.3).

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,35	(20)35	(70)75
Shrub layer	0,35 - 2,5	30	
Canopy layer	2,5 - 7,0	(20)25	

Floristics

Tarchonanthus trilobus, Parinari curatellifolia, Rothmannia capensis, Hyperacanthus amoenus, Vangueria infausta, Coddia rudis and *Hymenocardia ulmoides* were common in the tree layer. The epiphytic orchids *Cytorchis praetemissa, Mystacidium braybonae* and *Aerangis mystacidii* were found. *Tricalysia lanceolata, Englerophytum magalismontanum, Pteleopsis myrtifolia, Leptactina delagoensis* and *Coddia rudis* formed the bulk of the shrubs. *Sarcostemma viminale* was a common climber. In the fieldlayer, *Hypoestis forskaolii* was dominant together with *Cyperus albostriatus*. The ferns *Asplenium aethiopicum* and *Cheilanthes viridis* var. *macrophylla* were present.

12.5.2. Afforestation

A considerable area of the upper catchment and less in the middle reaches, are covered by plantations of pine (Fig. 12.4) and eucalyptus. In addition to timber, they provide firewood, thereby diminishing the pressure on the natural vegetation. On the other hand, these species are known to consume a great deal of water. In parts of the catchment, pines and eucalypts have escaped, invading open grasslands and riverine vegetation. This has prompted the "Work for Water Project" of the Department of Water Affairs and Forestry to ringbark and poison trees outside the plantations.

The structure of these communities depends upon the age of the plantation. Pines and eucalypts are strong competitors, so the sub-canopy and field layer are usually depauperate, with a few species present with low cover-abundance values.

Floristics

- 2.1 *Pinus* spp. Afforestation

Under *Pinus* spp. naturally occuring tree species such as *Schefflera umbelifera*, *Nuxia floribunda*, *Maesa lanceolata*, *Aphloia theiformis*, *Englerophytum magalismontanum*, and the climbers *Asparagus africanus*, *Senecio rhomboideus*, and *Secamone alpini* were recorded. Herbs present were *Commelina* sp., *Senecio inornatus*, *Anthospermum hispidulum*, *Vernonia* sp. and *Hemyzigia canescens*. The grasses *Oplismenus hirtellus* and *Setaria megaphylla* and the sedge *Cyperus esculentus* were also recorded (Fig. 12.4).

- 2.2 *Eucalyptus* spp. Afforestation

The understorey species found in a stand of *Eucalytus grandis*, had low cover-abundance values. Shrubs recorded were *Syzygium gerrardii*, *Rhus pyroides*, *Keetia gueinzii*, *Vangueria infuasta* and *Myrsine africana*. The only climber present was *Abrus laevigatus*.

12.5.3. Bushveld Communities

- 3.1. *Bridelia mollis - Euclea divinorum* Bushveld

The northerly exposed slopes of the catchment in the Mbahe area (Fig. 12.5) were studied by Phamphe (1997, unpublished) and the presented information is partly based on his work. He used the line-intercept, point-quarter and plot methods. The following information was obtained from the point-quarter centred method. No structural data was recorded for this community.

Floristics
In the tree layer, *Afzelia quanzensis* had the highest importance value, followed by *Euclea divinorum, Bridelia mollis, Coddia rudis, Combretum molle, Peltophorum africanum,* and *Flueggia virosa. Dichrostachys cinerea* was the most common shrub, followed by *Bridelia mollis, Combretum molle, Sclerocarya birrea, Pterolobium stellatum, Afzelia quanzensis, Euclea divinorum, Ehretia amoena, Burkea africana, Ximenia caffra* and *Grewia flavescens.* Some of these species indicate that there is disturbance present in the community. On the same mountain range, on northerly exposed slopes near the Mutshindudi - Luvuvhu confluence, the species composition changed. *Acacia nigrescens* together with *Kirkia acuminata, Sclerocarya birrea, Afzelia quanzensis* and *Berchemia discolor,* were common (Weisser & Mushasha, unpublished).

- **3.2 *Bauhinia galpinii - Annona senegalensis* Bushveld**

This bushveld, with a high degree of human disturbance, was found in the lower catchment on the bottom valley.

The following structural values were estimated:

	Height (m)	**Cover (%)**	**Total cover (%)**
Field layer	0 - 0,5	(10)15	(80)85
Shrub layer	0,5 - 3,0	75	
Tree layer	3,0 - 5,0	80	
Emergent layer	5,0+	5	

Floristics
This vegetation type was characterized by *Bauhinia galpinii, Dichrostachys cinerea, Annona senegalensis, Acacia karroo,* species which suggest a high degree of human interference. The presence of *Burkea africana, Terminalia sericea* and *Berchemia zeyheri* suggested that the area could originally have been a *Burkea africana - Terminalia sericea* Woodland. Emergent trees which occurred occasionaly were *Combretum molle, Diospyros mespiliformis* and *Celtis africana.* Other common woody plants were *Clausena anisata, Piliostigma thonningii, Carissa edulis,* and *Peltophorum africanum.* In the sparse field layer, the grasses *Panicum*

deustum, *P. maximum* and *Brachiaria serrata* were recorded. The only fern found was *Cheilanthes viridis*.

12.5.4. Secondary Thickets

- 4.1 *Dichrostachys cinerea - Panicum maximum* Secondary Scrub

This type of thicket is often found along roadsides (Fig. 12. 6) and on abandoned fields. It is the product of secondary succession. It is continuously disturbed by direct or indirect human impact, such as goat and cattle grazing and wood gathering. Discontinuity in the vegetation cover has made these areas less likely to be burned, allowing a suite of invasive species to colonize.

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,5	35 - 75	85 - 98
Sub-canopy	0,5 - 3,0	35 - 70	

Floristics

Dominant was *Dichrostachys cinerea*, which was often accompanied by *Pterolobium stellatum*, *Diospyros lycioides* subsp. *sericea*, and *Ehretia amoena*. Under the protective cover of these shrubs, widely distributed grasses such as *Panicum maximum*, *Hyperthelia dissoluta*, *Chloris virgata*, *Brachiaria serrata*, and *Aristida congesta* subsp. *barbicollis* prosper. *Hyparrhenia tamba* were present. Pioneers and weeds such as *Bidens pilosa*, *Lantana camara*, *Vernonia colorata*, *Cardiospermum helicacabum*, *Anonna senegalensis* and *Acacia* spp.were common. Noteworthy, were the great amount of seedlings and young plants of successional trees, many of them distributed by wind or birds, such as *Dombeya rotundifolia*, *Combretum molle*, *Diopyros mespiliformis*, *Combretum imberbe*, *Combretum collinum* subsp. *gazense*, *Euclea divinorum* and *Piliostigma thonningii*, most of which occur in the nearby bushveld of the Mbahe area.

- 4.2 *Caesalpinia decapetala - Lantana camara* Secondary Thicket

This was a dense thicket in the upper catchment above the Phiphidi Reserve, in a very disturbed area where water was collected and where cattle came for grazing and drinking. The soil was a fertile, red clay. It was a community dominanted by noxious invaders, such as *Caesalpinia decapetala* and *Lantana camara*. The vegetation was upto 6 m high.

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,35	20	80
Sub-canopy	0,35 - 3,0	45	
Canopy	3,0 - 6,0	30	

Floristics

Some of the tree species naturally occuring in the area such as *Bridelia micrantha, Ficus sur, Croton sylvaticus* and *Combretum molle* were present. However, their growth is threatened by aggressive invasive weeds such as *Lantana camara, Solanum mauritianum* and *Caesalpinia decapetala*. Noteworthy woody plants were *Croton sylvaticus, Brachylaena transvaalensis, Tecomaria capensis, Euclea divinorum, Nuxia floribunda*, and *Diospyros lycioides* var. *lycioides*. The climbers such as *Cissampelos torulosa, Helinus integrifolius, Clematis brachiata, Cassytha* sp.(a parasite) were present.

12.5.5. Grassland Communities

- 5.1 *Eragrostis curvula - Themeda triandra* Montane Grasslands

This grass dominated community was found near Ebber Dam, in the upper catchment. Only one plot was sampled. It is possible that this grassland is being maintained by regular fire management by the Department of Forestry and Water Affairs. The area is grazed by cattle.

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,3	65	70
Sub-canopy	0,3 - 1,5	5	

Dominant species were the grasses *Eragrostis curvula, Themeda triandra, Knowltonia transvaalensis*. Other grasses present were *Monocymbium ceresiiforme, Setaria sphacelata, Andropogon schirensis*, and *Loudetia flavida*. There were many herb species with low cover values, such as *Helichrysum* sp., *Scabiosa columbaria, Clutia monticola* and *Aristea woodii*. Shrubs recorded were *Rabdosiella calycina* and *Clutia abyssinica*.

- 5.2 *Panicum natalense - Loudetia flavida* Montane Grasslands

This community occurred on moderate slopes of quarzitic outcrops in the upper catchment (Fig. 7. 7). They had a species-rich flora of grasses, herbs, ferns and shrubs. Shrubs and low trees which grew between the rocks did not, however, attain great heights, probably because of the shallow soils and low air temperatures at that altitude.

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,8	65	70
Sub-canopy	0,8 - 3,0	10	

Floristics

The grasses *Panicum natalense, Loudetia flavida, Setaria sphacelata, Monocymbium ceressiiforme* and *Cymbopogon excavatus* were common. Noteworthy, were *Aloe vossii*,(a threatened endemic species, *vide* Willis & Willis, 1995) and *Aloe vogtsii*, both Soutpansberg endemics. Herbs recorded were *Agapanthus* sp. *Berkehya* sp., *Clutia pulchella* and *Eriosema* sp., *Crassula capitella* subsp. *columnaris* and the orchid *Eulophia ensata*. The ferns *Blechnum attenuatum, Pellaea calomelanos* and *Cheilanthes viridis* subsp. *macrophylla* were also found.

- 5.3 *Heteropogon contortus - Chloris virgata* Secondary Grassland

This grass dominated community developed on old fields (Fig. 12.8) on red clay loam in the lowlands of the lower catchment (Mbahe area).The old fields are used for cattle grazing, and after being rested for some time before being plowed again.

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,5	45 - 95	50 - 95
Shrub layer	0,5 - 2,0	5 - 15	

Floristics

The species composition varied depending on the length of time the land has lain fallow. Seedlings of seral shrubs present, typical of the nearby bushveld, were *Combretum collinum* subsp. *gazense, Acacia sieberiana, Combretum imberbe, Peltophorum africanum, Bridelia mollis,* and *Diospyros mespiliformis*. The invasive species *Lantana camara, Solanum eleagnifolium* and the pioneers *Anonna senegalensis* and *Dichrostachys cinerea* were common. This species composition indicate that if left undisturbed by fire and plowing, this community would probably evolve towards a thicket. In the fieldlayer, the grasses *Chloris virgata, Panicum maximum, Hyparrhenia tamba, Heteropogon contortus, Brachiaria serrata* and *Aristida congesta* subsp. *barbicollis* were dominant. The herbs *Indigofera* spp., *Rhynchosia* sp., *Otiophora* sp., *Tylosema fassoglense*, *Tragia capensis*, *Jasminum fluminense* and *Zornia capensis* were recorded.

12.5.6. Vegetation on abandoned fields

- 6.1 *Vernonia poskeana - Perotis patens* Community

Vegetation on fallow fields (Fig. 12. 9) varied depending on the time, soil factors and available seed bank. It was usually a mixture of herbs and grasses.

The following structural values were estimated:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,4	15 - 55	20 - 60
Emergent layer	0,4 - 1,8	7 - 30	

Floristics

Dominant herbs were *Hibiscus meeusei*, *Dicerocaryum eriocarpum*, *Vernonia poskeana*, *Hibiscus engleri*, *Abutilon sonneratianum*, *Indigofera* sp., *Waltheria indica*, *Bidens bipinnata* and *Triumfetta pilosa*. Common grasses were *Cynodon dactylon*, *Perotis patens*, *Melinus repens*, *Pogonarthria squarrosa*, *Panicum maximum*, *Digitaria enriantha* and the sedge *Cyperus esculentus*.

12.5.7. Reed beds, sedge marshes, littoral and aquatic vegetation

Before the arrival of man, most of the Mutshindudi River banks were probably covered by pristine riverine forests. Sedge marshes were, consequently, rare. In some areas, this riverine forest survives today only as remnants, such as in the middle section of the river and below the Phiphidi Reserve. The opening by clearing of the riverine forest and the building of dams has allowed reed beds and sedge marshes to form. Increased soil erosion has resulted in sedimentation areas forming in the river, creating habitats for species such as *Phragmites mauritianus*. Some sedge dominated patches are on the shores of the Phiphidi Dam.

- 7.1 *Phragmites mauritianus* Reed Community

This community was found colonizing the river banks, in the middle and lower reaches of the Mutshindudi River. It was mainly present in the Phiphidi Dam (Fig. 12.10), but not in the higher regions of the catchment. It often formed monospecific stands.

The following structural values were obtained in winter at a stand at the Phiphidi Dam:

	Height (m)	Cover (%)	Total cover (%)
Reeds	0 - 3,5	70	70

- 7.2 ***Typha capensis*** **Reed Community**

This community was less common along the Mutshindudi River. It was found as pockets in sedimentation areas and along the shores of dams such as the Phiphidi Dam (Fig. 12.10).

The following structural values were obtained in winter at a stand at the Phiphidi Dam:

	Height (m)	Cover (%)	Total cover (%)
Field layer	0 - 0,8	30	70
Reeds	0,8 - 1,8	40	

Floristics

Typha capensis tended to form monospecific patches of vegetation, that towards the landside was invaded by grasses such as *Cynodon dactylon, Leersia hexandra* and by sedges e.g. *Juncus lomatophyllus*.

- 7.3 ***Setaria sphacelata - Juncus lomatophyllus*** **Littoral Community**

A special hygrophilous community type was found along drainage lines in the upper reaches of the catchment.

Floristics

Grasses such as *Setaria spacelata* and *Andropogon schirensis* and the sedge *Juncus lomathophyllus* formed the bulk of the vegetation. The humid conditions favoured the presence of ferns such as *Cyathea dregei, Osmunda regalis, Dryopteris dentata* and *Blechunun attenuatum*. A livermoss belonging to the genus *Marchantia* was found in two of the plots.

- **7.4. *Nymphoides* sp. - *Isolepis fluitans* Littoral Community**

Littoral species were sampled along the western shores of the Ebber Dam, near the source of the Mutshindudi River. The structure of this community was ill-defined due to a mixture of aquatic and semi-aquatic species. The total plant cover was estimated at 80%. The sedges were 0,5 m high. Some emergent plants reached 1,0 m. Floating near the shores was *Nymphoides* sp., and landwards were sedges such as *Juncus lomatophyllus, Juncus congestus,* *Scirpus* sp, *Schoenoplectus* sp., *Cyperus rubicundus* and *Isolepis fluitans*. The grass species *Leersia hexandra* and *Setaria sphacelata* and the herb *Persicaria* sp. were also common. Some grazing by cattle was observed.

12.6. CONSERVATION STATUS OF THE CATCHMENT

The vegetation of the Mutshindudi Catchment is mostly secondary. The pristine vegetation occurs mainly in the upper catchment (Fig. 12. 2) and in some bushveld areas of the mountain slopes in the lower catchment. The riverine vegetation is in an acceptable conservation status from the source to the Phiphidi Nature Reserve. Downstream from Phiphidi Nature Reserve, the vegetation shows a high degree of degradation, and the natural vegetation is composed mainly of remnants. The human impact was greatest near washing and water collecting places and at river crossings. From the eastern limit of the Phiphidi Nature Reserve, the riverine vegetation is often invaded by exotic invader plants such as *Lantana camara, Psidium guajava, Caesalpinia decapetala* and *Vernonia colorata*. The custom of extending the cultivation fields and the orchards down to the river endangers the river banks so that they are no longer protected, and are therefore susceptible to water erosion and invasion by the fast spreading invasive species.

The great number of species found in the plots sampled, show that species diversity is high in relation to the small size of the catchment. This high species diversity is due to the diverse types of habitats that are in the catchment; mountain tops and slopes, river courses; as well as to a variety of soil types - some red with high clay contents and others more sandy and with quarzite as parental material. The species diversity is also a consequence of human interferance, as there are many introduced species.

Noxious weeds are progressively becoming a great problem. They are invading openings created, aggressively displacing the natural vegetation. Species of special concern are *Lantana camara, Solanum mauritianum, Vernonia colorata, Caesalpina decapetala, Opuntia sp.* and *Melia azedarach*. They seem to be spreading fast through the catchment, and are progressively becoming more common.

12.7. CHECKLIST AND FLORISTIC INFORMATION

A total of 645 species (Appendix 1) of 404 genera, representing 112 families, were recorded. Four endangered and three endemic species were found. Over a quarter (28%) of the total species were weed or exotic species. The proportion of exotic and weed species to naturally occurring ones was less than a quarter (23,3%) in the upper catchment, and a third (33,7%) in the lower catchment.

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Figure 12.1 An example of Riverine Forest which occurs along the Mutshindudi River (1996 07 14)

Figure 12.2 View of the upper Mutshindudi Catchment in the Entabeni Forest Reserve. The vegetation is a mosaic of forest and grassland communities. The peak in the background is Korongoro (1997 06 06)

Figure 12.3 *Tarchonanthus trilobus- Coddia rudis* Open Low Forest on the top area of the Makonde Mountain range (1998 04 08)

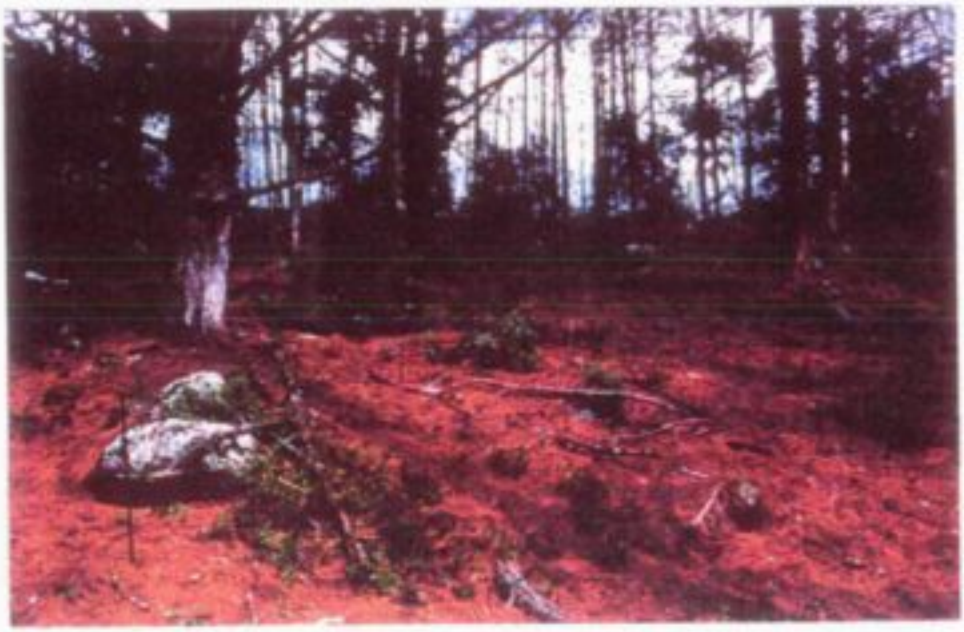

Figure 12.4 *Pinus* stand showing afforestation and the sparse understory.

Figure 12.5 *Bridelia mollis* - *Euclea divinorum* dominated Bushveld in the Mbabe area (1996 10 03)

Figure 12.6 Scrub with *Dichrostachys cinerea* and *Panicum maximum* in the Mbabe area

Figure 12.7 Grassland with rocky outcrops, Entabeni Forest Reserve (1997 06 06)

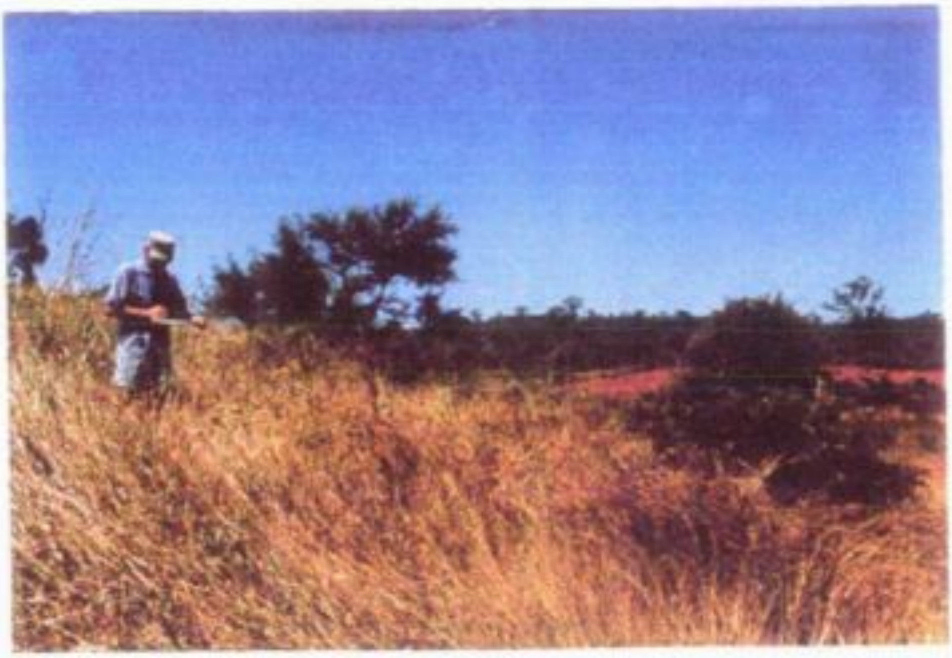

Figure 12.8 Grassland near Mbahe, dominated by *Heteropogon contortus* and *Chloris virgata* (1997 04 07)

Figure 12.9 A fallow field in the Kubvhi area, where weeds such as *Hibiscus* sp dominate (1997 04 08)

Figure 12.10 Reed communities colonising the Phiphidi Dam shores. At the left is a stand of *Typha capensis*, and on the opposite side to the right is an area colonized by *Phragmites mauritanus* (1998 08 03)

CHAPTER 13

FISH AS INDICATORS OF WATER QUALITY IN THE MUTSHINDUDI RIVER CATCHMENT

13.1 SUBPROJECT : FISH DISTRIBUTION IN THE MUTSHINDUDI RIVER SYSTEM

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13.1.1 A GENERAL REVIEW OF FISH DIVERSITY IN THE LIMPOPO RIVER SYSTEM

The Limpopo River system contains 48 species of primary and secondary freshwater fish species representing ten families (Protopteridae, Mormyridae, Characidae, Cyprinidae, Schilbeidae, Amphiliidae, Mochokidae, Cyprinodontidae and Cichlidae) and 20 genera (*Protopterus, Marcusenius, Petrocephalus, Hydrocynus, Brycinus, Micralestes, Barbus, Labeo, Opsaridium, Mesobola, Schilbe, Amphilius, Clarias, Synodontis, Chiloglanis, Aplocheilichthys, Oreochromis, Tilapia, Chetia and Pseudocrenilabris*). This excludes the Anguillidae (4 species), Gobiidae (2 species) and two cichlid species which occur in coastal lakes adjacent to the system but not in the system. The Cyprinidae is the dominant family with 25 species.

Only two cyprinids (*Barbus motebensis* and *B. treurensis*) and one cichlid (*Chetia flaviventris*) are endemic to the system. Seven species are endemic to this system and the adjacent east-flowing Incomati and Phongolo River systems. A further two cyprinids (*B.*

anoplus and *B. pallidus*) are endemic to the Limpopo River system and systems to the south of it. Nine species are endemic to southern Africa (Kunene/Okovango/Zambezi and southward) and the remainder (28 species) also occur further north in Africa.

Based on distribution and habitat preference, Gaigher (1973) divided the fishes of the Limpopo River system into five ecological groups namely species confined to well-oxygenated middle and highveld streams, species with a wide distribution (cold and warm water) and a wide habitat preference (occurs in pools and riffles), species with a wide habitat preference, but which are confined to the warmer middle and lowveld streams, pool-loving species confined to warmer middle- and lowveld streams and species with a restricted distribution and/or specialised habitat preference.

Nine Limpopo River system species (19%) are confined to well oxygenated middle and highveld streams. One of these, *B. treurensis*, is endemic with a very restricted distribution (Kleynhans, 1986). A further three species are endemic to the Limpopo River system and rivers to the south of it and the remaining three occur north as far as the Zambian Congo.

All six species (13%) with a wide distribution and habitat preference also occur in the Okovango/Zambezi systems or systems further north. One of these, *B. marequensis*, is specialised to a certain degree in the sense that it only occurs in well-oxygenated streams.

Approximately half (47%) of the species are tropical being confined to warmer middle and lowveld streams and most of these (34% of total species) prefer pools. Two of the pool-loving species (*L. rosae* and *L. ruddi*) are endemic to the Limpopo, Incomati and Phongolo River systems.

Eleven (23%) of the species cannot be classified into any of these ecological categories. Four species (8% of total) are typical reophilic species, being confined to well-oxygenated perennial streams. Two of these, *Chiloglanis pretoriae* and *C. paratus*, are endemic to the Limpopo, Incomati, and Phongolo River systems while one, *Amphilius natalensis*, occurs into Zimbabwe and one, *A. uranoscopus*, occurs to north of the Zambezi/Okovango system. One species, *C. swierstrae*, is confined to fast-flowing sections of perennial middle and lowveld streams with a sandy or pebly bottom. This species is also endemic to the Limpopo, Incomati and Phongolo River systems. Only two species namely *Aplocheilichthys johnstonii* and *A.*

katangae, both having a wide distribution in Africa, are restricted to clear pools and slow-flowing sections of perennial streams with abundant aquatic vegetation. One species, *Opsaridium peringueyi*, is considered to be specialised because it only occurs in clear, perennial middle and lowveld streams. The tiger fish (*Hydrocynus vittatus*) is also confined to relatively well-oxygenated lowveld streams. *Clarias theodorae* has only been collected from two densely vegetated perennial streams in the system (Skelton, 1987). The lungfish is specialised in being restricted to floodpans and pans that dry up wholly or partially during the dry months.

Four Limpopo system species are listed in the South African Red Data Book on fishes (Skelton, 1987) namely *P. annectens* (vulnerable), *B. treurensis* (vulnerable), *C. theodorae* (rare) and *O. peringueyi* (rare). According to Kleynhans (1986) the restricted presence of *A. natalensis* in the Blyde and Ohrigstad Rivers (the only known localities in the system) is of special conservation interest, and he considers this species to be "rare".

None of the Limpopo river system fish species are therefore considered to be in immediate danger of extinction. All the threatened species have viable populations within conservation areas and are receiving special attention due to their declared conservation status. However, generally, the conservation status of fish in the system have declined. A comparison of the distribution patterns of fish recorded over the past 35 years shows that as many as 26 species may have been negatively affected by human induced changes. Some species such as *C. gariepinus*, *T. sparrmanii* and *P. philander* may have benefited from the changes in some rivers. It is also evident that some "generalists" are relatively sensitive to changes in runoff and that some widespread species have specialised habitat preferences that make them vulnerable to certain changes.

The Limpopo River system is characterised by relatively small but well oxygenated perennial streams in the upper reaches with limited fluctuation in turbidity but with extreme fluctuation in temperature. Downstream minimum temperatures are less severe but the aquatic environment becomes increasingly less stable in terms of flow rate, turbidity and dissolved oxygen concentration. Parts of the system in the lower reaches stop flowing during the dry season with the result fish become isolated in pools. These conditions become more severe during droughts and due to increasing water extraction. Generally the system provides little scope for specialisation due to limited habitat diversity in the upper reaches and instability of lower reaches. It is therefore not surprising that species diversity is low compared to systems further north. Diversity is relatively high compared to systems to the south, probably due to a difference in the degree of isolation (O Keeffe, et al., 1991) The fact that a degree of speciation occurred in riffle species (e.g. *Chiloglanis*) and in detritivores (e.g. *Labeo*) of taxa that apparently originated from northern systems (Bowmaker, et al., 1978) indicate that a lack of opportunity rather than a lack of time may have been the reason for the limited adaptive radiation. Riffles provide a relatively stable environment in perennial streams while detritus is a stable food source even in rivers with extreme fluctuations in water level.

The general unpredictability of the environment in the system and tropical origin of most groups are reflected in habitat preferences and distribution of fishes: most species are generalists and a large percentage is restricted to warmer regions.

13.1.2 THE DIVERSITY, DISTRIBUTION AND CONSERVATION STATUS OF FISHES IN THE MUTSHINDUDI RIVER SYSTEM

Twenty seven fish species have been collected from the Mutshindudi River system since the commencement of the project (Table 13.1.1). Unfortunately no information on previous collections from this system could be obtained.

According to Gaigher (1973), of the 25 primary freshwater fish species collected from the Mutshindudi system, six (*B. marequensis, B. paludinosus, B. trimaculatus, C. gariepinus, P. philander and T. sparrmanii)* can considered to be euryecious and eurythermal, six (*B. unitaeniatus, B. viviparus, L. cylindricus, L. molybdinus* and *M. brevianalis* are euryecious but restricted to warm water, six (*M. macrolepidotus, P. catostoma,B. toppini, S. intermedius, O. mossambicus* and *T. rendalli*) prefer pools in warmer water, three (*B. eutaenia, B. lineomaculatus* and *B. neefi*) are restricted to well-oxygenated middle and highveld streams and four (*O. peringueyi, A. uranoscopus, C. paratus* and *C. pretoriae*) are specialised. According to this author *O. peringueyi* is restricted to clear, fast-flowing perennial streams and the other three species are rheophilic.

Table 13.1.1. A check list and sensitivity of fishes collected from the Mutshindudi River system (sensitivity after Kleynhans, 1991)

FAMILY	SPECIES	SENSITIVITY
Mormyridae	*Marcusenius macrolepidotus*	2
	Petrocephalus catostoma	2
Cyprinidae	*Barbus eutaenia*	4
	B. lineomaculatus	3
	B. marequensis	1
	B. neefi	3
	B. paludinosus	1
	B. trimaculatus	1
	B. unitaeniatus	1
	B. viviparus	3
	B. toppini	1
	Labeo cylindricus	1
	L. molybdinus	1
	Mesobola. brevianalis	1
	Opsaridium peringueyi	4
Characidae	*Micralestes acutidens*	1
Schilbeidae	*Schilbe intermedius*	1
Amphiliidae	*Amphilius uranoscopus*	4
Clariidae	*Clarias gariepinus*	1
Mochodae	*Chiloglanis paratus*	2
	C. pretoriae	3
Cichlidae	*Oreochromis mossambicus*	1
	Tilapia rendalli	1
	T. sparrmanii	1
	Pseudocrenilabris philander	1
Anguillidae	*Anguilla mossambica*	1
Gobiidae	*Glossogobius giuris*	1

It is interesting to note that all the species recorded are of Zambezian affinity showing that the Mutshindudi River system and immediate environment provided little scope for adaptive radiation, probably due to instability or the nature of the geomorphological history.

Based on the sensitivity classification of our indigenous fish proposed by Kleynhans (1991), a relatively large percentage (58%) of the species are relatively insensitive (sensitivity class 1) while only 31% fall in sensitivity class 3 or higher. The figures are 26 % and 46 % for all former Transvaal species (Kleynhans, op cit). However, this is probably a natural pattern, and although distribution within the system has probably been affected by unnatural factors, no species could be identified that might have dissappeared due to human induced changes.

Appendix 2 shows the recorded distribution of species. Natural distribution is clearly affected by three main factors namely temperature, geomorphology and habitat requirements. The Phipidi waterfall might be a geographical barrier to some species. Relatively low temperature (and associated dissolved oxygen content) due to high altitude and shading by riparian trees provide a suitable environment for some species but exclude others. Man obviously has played a role by introducing species and by changing the environment.

Eight species, namely *B. eutaenia, B. marequensis, A. uranoscopus,C. pretoriae, O. mossambicus T. sparrmanii,T. rendalli and A. mossambica* were collected above the Phipidi Falls. Three of these namely *T. sparrmanii, T. rendalli* and *O. mossambicus* may have been introduced to the Vondo Dam or smaller dams in this region as angling or fodder fish. The Phipidi falls may be a geographical barrier to *B. neefi* as it was found below but not above the falls.

Four species namely *B. eutaenia, A. uranoscopus, T. sparrmanii* and *A. mossambica* occur naturally throughout the system. As mentioned, *T.sparrmanii* may have been introduced above the Phipidi Falls. *B. marequensis, B. neefi* and *C. pretoriae* are only absent from the small upper reaches above the Phipidi Falls or Vondo Dam.

M. macrolepidotus, B. paludinosus, B. trimaculatus, B. unitaeniatus, L. cylindricus, L. molybdinus, O. peringueyi, M. acutidens,C. paratus, O. mossambicus and *T. rendalli* occur naturally throughout the middle and lower reaches of the system where the habitat is suitable (assuming that *O. mossambicus* and *T. rendalli* were introduced above the Phipidi falls. *B. lineomaculatus* may have had the same distribution in the past but was only collected from a restricted area above the confluence of the Mutshindudi and Tshinane Rivers.

The restricted recording of *B. viviparus P. catostoma, C. gariepinus, G. giuris* and *P. philander* in the middle and lower reaches of the system is probably due to habitat requirements and habitat deterioration rather than temperature. Temperature probably restricts *B. toppini, M. brevianalis* and *S. intermedius* to the lower reaches.

The highest species richness (19 to 21) occurred at an altitude of roughly below 600m, it then decreased to 8 or 9 up to an altitude roughly 100m and fell to 4 above this. Increased diversity with a decrease in altitude is probably related to a greater diversity of niches lower down.

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13.2 SUBPROJECT : TROPHIC NICHE DIFFERENTIATION IN RHEOPHILIC FISHES OF THE MUTSHINDUDI RIVER SYSTEM

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13.2.1 INTRODUCTION

The term "niche" traditionally refers to the role, profession, position or status of an organism or species within a community or ecosystem (Odum, 1975). According to Levine & Miller (1994) the full description of a niche should include as parameters the physical and biological factors as well as the organism's behaviour and food as one of the important axes or dimensions. Food and feeding habits such as "when", "where" and "upon what" the organism feeds is therefore an important component of the niche and needs investigation. A study of anatomical and morphological adaptations for feeding helps to define the trophic niche of a species (Weatherly, 1974). Another important aspect in categorising species is niche breath. Organisms with a narrow breadth in terms of a specific aspect are regarded as specialists that efficiently utilize a specific resource but are also vulnerable. Generalists, that have wide niche breadths, on the other hand, are more adaptable to change. Knowledge of niche breadth would therefore be valuable in the choice of indicator species.

This part of the study investigated trophic niche differentiation amongst the rheophilic fish species of the Mutshindudi River. This was not only done by investigating the food habits of the fish, but also by examining the external morphological adaptations of the fish as well as the morphology and histology of their digestive tracts.

13.2.2 MATERIALS AND METHODS

The fish used in this study were the thirteen rheophilic species identified by Gaigher and Fouche (Chapter 13.3) as suitable candidates for an Index of Biotic Integrity. To compare diets and allow for seasonal differences only fish collected during the period 7/6/98 to 11/6/98 were used. The fish were collected by electronarcotization from predetermined sites in the Mutshindudi River and the samples from each site was preserved and transported to the laboratory, where the species were identified according to the morphological characteristics described by Crass (1964), Jubb (1967), Bell-Cross and Minshull (1988) and Skelton (1993). Special care was taken in the case of the closely related *Barbus neefi* and *Barbus lineomaculatus* in order to avoid misidentification and doubtful specimens were duly excluded. The total length, mass and volume of each specimen were then determined and recorded. External characteristics, such as the size of the eyes, size and positioning of the mouth and the type of lips were also determined. Using the method described by Willers (1991), the fish were dissected to expose the viscera and the lengths and diameters of the stomach and intestines measured. For length measurement the intestines were measured at full length, taking care not to over-stretch the organ. The diameter was measured over the widest section of the organ in question. The measured dimensions, obtained in the methods mentioned above, were used to calculate the volumes of the intestines, stomach and total gut and this were expressed as a ratio of the body volume. For comparison the stomach, intestine and total gut length were also converted into relative lengths, which is a percentage ratio of the body length. In the case of gut lengths, the mean relative gut lengths (mRGL) were statistically determined (Wootton, 1990; De Silva & Andersson, 1995). Stomach fullness was estimated as ¼, ½, ¾ or completely full (Bowen, 1976) by holding the stomach up against a strong light source. In the case of large specimens, the contents were removed and the volume determined using the water replacement method described by Göldner (1964).

The stomach contents were microscopically investigated and individual food items identified. The volumes of each food type were estimated with the aid of a grid (Gaigher, 1969) and then expressed as a percentage of the stomach content. Frequency of occurrence of the food types was determined by tabulating the food types identified in the stomachs of each species. To determine the percentage frequency of occurrence, the individual food items were sorted out and the number of the stomachs in which it occurred was expressed as a percentage of the total number of stomachs of the specific species (Gaigher, 1969; Windell, 1971). As a measure of food resemblance between two species an index of similarity was calculated by adding the smallest percentages of each food type. Rather than using the dried mass as suggested by Windell (op cit.), these calculations were based on the percentage volume of each food item.

Tissue samples of stomachs and intestines were dissected out in the laboratory subsequent to measuring. In order to simultaneously study the micro-anatomy and histology, the tissue samples were dissected out as complete cross sections through the organ. The tissue was then fixed for a preliminary period of 12 hours in formol saline, followed by a secondary fixation period of 12 hours in Zenker formol (Roberts *et al*, 1979), processed, embedded in paraffin wax and sectioned at 8 µm on a rotary microtome. Sections were routinely stained for light microscopy with haematoxylin and eosin (Humason, 1979) and methylene blue and eosin (Pantin, 1969).

13.2.3 RESULTS

13.2.3.1 External anatomy

With the exception of *Labeo molybdinus* and *Barbus marequensis*, where body lengths ranged from 301 to 600 mm, and *Amphilius uranoscopus* and *Labeo cylindricus*, with lengths between 151 and 300 mm, all other species in this study could be regarded as small, with body lengths varying from 40 to 150 mm. *Opsaridium peringueyi* and *Micralestes acutidens* were the only species with relatively large eyes, while the eyes of the labeos, *A. uranoscopus*, *Chiloglanis pretoriae* and *B. marequensis* were small. In all the fish the eyes are situated on the side of the head, with the exception of *A. uranoscopus* and *C. pretoriae*, where the eyes are on top of the head.

The mouths of all the barbs are situated marginally below the line connecting the tip of the snout and the lower orbit of the eye. They can therefore be regarded as sub-terminally positioned. With the exception of *O. peringueyi*, where the mouth is large and the lower jaw extended to below the eye, the mouths of all these specimens were small. In both the labeos the mouths are ventro-terminally positioned, being lower than those of the previous species, and they are the only species with fleshy lips. The same positioning was also observed in *A. uranoscopus* and in *C. pretoriae* where the disc shaped mouth is ventrally positioned. *M.*

acutidens was the only species were the mouth is positioned at the tip of the snout and was therefore described as terminal.

13.2.3.2 Morphology and physical dimensions of the alimentary tract

In many species of fish the stomach is a relatively simple tubular expansion or widening of the digestive tract and the exact place where transition from stomach to intestines occurs can often be difficult to determine. Except for *C. pretoriae* and *A. uranoscopus* where a clearly visible valve demarcated this changeover, this was also the case with all the other species in this study. For this reason the term "stomach", in this report, is used to describe the part of the "rumpfdarm" (De Silva & Andersson, 1995) immediately posterior to the esophagus and does not necessarily refer to a stomach in the classical sense. In order to measure the physical dimensions in species where the borders between stomach and intestine were not clearly visible, the point of change-over was arbitrarily chosen as the area where a distinct narrowing was accompanied by a curvature in of the digestive tract. Microscopical examination of the narrowing area showed that the change in external morphology was accompanied by changes in the internal morphology topography. In this area the folds in the internal surface of the digestive tract abruptly became lower and more widely spaced, a fold pattern characteristic of the small intestines. The changeover from esophagus to stomach on the other hand was easy to detect and was characterized by a sudden narrowing of the digestive tract.

The stomachs of all the fish were monogastric (Eckert *et al*, 1988) and pyloric caecae were observed only in *M. acutidens*. If classified according to shape (Stevens, 1988), two distinct types of stomachs groups were observed. The stomachs *C. pretoriae, A. uranoscopus and M. acutidens* were siphon- or U-shaped while all the other fish the stomachs were straight tubes. The straight-tube stomachs are wide at the anterior end and tapers towards the posterior. In the U-shaped stomachs the lengths and widths of the sections before and after the stomach curvature were measured separately and the individual volumes of the two sections then calculated. The value obtained was than added to determine the total volume of the stomach.

When the physical dimensions of the digestive tracts are compared, the results obtained with *B. unitaeniatus, B. trimaculatus B. euteania* and *B. lineomaculatus* should not be considered due to the small sample size. In this comparison the relative gut length (table 13.2.1), indicate the following groupings:

Group 1, where the gut length is six times the body length (the two labeos), group 2 where the gut is twice as long as the body (*B. marequensis*), group 3 where the gut is as long as the body (*C. pretoriae*), group 4 where the gut is ¾ of the body length (*B. neefi and B. viviparus*) and group 5 where the gut length is less than $^{2}/_{3}$ of the body length (*A. uranoscopus, M. acutidens* and *O. peringueyi*). It is also possible to view *O. peringueyi* as a grouping in its own right. When stomach length is expressed as a ratio of the total gut length it is important to note that a different grouping is displayed. The same grouping is not reflected when the calculated volumes of both the stomachs and the intestines are expressed in the same manner. It is however important to take note of the small stomach volumes observed in the two labeos.

13.2.3.3 Histology of the alimentary tract.

Table 13.2.2 shows that the typical cellular layers, characteristic of vertebrate digestive tracts (Copenhaver *et al*, 1979; Weichert, 1970), were observed in the stomachs. A distinction between longitudinal and circular muscles could only be made in the case of *A. uranoscopus*. When the thickness of the stomach wall is considered, the fish can be classified into distinct groups. The first group, where the thickness ranged from 0,15 to 0,6 mm, consisted of *C. pretoriae, A. uranoscopus* and *M. acutidens*. All the other fish, with the exception of *O. peringueyi*, forms the second group with thin stomach walls, ranging from 0,01 to 0,03 mm. *O. peringueyi*, where the stomach walls are between 0,05 - 0,15 mm thick is an intermediate. Gastric glands, which indicate digestive activity, were observed in the first group as well as in *O. peringueyi*.

Two sub-groups, based on the appearance of the rugae, could be distinguished in the thin-walled stomachs. In *B. eutaenia* and the two labeos the individual folds are thin and intricately branched, giving the stomachs a compartmentalized appearance. This intricate folding pattern of the rugae was also observed in the walls of *O. peringueyi*, but here the individual rugae were thicker and epithelial tissue with gastric glands clearly visible. In the other thin-walled stomachs the rugae are simple and lower. The rugae of *C. pretoriae* and *A. uranoscopus* are broad and flat-topped with a very distinct The rugae of *C. pretoriae* and *A. uranoscopus* are broad and flat-topped with a very distinct *lamina propria* that extends into the rugae indicating an ability for the rugae to contract and expand. In *M. acutidens* the rugae are also thick and display an intricate pattern which suggests that the stomach wall is extensively folded.

The histology of the intestinal wall could not be determined since no successful sections of the intestines were obtained using the methods employed. This can be ascribed to the very thin walls of the intestines, which proved difficult to support for sectioning. It could however be determined that the thickness of the walls varied between 0,01 to 0,03 mm and that the folds in the walls stayed intact regardless whether the intestines were empty or not.

13.2.3.4 Food habits

Due to the small size of the fish species involved the water replacement method of stomach volume determination could only be applied to fifteen specimens and it was decided to discard the method for this study.

Table 13.2.3 shows the estimated stomach fullness of the fish collected during the same period in June 1998. Because of small sample size, the results obtained with the stomach contents of *B. eutaenia, B. lineomaculatus, B. unitaeniatus and B. trimaculatus* were not considered for comparison with the other fish. The number of stomachs containing food ranged from as low as 10 %, in the case of *L. cylindricus*, to as high as 88% in the case of *B. neefi*. It is of interest to take note that in the case of *C. pretoriae, A. uranoscopus, M. acutidens, O. peringueyi* and *B. neefi* 70% of the stomachs were half filled with food. When comparing stomachs that are more than half filled, the picture changes considerably with only the first three species having more than 64 % stomachs with food. When the time of collection is taken into consideration, table 12.2.3, an indication of the time of ingestion of food as well as retention time of the food in the stomachs is obtained. The time of collection was arbitrarily divided into three groups to represent early morning, midday and afternoon. Except for *A. uranoscopus* and *B. marequensis* where the stomach contents were similar for the three periods, stomachs of the other fish were predominantly filled with food in one or at the most two of the periods. More stomachs of *L. molybdinus* and *O. peringueyi* contained food in the earlier periods of the day, while *Barbus viviparus* and *A. uranoscopus* had more stomachs containing food in the later part of the day.

The frequency of occurrence of food types, such as shown in table 13.2.4, illustrates the diet composition of the fish, but gives no indication on quantities (Windel; 1971). This is obtained when percentage frequency of occurrence is calculated, such as in table 13.2.5. Table 13.2.4 however indicates that the stomach contents of *B. viviparus, B. eutaenia*, and the two labeos consisted of only *aufwuchs* and no insect material at all could be identified. Although the stomach contents of *B. lineomaculatus* contained *aufwuchs* as well as some insect material it should be borne in mind that only two stomachs, one which was ¼ full and one with even less food, were examined. The stomach contents of *O. peringueyi* consisted only of animal material and it should be noted that all the contents were covered with a mucus layer, as if it had been coated prior to being swallowed. In the case of two individuals of this species, the stomach contents also contained immature tick specimens. In *C. pretoriae* the aufwuchs in the stomach contents appeared to have been rolled into "balls", which could indicate that food was scraped from a hard surface. Filamentous algae was also present the stomach contents of all the fish feeding on aufwuchs, with the exception of *B. lineomaculatus* and the two labeos. Table 13.2.4 shows that the major portion of insects in the stomach contents are the juvenile stages. Of these juvenile stages only the Chlorocyphidae nymphs, who can scramble between plants and the larvae of the Culicidae are regarded as free swimming. The rest of the juvenile stages are either found on or under stones or in the detritus where they are burrowed into the mud. The adult form of the Staphylinidae is semi-aquatic and live in wet habitats close to running water. All adult forms of the other insects, with the exception of the Coleoptera which are the water beetles, have the ability to fly and could only be ingested if they land on the surface of the water.

Indices of food similarity can be regarded as a measure of resemblance between two species in respect of food consumed. For the index in this study, food was not only selected by species but life history stages of each species were considered as well. Indices calculated for the five of species, Table 13.2.6, shows that the greatest amount of similarity exists between *B. marequensis* and *C. pretoriae* and between *M. acutidens* and *O. peringueyi*. The high index calculated for the first pair can be attributed to the large volume of "aufwuchs" present in the stomach contents. In the second pair the high index of similarity can be regarded as significant, since it is based upon specified food items.

13.2.4 DISCUSSION

The classical trophic grouping of fish into herbivores, omnivores and carnivores, is based on the food ingested. This grouping is however, due to their dependency on a mixed diet, not always strictly valid in freshwater fish (De Silva & Andersson, 1995). Feeding conditions, on the other hand, are also used to categorize fish into benthic or pelagic feeders, of which the latter can be subdivided into surface or column feeders.

In the group of fish where a true stomach, based on histology and morphology, could be identified, diets were very similar and it could suggest that they were competing for food resources. The stomach contents of *O. peringueyi* indicated carnivory and this is supported by the positioning and size of the mouth, the large eyes, short relative gut length as well as the relatively large stomach. The stomach, however, did not have the typical U-shape and thick wall associated with carnivores (Willers, 1991), but it is important to note that the wall was muscular and that gastric glands were present as is characteristic of the carnivores (Sheperd and Bromage, 1992).

Although the short relative gut lengths as well as the stomach morphology and histology would classify *A. uranoscopus* and *M. acutidens* as carnivores, their stomach contents also include "aufwuchs" and algae. The same type of stomach contents is observed in *C. pretoriae*, but here there is a tendency towards the characteristics, such as a longer gut length and smaller stomach, more typical of detritus feeders or herbivores (Wootton, 1990). When the frequency of occurrence was determined as in table 13.2.5, the diets of the four species appeared to be similar, but calculated indices of food similarity (table 13.2.6) showed that a high index of similarity, close to 50 %, only exist between *M. acutidens* and *O. peringueyi*. This high amount of similarity indicated that the same resources are utilized by the two species and created the idea that competition between the two species was taking place. When the percentage of stomachs containing food at the different times of collection was taken into consideration, it became clear that where *O. peringueyi* was ingesting food early during the day, the opposite was true for *M. acutidens*. Careful investigation of the food types also revealed that the more than 50% of the stomach contents of *O. peringueyi* consisted of adult dipterans. This together with the terminal placing of the mouths indicated that this fish is a predator that feeds from the surface or the middle water column (Skelton *et al.*, 1991). It was also the only fish in which semi-aquatic insects were observed in the stomach contents. The abovementioned indicates that the realized niche of *O. peringueyi* could be regarded as narrow, which makes the it a specialist, with an ability to efficiently utilize resources but at the same time being vulnerable to changes in the environment. *A. uranoscopus*, with respect of the wide variety of food utilized, could be categorized as a generalist or non-specialist and it would be far more adaptable to changes. When diets were considered, the other two species in this group also tended towards being generalists. Sight should however not be lost of the special feeding adaptations displayed by *C. pretoriae* and the fact that it could also be adversely affected by increased sedimentation.

The other species in the study, where the "stomach" was only a widening in the digestive tract and no true stomach could be identified, formed the second group. Although regarded as stomachless, food items in the stomach showed, as suggested by Bitterlich (1985), that they were not primarily herbivores or detritivores. Frequency of occurrence of food items showed that the stomach contents of *B. marequensis*, *B. neefi* and *B. lineomaculatus* included invertebrates, organic matter and even algae which would categorize them, according to Skelton *et al,* 1991, as unspecialized facultative feeders competing for the same resources. Between the first two species, mentioned above, there is niche differentiation. Table 13.2.5 shows that not only does the stomach contents of *B. marequensis* contained a larger percentage of "aufwuchs" than in the case of *B. neefi* but it also has a longer relative gut length that would enable it to cope with food types that are more problematic to digest. Because of the few *B. lineomaculatus* specimens collected, it was not clear whether their niches differentiated from the other two species. The two labeo species displayed the complex ventro-terminal mouth and long coiled intestines that are specialized features associated with epibenthic microphagy (Skelton *et al*, 1991) and their large soft lips indicated that they are grubbers. Their stomach contents included organic detritus, diatoms and filamentous algae. They are therefore specialists that could be affected adversely by environmental changes such increased sedimentation. Since a total of only eight stomachs investigated contained food, no definitive conclusion could be made about niche differentiation between the two species. The stomach contents, based on the frequency of occurrence, of *B. viviparus* was found to be similar to that of the two labeo species. The times at which stomachs containing food were collected were however different from the labeos, which indicated, that niche differentiation between this species the two labeos existed.

13.2.5 CONCLUSION

Of the thirteen candidates species earmarked for an Index of Biotic Integrity, twelve were collected during this period in June 1998. Sufficient data were collected of 8 of these to investigate trophic niche differentiation. It was found that differentiation existed between the realized niches of *B. neefi, B viviparus, B. marequensis, L. cylindricus, C. pretoriae, A. uranoscopus, M. acutidens* and *O. peringueyi.*

The study also emphasizes the importance of using different aspects, such as the external morphology, the intestinal morphology and histology, over and above the feeding and food data, in order to make decisions about trophic niche differentiation.

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Table 13.2.1. The physical dimensions and ratios of the digestive tracts of the thirteen rheophilic fish species from the Mutshindudi River .

Specie	n	Average intestinal Volume (mm^3)	Average Stomach Volume/s (mm^3)	Average Gut length (mm)	Intest. volume (% of body volume)	Stomach volume (% of body volume)	Intestine Length (as % of body length)	Relative gut length (as % of body length)	Ratio of intestine : Stomach lengths
B. viviparus	28	25,1	13,8	34,3	1,3	2,4	52,7	78,1	67 : 33
B. unitaeniatus	1	20,1	48,2	57,0	0,4	1,0	54,1	77,0	70 : 30
B. trimaculatus	2	49,7	90,9	46,0	1,4	2,9	47,4	73,2	66 : 34
B. eutaenia	5	25,4	43,7	40,8	0,9	1,6	47,5	69,8	67 : 33
B. neefi	26	17,8	33,2	27,5	1,9	3,5	47,2	71,6	66 : 34
B. lineomaculatus	3	21,0	24,0	29,1	2,7	2,5	50,8	72,1	71 : 29
B. marequensis	105	201,1	93,2	175,1	2,1	1,4	197,1	224,4	87 : 13
L. molybdinus	11	828,7	291,9	927,5	2,5	0,7	647,7	676,5	95 : 05
L. cylindricus	20	690,8	162,9	740,1	2,0	0,5	557,1	585,3	95 : 05
C. pretoriae	65	65,8	14,8/15,0	52,8	2,5	1,2	76,2	91,9	82 : 18
A. uranoscopus	57	61,5	50,1/34,1	44,0	1,2	1,8	40,5	56,8	71 : 29
M. acutidens	27	18,0	20,1/ 9,3	31,5	1,2	2,3	39,5	61,4	64 : 36
O. peringueyi	32	20,6	60,4	27,2	0,9	3,0	28,1	47,5	60 : 40

Table 13.2.2. The micro-anatomy and histology of the stomachs of rheophilic fish species from the Mutshindudi River.

	Layers				Other histological features			Micro-anatomy	
Fish Species	Mucosa	Sub-mucosa	Muscle (as % of wall)	Serosa	Epithelium	Lamina propria	Gastric Glands	Rugae Shape and height (mm)	Thickness of wall (mm)
B. eutaenia	•	•	Thin	•	column			intricate thin, 0,2	0.03
B. neefi					column			simple, 0,1	0,02
B. lineomaculatus								simple, 0,1	0,02
B. marequensis			10					simple 0,03	0,01
L. molybdinus								intricate, thin, 0,1	0.01
L. cylindricus								intricate, thin, 0,05	0.02
C. pretoriae	•	•	50	•	column	•	yes	broad & flat, 0,06	0,15 - 0,4
A. uranoscopus	•	•	50	•	column	•	yes	broad & flat 0,3	0,3 - 0,6
M. acutidens	•	•	50	•	column	•	yes	intricate, thick 0,3	0,45
O. peringueyi	•	•	20	•	column	•	yes	intricate, thin 0,4	0,05 - 0,15

Table 13.2.3. Estimated stomach fullness and percentage of stomachs containing food of fish from the Mutshindudi River, collected from 7.6.98 to 11.6.98 (nc - not calculated).

			Estimated fullness of stomach					Percentage stomachs containing food at different collection periods		
Specie	Number of stomachs examined	Number of stomach containing food	Full	¾	½	¼	Less than ¼	9h00 - 11h00	11h00- 13h00	13h00- 15h00
B. viviparus	28	18	0	0	5	10	3	0	11	89
B. eutaenia	5	2	0	0	0	1	1	nc	nc	nc
B. neefi	26	23	8	2	4	5	4	22	48	30
B. lineomaculatus	3	2	0	0	0	1	1	nc	nc	nc
B. marequensis	105	49	6	2	11	15	15	26	37	37
L. molybdinus	11	6	0	0	3	1	2	50	33	17
L. cylindricus	20	2	0	0	0	1	1	nc	nc	nc
C. pretoriae	65	49	33	0	9	6	1	14	61	25
A. uranoscopus	57	37	26	2	5	4	0	28	36	36
M. acutidens	27	17	10	1	2	3	1	6	18	76
O. peringueyi	32	25	3	0	11	9	2	44	56	0
B. unitaeniatus	1	0	0	0	0	0	0	nc	nc	nc
B. trimaculatus	2	0	0	0	0	0	0	nc	nc	nc

Table 13.2.4. Frequency of occurrence of the food items in the stomach contents of rheophilic fish species from the Mutshindudi River, June 1998 : (A) - algae; (L) - larvae; (N) - nymph; (Ad) - adult.

		Insect Orders													
		Epheme-Roptera		Odonata		Trichoptera			Coleoptera		Diptera				
		Families													
		Baetidae		Chloro-cyphidae	Gomp-hidae	Hydropsy chidae	Polycentra - podidae	Lepto-ceridae	Dytis-cidae	Staphy-linidae	Culici-dae	Chirono-Midae		Simulidae	
Fish species	Auf-wuchs	N	Ad	N	N	L	L	L	L	Ad	L	L	Ad	L	Ad
B. viviparus	• (A)														
B. eutaenia	• (A)														
B. neefi	• (A)						•					•			•
B. lineomacul.	•						•					•			
B. marequensis	• (A)											•			•
L. molybdinus	•														
L. cylindricus	•														
C. pretoriae	• (A)	•										•	•	•	
A. uranoscopus	• (A)	•	•	•	•	•		•	•			•	•	•	
M. acutidens	• (A)	•				•	•					•	•	•	•
O. peringueyi		•				•		•		•		•	•	•	•

Table 13.2.5. Percentage frequency of occurrence of food items in the stomach contents of rheophilic fish species from the Mutshindudi River, June 1998 : (N) - nymphs; (L) - larvae; (Ad) - adult.

	FISH SPECIES					
Food type	C. pretoriae	A. uranoscopus	M. acutidens	O. peringueyi	B. neefi	B. marequensis
Aufwuchs	55	4.9	3.2	0	82.2	87.1
Algae	0.5	1.0	0.7	0	2.8	10.8
Baetidae (N)	2	8.8	12.6	12.7	0	0
Baetidae (Ad)	0	5.0	0	0	0	0
Chlorocyphidae (N)	0	2.6	0	0	0	0
Gomphidae (N)	0	5.8	0	0	0	0
Hydropsychidae (L)	0	22.4	0	6.4	0	0
Polycentrapodidae(L)	0	0	7.2	0	0.6	0
Leptoceridae (L)	0	1.4	0	1.7	0	0
Dytiscidae (L)	0	0.9	0	0	0	0
Staphylinidae (Ad)	0	0	0	1.0	0	0
Culicidae (L)	0	0.3	0	0	0	0
Chironomidae (L)	42	19.6	16.2	11.6	14.4	1.3
Chironomidae (Ad)	0.5	1.0	12.9	36.4	0	0
Simulidae (L)	0.5	1.5	6.8	1.5	0	0
Simulidae (Ad)	0	0	9.3	20.9	0	0.8

Table 13.2.6. Indices of food similarity of eight pairs of rheophilic fish species from the Mutshindudi River, June 1998.

Food Type		*C. pret./ A. urano*	*C. pret./ M. acuti*	*C. pret./ O. perin*	*A. urano./ M. acuti*	*A. urano./ O. perin*	*M. acuti./ O. perin*	*B. mareq./ O. perin*	*B. mareq./ C. pret.*
Aufwuchs		4.9	3.2	0	3.2	0	0	0	55
Algae		0.5	0.5	0	0.7	0	0	05	0.5
Baetidae	(N)	2	2.0	2.0	8.8	8.8	12.6	0	0
Baetidae	(A)	0	0	0	0	0	0	0	0
Chlorocyphidae	(N)	0	0	0	0	0	0	0	0
Gomphidae	(N)	0	0	0	0	0	0	0	0
Hydropsychidae	(L)	0	0	6.4	0	6.4	0	0	0
Polycentropodidae	(L)	0	0	0	0	0	0	0	0
Leptoceridae	(L)	0	0	0	0	1.4	0	0	0
Dytiscidae	(L)	0	0	0	0	0	0	0	0
Staphylinidae	(L)	0	0	0	0	0	0	0	0
Culicidae	(L)	0	0	0	0	0	0	0	0
Chironomidae	(L)	19.6	16.2	11.6	16.2	11.6	11.6	1.3	1.3
Chironomidae	(A)	0.5	0.5	0.5	1.0	1.0	12.9	0	0
Simulidae	(L)	0.5	0.5	0.5	1.5	1.5	1.5	0	0
Simulidae	(A)	0	0	0	0	0	9.3	0.8	0
Calculated indices		28.0	22.9	21.0	31.4	30.4	47.9	2.1	56.8

13.3 SUBPROJECT: AN INDEX OF BIOTIC INTEGRITY BASED ON RHEOPHILIC FISH

13.4

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13.3.1. INTRODUCTION

Rapid human population growth in some underdeveloped rural regions of the Northern Province, South Africa, is causing serious environmental degradation. The main negative effects on rivers are siltation, increased turbidity and the destruction of habitats of fish and other organisms caused by overgrazing, cultivation, removal of riparian vegetation and direct disturbance of river banks. Due to limited industrial activity in these regions, "water quality" remains relatively good and standard methods of water analysis do not pinpoint the effects of these changes, which can have serious negative effects on aquatic life.

Because the diversity, abundance and relative densities of aquatic organisms change in response to human induced environmental changes, it is possible to use these changes as an index of environmental degradation under such conditions. The index of biotic integrity first proposed by Karr (1981) and adapted by various other authors is today generally accepted as a reliable tool for water resource assessment and monitoring.

The criteria used by different authors to calculate an index vary. For example, Karr (op cit) used the total number of species, the total number of individuals, the number of intolerant species and the numbers of three selected species groups. Harris (1995) proposed the use of twelve criteria including the proportion of individuals as microphagic omnivores, the proportion of individuals as microphagic carnivores, proportion of individuals as macrophagic carnivores, etc. Hay *et al.* (1996) evaluated six basic categories, including pollution expressed as the concentration of soluble orthophosphate. In most cases a value is assigned arbitrarily by an experienced ichthyologist to each criterium as follows : 5 = pristine condition, 3 = condition deviates somewhat from pristine, 1 = deviates strongly from pristine. The sum of the scores gives an index of the integrity. Due to geographical variation in species composition and community structure, it is necessary to adapt the index for each river system and for different reaches within a river system.

In the Northern Province an index was required that would allow rapid assessment of integrity in relatively small perennial streams in the subtropical middle reaches of the Limpopo River system. These streams contain a relatively uniform component of rheophilic species that can be easily sampled with a small electric shocker. Sampling of pools is more difficult and time consuming due to the depth of the water, the presence of rocks and submerged tree trunks and the danger of crocodiles. For this reason it was decided to limit the method to an assessment of species that occur in shallow riffle and rapid habitats and associated shallow marginal areas. The index was evaluated in the Mutshindudi River, a tributary of the Levuvhu River, Limpopo River system.

13.3.2 THE FISH

Twenty six species of fish were collected from the Mutshindudi River system during this study but only 11 species were included in the index due to their preference for relatively shallow rheophilic or marginal habitats (Table 13.3. 1)

13.3.3 A PROPOSED BIOTIC INDEX

The proposed index compares the presence and abundance of the 11 species listed at the site under investigation with their presence and abundance in a pristine environment. The index differs from published indices in that each species is scored separately in terms of presence and abundance, the assumption being that, because the niches of these species are segregated, they will respond differently to negative influences. The sum of the responses should thus give a rough indication of the severity of degradation (not at all assuming that the relationship is linear). Based on existing information, it seems as if an increase in turbidity and siltation, reduction in velocity and destruction of marginal habitats may be the key factors under these rural conditions. Once more information is available it will be possible to evaluate the severity of different types of influences from the responses of groups of species known to be sensitive to particular changes.

Table 13.3.1. A list of species used in the calculation of the biotic index

SPECIES	HABITAT PREFERENCE (GAIGHER, 1973)	SENSITIVITY ACCORDING TO KLEYNHANS(1991)	ASSUMED TO BE SENSITIVE TO THE FOLLOWING CHANGES
Barbus eutaenia	Rapids in clear, well aerated perennial streams	Highly sensitive	Decrease in oxygen concentration and increase in turbidity
B. lineomaculatus	Rapids and pools in clear, well oxygenated perennial streams	Highly sensitive	Decrease in oxygen concentration and increase in turbidity
B. marequensis	Pools and rapids, mainly in perennial streams	Insensitive	Reduction in flow rate and siltation of breeding sites
B. neefi	Pools and slow-flowing marginal habitats of clear perennial streams	Highly sensitive	Reduction in oxygen concentration and increase in turbidity
B. viviparus	Occurs in perennial and season streams but with a preference for perennial streams and low turbidity	Highly sensitive	Disturbance of marginal habitats and increase in turbidity
Labeo cylindricus and *L. molybdinus*	Rapids in perennial streams	Insensitive	Reduction in flow rate
Opsaridium peringueyi	Clear, fast-flowing perennial streams	Highly sensitive	Reduction in flow rate and siltation
Micralestes acutidens	Well aerated water	Insensitive	Decrease in oxygen concentration
Amphilius uranoscopus	Rapids in perennial streams	Highly sensitive	Reduction in flow rate and decrease in oxygen concentration
Chiloglanis pretoria	Rapids in perennial streams	Sensitive	Reduction in flow rate

Each species is given a score of 0.5 if present and 0 if absent. Based on the results of this study, and experience elsewhere, the number of individuals of each species that should be collected after 20 minutes of electro-shocking is listed. If this expected number of individuals or more are collected at the site, 0.5 is added to the score. If fewer are collected, the added score is obtained by dividing the number collected by the number expected, and multiplying this by 0.5 (e.g. if 5 are expected and 2 are collected, the score is 0.5 plus (2/5 x .5) = 0.7). The average of the scores of all species gives the index. An index between 0.7 and 1.0 would indicate relatively pristine conditions and lower values would indicate increasing degrees of deterioration with the other extreme close to 0.

Table 13.3.2 gives the results obtained at a locality in the Mutshindudi River below a measuring weir as an example

Table 13.3.2. Biotic integrity of the Mutshindudi River at Matshika

SPECIES		N EXPECTED	N COLLECTED	SCORE
B. eutaenia	*	5	0	0
B. lineomaculatus		5	0	0
O. peringueyi		5	1	.6
B. marequensis	**	30	53	1
L.cylindricus		5	0	0
L. molybdinus		2	1	.75
A. uranoscopus		5	2	.7
C. pretoriae		50	26	.76
B. neefi	***	5	0	0
M. acutidens		5	7	1
B. viviparus		5	3	.8
			Total	5.61
			Average (index)	0.51

* : species apparently sensitive to high turbidity and/or siltation
** : species apparently sensitive to reduced flow
*** : species apparently sensitive to marginal habitat destruction

This site can be considered to be degraded due to increased turbidity, reduced flow and a degree of disturbance of marginal habitat. The presence of *O. peringueyi*, which is considered to be highly sensitive to siltation, might be due to reduced sedimentation because of the presence of the weir upstream. It was not collected from the river section above the weir.

13.3.4 EVALUATION OF THE INDEX

The proposed index was evaluated in the middle and lower reaches of the Mutshindudi River (Table13.3.3). All sites gave low biotic index scores indicating poor habitat integrity throughout this part of the river. Another tributary of the Levuvhu River, the upper Mutale River, which is still relatively undisturbed, gave a score of 0.95.

The scores obtained are in line with a subjective evaluation of the condition of the Mutshindudi River by the authors and co-workers. The scores are also substantiated by the riverine vegetation index scores obtained by Angliss et al. (in preparation) based on a method proposed by Kemper (1999). However, the habitat quality index score for aquatic insects recorded by the same authors indicate good to very good conditions. Thirion (1999) criticizes the habitat index score method (Chutter, 1998) used by these authors, indicating that in her studies there was no strong relationship between the habitat index and the SASS score for aquatic insects. Also that the habitat indices tended to remain high, even when there were obvious habitat problems. Van Ree (1999) found that the chemical quality of the Mutshindudi River is good but that suspended solids increase dramatically after rains.

Table 13.3.3. Biotic index scores obtained at seven localities in the lower Mutshindudi River. The values are compared with habitat quality index values for aquatic insects and riverine vegetation index values recorded by Angliss et al. (in press) during 1999.

CO-ORDINATES	BIOTIC INDEX SCORE	HABITAT QUALITY INDEX SCORE FOR AQUATIC INSECTS	RIVERINE VEGETATION INDEX SCORE
$22^0$54' S, 30^0 29' E	0.45	116: very good	7.6, Class E : seriously impared
22^0 57' S, 30^0 27' E	0.55	-	-
22^0 54' S, 30^0 32' e	0.33	99: good	5.6, Class E: seriously impared
22^0 54'S, 30^0 33' E	0.36	-	-
22^0 53' S, 30^0 35' E	0.35	-	-
22^0 52' S, 30^0 40'E	0.53	97: good	9.3, Class D: largely impared
22^0 51' S, 30^0 41'E	0.51	97: good	6.9, Class E: seriously impared

*Angliss et al. (in prep)

13.3.5 DISCUSSION

All existing biotic index methods are, to a certain degree, subjective and based on assumptions which do not always apply. Methods based on fish are also generally time consuming and expensive and require a high level of expertise, even for field surveys. However, they are useful management tools because they enhance our ability to assess the habitat integrity of rivers

Small perennial streams in parts of the Northern Province contain an assemblage of fish species in rheophilic habitats that can be efficiently sampled with an electric shocker. The proposed method is based on the assumption that a deterioration of habitat integrity will be reflected in a reduction of density or the disappearance of these species. The types and numbers of species that disappear will depend on the type and severity of disturbance. Because all species are considered to be "sensitive" to a certain extent, the same weighting is given to each species' presence or absence. The influence on density is evaluated differently because the density of species differ. Although the fishes can be categorized into groups dependent on their presumed sensitivity to different types of environmental changes, these groups are not analyzed as separate units because of a lack of information.

Results in the Mutshindudi River indicate that the proposed method is sensitive to a wide range of environmental factors, some of which are not readily detected by other methods. The method is rapid and cheap, does not require expertise in the field, and is not dependent on the subjective evaluation of conditions in the field. However, the method will have to be evaluated in a variety of different streams with known environmental disturbances to assess its applicability compared to standard methods.

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CHAPTER 14

THE AVIFAUNA OF THE MUTSHINDUDI RIVER CATCHMENT : INDICATOR SPECIES FOR ECOLOGICAL INTEGRITY

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14.1 INTRODUCTION

The Mutshindudi River is part of a corridor that connects Mozambique to the Soutpansberg mountains. As such it provides a potential route for the migration of species between the forests of Mozambique and the high mountains of the Northern Province and thus offers the potential for providing a high species diversity along its length.

14.2 AIMS OF THE STUDY

The study attempts to ascertain whether there are any differences in the distribution and abundance of birds, between disturbed and undisturbed areas of the Mutshindudi River catchment.

It attempts to identify key bird species whose presence can reliably indicate the healthy ecological functioning of the water catchment; or conversely, those birds whose presence may indicate the collapse, or degradation, of the integrity of the river catchment as a healthy ecological system.

14.3 METHODOLOGY

The avifauna was surveyed for species diversity and distribution of those species across the various habitats associated with the Mutshindudi River along its full length. The habitats were classified into six primary categories, viz : Aquatic, Forest, Woodland, Grassland, Scrub, and Montane to Rocky. Only three of these were used in the final analysis namely Forest, Woodland and Grassland.

Forest

True forest has a continuous canopy and the trees are likely to be 5 m or more in height. All forest in Southern Africa is evergreen.

Woodland

Woodland is tree growth with canopies not touching but of varying densities depending on the soil and moisture conditions prevailing

Aquatic

In this study there were only two aquatic habitats, the Thathe vondo Dam and the river itself (see data ananalysis).

For further discussion on the categories, see below.

The complete list of birds recorded has been included as Appendix 3, and broken down by habitat in Appendices 4 – 12.

14.3.1 Survey Sites

The Mutshindudi River was divided into six portions for the purposes of this survey:

1. Upper Catchment.

This extends from immediately above the Thathe Vondo dam to the source.

2. The Thathe Vondo Dam.

This includes the lake itself as well as the surrounding and emergent vegetation and extends downstream as far as the Sibasa to Nzhelele Valley tarred road

3. The Middle River extending from the Sibasa - NZhelele road down to the Sibasa to Mutale road, but excluding the Phiphidi Falls Nature Reserve.

4. Phiphidi Falls Reserve and the associated areas of forest and dense woodland

5. The Lower River from the Sibasa - Mutale road to the junction with the Levuvhu River.

6. Plantation areas.

These occurred throughout the length of the river and include pine and blue gum plantations, as well as the tea plantations above the dam.

A. Upper Catchment (UC)

The upper stream is fast flowing over most of its length with a rocky bed. The valley is steep sided with the surrounding mountains rising sharply up from the river and with lengths of vertical cliffs. The valley is cut by a number of tributary streams, most of these seem to arise on the southern side of the river where the topography is generally slightly less steep.

The water quality would appear good with much in stream invertebrate life. Of particular interest were the large number of dragonfly and damselfly larva inadvertently netted while surveying for tadpoles. Additionally, several small (1.5 cm) catfish were netted, some high in the tributaries, above waterfalls.

The vegetation is either natural forest or plantations of both blue gum and pine over most of the upper length. In the upper reaches of the watershed there are areas of montain grassland with proteas and *Ericas*.

B. Thathe Vondo Dam (TV)

Surrounding the lake itself there is a thin strip, up to 10 - 1 5 metres wide, of scrub and regenerating secondary forest and woodland on the southern bank, above which are tea plantations. The northern shore is largely pine plantation rising up to the Sibasa - Nzhelele road and higher. These plantations extend right down into the water where the lower reaches were flooded when the dam wall was raised. Between the dam wall and the tar road there is a short stretch of riparian scrub and secondary woodland, but this is rapidly being cleared for subsistence agriculture with maize being planted on even the steepest slopes.

C. Middle River (MR)

This area has been extensively cleared for agriculture and human habitation. The area includes a smaller dam surrounded by fields and villages. The dominant vegetation is grassland with some degraded strips of riparian scrub and areas of blue-gum plantations. Roughly in the middle of this stretch lies the Phiphidi Falls Nature Reserve.

D. Phiphidi Falls (PF)

This is a conservation area consisting of a stretch of slow flowing river followed by the falls themselves. The vegetation is good quality riparian forest with a closed canopy and relatively free of scrub undergrowth except bordering footpaths and the edge strips. In the upper areas toward the road there is thick scrub regrowth where the forest has previously been cleared

E. Lower River (LR)

The Lower River is a fairly mature river that meanders through a flat plain. The flow is restricted by two weirs that impound the water for agricultural purposes. The area is relatively densely settled with several large villages along its length, and at the lower end before it enters the Levuvhu river there is and agricultural irrigation project that draws water from the Mutshindudi for banana and mango plantations.

The vegetation is fragmented into islands of relict riparian forest with a closed canopy, open woodland and scrub grassland, and fields ploughed down to the river bank in places. At an agricultural project on the north bank the vegetation has been left in a strip 10 - 20 metres wide, beyond which there is a fence between the riparian vegetation and the orchards. This is some of the "best" forest below the High Catchment with a closed canopy meeting over the river. In addition it is relatively undisturbed by human activity except for fishermen.

F. Plantations (p)

The Plantations are of four types : blue-gum, pine, tea, banana and mango. To all intents and purposes these areas are ecological deserts and it is disappointing to find these plantations, particularly the forestry ones, planted right down to the water's edge. In these places as there is little to no ground cover in these to prevent erosion.

14.3.2 Survey methods

The lower river from Thathe VondoDam down to the junction with the Levuvhu River was surveved over most of its length using a series of point survey sites. A site was surveyed for 15 minutes, walking for half an hour and stopping again for another 15 minutes and so on. During the walk a note was made of the vegetation through which the walk was being made and a record kept of all birds seen during the transect. The records were made onto a tape recorder and transcribed later.

The nature of the terrain and vegetation above the Thathe Vondo Dam made this method impractical. Instead forestry roads and paths were used to walk down to sites along the river. The coverage here was not as good as for the lower river, nevertheless 6 sites on the river were surveyed as well as another 6 on tributary streams and in the catchment forest.

Netting and ringing of birds was attempted using 100 metres of mist nets on three separate occasions. However, this was abandoned as a survey method because of the difficulty of capturing forest birds, most of which are found in the canopy.

14.3.3 Analysis

The data was analvsed using a simplified version of a habitat annotation system developed by the Avian Demography Unit of the University of Cape Town. (J.A.Harrison et al, 1994).

Birds species are habitat specific and, if the habitat requirements are known, the presence of any species serves as an indicator of its preferred habitat. The Southern African Bird Atlas Project has built up a detailed database of bird distribution and habitat requirements for the whole of Southern Africa. This information has been tabulated giving the habitat requirements of all Southern African species.

By cross referencing the species recorded in the course of the survey against the habitat requirements of the species, a profile of the integrity of the habitat is obtained along the length of the river system. The habitats are divided into a hierarchy of habitat categories and a species can fall into all three. Thus a species may fall into Forest, FR (a primary category), Indigenous, I (Secondary) and Riverine, RV (Tertiary). The symbols of these used in the tables are;

Primary 1	Secondary 2	Tertiary 3
AQ - Aquatic	LC - Lacustrine	WX - Open water
FR - Forest	MN - Afromontane forest	WP – Emergent/marginal
WO - Woodland	EG - Forest edge	BR - Broadleaved
GR - Grassland	IN - Indigenous	TH - Thicket
RC - Montane & Rocky		RV - Riverine
		GR - Grassland
		NT - Natural grassland
		SW - Sweet
		SU – Sour
		SC – Scrub habitats

14.4 RESULTS

A total of 125 species were recorded throughout the total length of the survey. These were made up of 110 species that can be tied to a habitat and 15 generalists showing no particular habitat preference. The house sparrow, *Passer domesticus*, has been classified as a generalist although in fact it is only found around human habitation, but is likely to be found in any habitat where people live.

TABLE 14.1. NUMBER OF SPECIES COLLECTED AT EACH SURVEY AREA

SURVEY AREA	SPECIES
High catchment	56
Thathe Vondo dam	41
Middle River	21
Phipidi Falls	12
Lower River (open woodland)	37
Lower River (forest)	41

Only results for five of the six survey areas are given here because to all intents and purposes the plantation areas were devoid of ornithological life. No more than a handful of birds were recorded as using them - see discussion, below.

The results for the Lower River have been split into (a) open woodland and grassland, and (b) forest and dense woodland, as the species composition and habitat type was quite distinct for both. The species recorded for each survey area are given in Appendices 3– 10.

14.4.1 Discussion of Results

Although the occurrence of the species was categorised according to their preference for all three levels of habitat classification, analysis was only carried out for three primary levels, viz. forest; woodland and aquatic habitats. This simplification was done because of the difficulty of obtaining an accurate description of the habitat type in which the bird was recorded in the time available.

The species were categorised according to whether they were indicator (I) species for the habitat, or whether they were only associated (A) with the particular habitat in which they were recorded. (See Appendix 3)

TABLE 14.2. THE NUMBER OF SPECIES FOUND AT EACH SITE EXPRESSED AS A PERCENTAGE OF THE TOTAL

Survey Area	Species	% of Total
High CatChment	56	44.8
Thathe Vondo Dam	41	32.8
Middle River	21	16.8
PhiPhidi Falls	12	9.6
Lower River (open)	37	29.6
Lower River (forest)	41	32.8

Table 14.2 gives the number of species found in each survey area as a percentage of the whole 125 species. This is useful in giving a general impression of species richness of the different sites. It is not useful in distinguishing between the sites because of the overlap of species between sites; i.e. species may be found in more than one site.

It is more useful to calculate an index of similarity between the areas to determine the degree of similarity of the bird species present. A simple measure was used that is based on species presence only:

$$index\ of\ Similarity = 2c/(a + b)$$

where *a and b* are the number of species at each site and c is the number of species occurring in both sites.

The sites are compared with the upper catchment where the highest number of species was recorded, and where the vegetation is the least disturbed. The results are given in Table 14.3.

Of particular interest here is the low degree of similarity between the Phiphidi Falls area and the High Catchment: fully 75%of the species found there are found in common with the High Catchment. Additionally the vegetation is good forest with a closed canopy over much of the area. However, very few species were recorded there. Even if all the species there were found in common with the High Catchment, the Index of Similarity would only have been 0.0353 because of the low number of species recorded.

An explanation must be sought for the low number of species. It is possible that a number of species were missed during the survey. While species were undoubtedly missed, this should be true of all the sites, and there is no reason to suppose that a higher percentage were missed at this site than elsewhere. Two visits were made to the site, and the reserve was surveyed from both banks.

The reserve is small and this should be responsible for a low species count on its own. The reserve can be considered as an island separated from the main forest, the High Catchment, by non-forest environments of agricultural land and human habitation. Indeed this can be said for all the areas surveyed. The surviving remnants of forest patches may all be considered as islands with severely depleted bird fauna. All of them are small and it is to be expected that only a few species will be found at any one time.

However, turnover of species can be expected to be high given the connecting woodland corridor that typifies much of the river. This being the case, it is to be expected that by combining several sites a higher species count would be obtained than for any one place. This is in fact what has been done in the case of the Lower River where the results from eight separate survey sites were combined to produce the combined figure of 41 for the area. Of these eight sites, the spread was from a low of only seven species recorded, to a high of 18 species. (see Appendix 11 for a full species and site list for the Lower River). A simple total of species recorded at every site gives a total of 73. The figure of 41 is arrived at by deleting duplications.

The low figure for Phiphidi Falls is therefore not anomalous although it is bigger than any of the other individual sites on the Lower River. However, this reserve is heavily used by visitors at weekends and other holidays and so suffers more human disturbance, although of a transient nature than any of the other sites surveyed. This may be an additional pressure on this fragment.

The forest data were then analysed for similarity for each of the individual survey points. They were compared with the site having the highest number of species recorded during the survey, site LM10, 18 species. The results are given in Table 11. 4. The complete data is given in Appendix 12.

TABLE 14.3. THE DEGREE OF SIMILARITY OF THE SPECIES COMPOSITION OF THE SITES BY COMPARISON WITH THE SPECIES FOUND IN THE HIGH CATCHMENT

SURVEY AREA	NO OF SPECIES	SPECIES IN COMMON	SIMILARITY
High catchment	56		
Lower River forested	41	21	0.433
Thathe Vondo Dam	41	20	0.412
Lower River Grassland	37	14	0.301
Phiphidi Falls	12	9	0.265
Middle river	21	9	0.234

TABLE 14.4. INDEX OF SIMILARITY BETWEEN THE LOWER RIVER FOREST SITES (LM) AND PHIPHIDI FOREST SITE (PF), AND SITE LM10, THE SITE WITH THE HIGHEST NUMBER OF SPECIES RECORDED IN THIS SET.

Site	LM10	LM2	LM3	LMS	LM8	LM11	LM12	LM17	PF
Species	18	8	7	9	9	8	13	11	12
Overlap		5	4	3	2	3	5	6	2
Similarity		0.38	0.32	0.22	0.15	0.23	0.32	*0.41*	0.13

The difference between the sites was not found to be significant at p= 0.05. Comparison was also made between site LM17 and Phiphidi Falls site, the sites with the greatest differences between them. Again the differences were not found to be significant.

The low index of Similarity between the sites suggests that the bird life associated with relicts of the riparian forests is highly mobile, moving between the "islands' of forest on the Mutshindudi corridor. This indicates that the bird life of the river system itself, below the High Catchment, is considerably greater than that of any individual site.

This likely turnover of species between the different island patches of forest makes survey and predictive assumptions difficult. The fact that a bird is not seen in any group of patches does not mean that it is not normally there, just that it is not there at the time of the survey. *'Absence of proof is not proof of absence.'*

14.4.2 Forest indicator Species

The term "Indicator" has a specific meaning that the species so categorised has an obligate relationship with the forest (or other) habitat. This means that it will not be found in other primary level category, i.e. Aquatic, Woodland, Grassland, Scrub. It may, however, occur in more than one secondary or tertiary level category.

Significant differences were found between the occurrence of indicator species between the different sites. Looking first at the occurrence of species regarded as indicators of forest habitat, the differences between the other sites and High Catchment were found to be highly significant at p= 0.01. The species actually recorded are given in Table 14.6.

The **Forest buzzard** is found wherever there are suitable forest patches and It breeds In both indigenous and alien plantations. The highest reporting rates are for afro-montane forest.

The **Knysna Lourie** is an indicator of afro-montane forest and is unlikely to be found further down than the Thathe Vondo dam.

The **Emerald Cuckoo** Is found in evergreen forests, gallery and riparian with the highest reporting rates for afro-montane forest

The **Olive Woodpecker** is an indicator species for indigenous afro-montane forest and is found only above 1000 metres in the Northern Province

Both the **Chorister** and the **Starred Robins** are characteristically birds of the afro-montane forests, but do migrate to lower altitudes in winter where they frequent forested areas.

The **Dusky Flycatcher** is a forest bird preferring dense evergreen vegetation and Is also found in riverine strips.

The **Cape Batis** is typically a bird of evergreen forests with the highest reporting rates being for afro-montane forest, but is also found in valley bushveld and areas of forest fragments.

The **Longtailed Wagtail** is a bird of riverine forests and seldom moves far from the banks.

The **Olive Bush Shrike** is a forest species confined to areas less than 2000 metres in altitude and uses forest fringes as well as forest depths.

The **Longtail Wagtail** is the most likely individual bird species to be of value as an indicator of the health of the river system. It is a bird of riverine forests and forages for insects and larvae of dragonflies and mosquitoes entirely within the watercourses. Its normal distribution along rivers is about 1 pair per 0.5 km of pristine river and about 1 pair per 1 km of unclean river. (Piper & Schultz, 1989)

Other species that are likely to prove useful are the **Emerald Cuckoo**, **Dusky Flycatcher**, **Cape Batis** and **Olive Bush Shrike**. However, the first three have only limited value as they all have the highest reporting rates for afro-montane forest. Their presence is likely to be more valuable as an indicator of the integrity of the High Catchment than the Lower River.

TABLE 14.5. NUMBER OF INDICATOR SPECIES FOUND IN FORESTED SURVEY SITES

High Catchment	9
Thathe Vondo Dam	1
Phiphidi Falls	1
Lower River Forest	0

TABLE 14.6. FOREST INDICATOR SPECIES RECORDED DURING THE SURVEY

Buzzard, forest	High Catchment
Flufftail, buffspotted	Thathe Vondo Dam
Lourie, Knysna	High Catchment
Cuckoo, emerald	High Catchment
Woodpecker, olive	High Catchment
Robin chorister	High Catchment
Robin, starred	High Catchment
Flycatcher, dusky	High CatChment
Batis, Cape	High Catchment
Wagtail, longtailed	Phiphidi Falls/High Catchment
Shrike, olive bush	High Catchment

14.4.3 Woodland Indicator Species

Appendix 3 shows 11 indicator species for indigenous woodland of which only one was found in all three major habitat types in the study area, viz. the Chinspot Batis; two were found in two habitats, High Catchment and Lower River, viz. Threestreaked Tchagra and Gorgeous bush shrike. The Gorgeous bush shrike was recorded lower down the valley in the High Catchment, a few hundred metres upstream from the Thathe Vondo Dam and this was presumably near the limit of its distribution as it is not found above 1000 m. in South Africa. The other eight species were found at one habitat site only, Lower River 5 species, Thathe Vondo Dam 1 species and High Catchment 2 species.

Although there were five recordings for these birds in the High Catchment, none of these species is indicative of forested areas. Rather they were found in the scrub and woodland regrowth in plantation areas that had been clear felled at some stage in the past without being replanted.

TABLE 14.7. INDICATOR SPECIES FOR INDIGENOUS WOODLAND

Name	No.	Site(s)
African hawk eagle	*(141)*	LR
Bateleur eagle	(151)	HC
Striped kingfisher	(403)	TV
Little bee-eater	*(410)*	LR
Scimitar-bill woodhoopoe	(412)	HC
Rattling cisticola	(642)	LR
Chinspot batis	(673)	LR,TV, HC
Threestreaked tchagra	(714)	LR, HC
Gorgeoous bush shrike	(721)	LR HC
Brubru	(731)	LR
Plumcoloured starling	(736)	LR

No. refers to Roberts edition 5 number.

LR = Lower River: TV = Thathe Vondo Dam: HC = High Catchment

Except for the Little Bee-eater and the Gorgeous Bush Shrike which do use the forest edge as well as being indicators of woodland, all the others are restricted to woodland. Their presence should therefore be taken as an indicator of woodland rather than forest.

The fact that 8 of the 11 species were recorded in the Lower River below the Sibasa Mutale road should therefore be taken as indicative of the extent to which the riparian forest has been replaced by woodland.

14.4.4 Associate Species

Associate status is taken to mean that the species is very likely to use that particular habitat if it is available, but that this association is facultative and not obligate. As a consequence a species may be associated with more than one primary category.

Analysis of the occurrence of those species regarded as associated with a forest habitat are given in Table 14.10. Associate status does allow birds to be associated with more than one category. As Appendix 12 demonstrates, the species recorded are almost all associated with both forest and woodland and this results in the very close match between the figures for those two categories.

In the High Catchment the differences are that the Blackcollared Barbet is associated with woodland but not with forest, and the Rameron Pigeon and the Black Sawwing Swallow are associated with forest and not with woodland; the other 19 species are held in common. In the Thathe Vondo 10 of the species in each column common, in the Lower River, 11 are common, in the Lower River Woodland all 6 are common and in the middle river, both species are common.

TABLE 14.8. THE NUMBER OF FOREST AND WOODLAND ASSOCIATED SPECIES

	FOREST	WOODLAND
High Catchment	21	20
Thathe Vondo	13	12
Middle River	2	2
Loweer River forest	12	11
Lower River woods	6	6

The differences between the High Catchment and the Middle River is significant, and between the High Catchment and the Lower River Woods are significant at $p = 0.01$. The differences between the other sites are not significant.

Association is a weaker link to a habitat than indication and it is therefore not surprising that species associated with forest are also associated with woodland. Their distribution is more widespread and not confined to any one habitat type.

TABLE 14.9. INDEX OF SIMILARITY BETWEEN ASSOCIATE SPECIES IN THE HIGH CATCHMENT AND OTHER HABITATS

	Forest	Woodland
Lower River Forest	0.606	0.645
Lower River Woods	0.370	0.385
Thathe Vondo Dam	0.647	0.688

The index of similarity for these species is considerably higher than for the indicator species except for the Lower River. In the Thathe Vondo survey sites, 11 out of 13 forest species and 11 out of 12 woodland species are found in common with the respective categories in the High Catchment. In the Lower River Forest survey sites, 10 out of 12 forest species and 10 out of 11 woodland species are found in common with High Catchment. In the Lower River woodland the respective figures are 5 out of 6 for both categories. The only reason the Index is low for this site is the relatively few species found at all, only 6.

These figures suggest that an index of similarity for associated species for woodland and forest should be of use in assessing the quality of the remaining woodland in comparison with the High Catchment.

14.5 CONCLUSIONS

The river system of which the Mutshindudi forms a part plays an important role as a corridor linking the lowland forests of Mozambique and the Limpopo flood-plain with the forests of the Soutpansberg mountains via the Levuvhu river. For the terrestrial biota the most important aspect of this corridor is the integrity of the riparian forest, for the in stream biota it is the quality and f low of the water.

These two aspects are inter-related in many ways and it is not possible to think of securing one aspect without the other. Unfortunately the gallery forest is fast disappearing as it is being cleared for agriculture along much of the rivers length.
This will in turn effect the water flow and quality, increasing the speed of the runoff, increasing erosion of the river bank, increasing siltation and possibly raising the chemical

load on the river from agricultural chemicals and in the long term raising the likelihood of eutrophic conditions arising.

As the survey showed, the forest on the Mutshindudi has largely disappeared and now survive only as remnant "islands" along short sections of the river bank, and seldom on both banks at the same place. There are only one or two places where the remnant forest exists on both banks and these are on the lower reaches shortly before it joins the Levuvhu River.

If the remnant vegetation can be saved and then gradually allowed to spread back along the river, the conditions for the terrestrial biota can still be improved. If the destruction continues it cannot be very long before the river deteriorates to the extent that only major and expensive interventions could turn the situation around. As noted earlier, already the situation has deteriorated to the extent where no forest indicator species were recorded below the Phiphidi Falls during the survey. And even at the Falls themselves, only the Longtailed Wagtail was recorded as an indicator species, but this was a hopeful sign in itself as it suggests that the quality of the water is still relatively good at this location as well as the forest.

The primary focus of intervention therefore should be to save what remnants are left of the original riparian vegetation. This cannot be enforced without the acceptance of, and support for, such measures as would be required by the communities living along the length of the river and members of the local government institutions in the area.

As far as the High Catchment, above the Thathe Vondo Dam, is concerned the forest still appears in reasonably good condition. In the longer term this would allow the spread of the forest back down the river from this mountain refuge. However, in place the forestry plantations of blue-gum and pine have been planted right down to the bank of the Mutshindudi and some of its tributaries. This is likely to have effects on the water quality, possibly leading to acidification of the upper catchment if this is allowed to continue.

As in the lower river, it is important to conserve the river bank as a minimum requirement. However, if the alien plantations were removed from along the river banks, the disturbance caused by the felling and the forestry vehicles would be very damaging in itself. The loss of ground cover would lead to sharply increased run-off and siltation of the disturbed bank. It would be preferable to leave the dead trees standing while the natural forest regenerated.

Around the Thathe Vondo Dam the Sapekoe Tea Estate has left a strip of regenerating scrub woodland and remnant forest between 5-15 metres wide. Unfortunately the forestry plantations around the rest of the dam have been planted right up to the water's edge, and in some places parts of the plantations have been submerged when the dam wall was raised.

The forestry operations should be persuaded not to replant right to the waters edge after harvesting but to follow the example of Sapekoe. This would assist in maintaining a continuous gallery forest from the upper catchment to the dam and beyond and encourage downstream regeneration. Any attempts to persuade the communities bordering the lower river to conserve their areas of the river are only likely to be successful if the big plantations are prepared to be part of such a scheme.

As with the upper catchment, it would probably be better if the plantation trees were not felled, with the consequent disturbance of the lake bank. If the trees were killed but left standing to provide some protection while the natural vegetation reasserted itself, it would be less destructive and cause less erosion and siltation in the lake.

For the length of the river, and other rivers in the system, a protected gallery 20 metres wide on both banks would probably prove to be a sufficient minimum. However, in the Upper Catchment where there is still extensive forest remaining, every effort should be made to conserve this habitat, unique in the Northern Province. It should be preserved both in its own right and as a refuge from which future colonisation of the lower river could spread.

If the gallery forest could be saved and allowed to regenerate it would make an important contribution to increasing the water quality in the river. However, another problem is the increasing abstraction for agricultural purposes. Four large (150 – 200mm) bore pumps were recorded as being in operation during the survey. (This excludes the pumps for the irrigation project.). Additionally another 8 of various diameters were recorded, but were not in operation when seen.

If the abstraction is allowed to continue increasing unchecked it must inevitably lead to a situation where the river will stop flowing in the dry season months with catastrophic consequences for both the in stream and riparian biota.

Birds may be useful as indicators both as individual species whose presence or absence can act as an indicator of the quality of the forest and as assemblages of species whose diversity can act as an indicator. In order to do this, regular surveys of the avifauna would need to be undertaken to ascertain the status of these species and thus changes to their habitat, the forest.

As noted, there are two primary habitats associated with the river; the riparian vegetation and the water itself and different birds are associate or obligate users of the two habitats. Different species will therefore need to be used in determining the integrity of the two habitats.

In-Stream

Only two species were found that could be used as indicators of the in-stream quality, the African Black Duck and the Longtailed Wagtail.

The Longtailed Wagtail is the most valuable individual indicator species for the integrity of the river. Piper & Schultz (1989) report that the densities of these birds is much lower on polluted and degraded streams. This wagtail requires both riverine forest and within stream insect life as food, particularly the larva of dragonflies and mosquitoes. It is therefore sensitive to two types of interference, both the integrity of the riparian forest and the status of the water itself. Polluted streams in which insect life is diminished will support lower densities of these birds. Piper & Schultz suggest that in pristine conditions there should be about 1 pair per 0.5 km of river and about 1 pair per km of polluted or degraded river.

The African Black Duck has similar habitat requirements to the Longtailed Wagtail as far as the in stream integrity is concerned. It feeds mainly on chironomid larva and pupae which are found under stones in rapids. It also takes other insects, seeds, crabs small fish and plant material. It is not, however, dependent on the riparian vegetation nor on running water and is also sometimes found on dams and ponds as well as sewage ponds.

Riparian Forest

Given the fragmented nature of the remaining forest outside of the High Catchment, it would probably not be useful to rely on any one species to act as an indicator. Also the fragmented nature of the habitat does not make relying on indicator species for that habitat a viable option. The movement of the birds between the remnants and the likely low densities given the relict nature mean that the presence of individual birds is easily overlooked. As noted earlier, *"Absence of proof is not proof of absence."*

It is also problematic in trying to make comparisons along the length of the river using indicator species as they are often obligate with specific forest types. Thus birds indicative of afro-montane forest will not be found further downstream. A further problem is that the degraded nature of the downstream forest is such that very few indicator species were recorded; one at Thathe Vondo Dam, one at Phiphidi Falls, and none in the Lower River. Indicator species could however be used for monitoring the High Catchment where 10 species were recorded (Table 14.10). It is likely that a more comprehensive survey could record further species. The nature of a limited survey such as this is that only about 60-70% of the species present will be recorded. In addition there will be fluctuations in both numbers and species during the course of the seasons.

For the Lower and Middle River, essentially all areas below the Thathe Vondo Dam, birds associated with woodland and forest should be used as indicators. The list in Appendix 9 should provide a basis for such a measure, but it is likely that it will be added to continuously because of the transitory nature of the avifauna in such a fragmented habitat. The monitoring should take place in all the remaining fragments of forest/dense woodland. The majority of the surviving fragments are probably too small to make any meaningful measure by themselves.

TABLE 14.10. RECORDED INDICATOR SPECIES FOR HIGH CATCHMENT

Buzzard, forest
Lourie, knysna
Cuckoo, emerald
Woodpecker, olive
Robin, chorister
Robin, starred
Flycatcher, dusky
Batis, cape
Wagtail, iongtailed
Shrike, olive bush

Any diminution of the number of species in the assemblage would be taken to mean a declining woodland habitat, so would any increase in the number of pure woodland species as against those which are associated with both woodland and forest. Of particular concern would be a rise in the number of species associated with grassland as this would indicate a loss of even the woodland.

14.5 RECOMMENDATIONS

A detailed study of the Mutshindudi riparian zone should be made to determine the number of pairs of Longtailed Wagtails along its length and the approximate distances between sightings. This should be done more than once in a season to establish a base line.

Given the already fragmented nature of the remnant forest this should not be done by point surveys, but by surveying the whole length of the river on foot. This would provide a yardstick against which future changes in population density could be measured as well as differences in densities, and thus habitat integrity, along the river at present.

This survey would also record the distribution and abundance of the African Black duck for similar purposes

It is recommended that the list of indicator bird species, and any additional indicator species recorded during such a survey, be used to monitor changes to the integrity of the Upper Catchment

The existing forest remnants on the lower river need to be preserved from clearance as an immediate priority

A system of increasing the existing forest and encouraging regeneration by preventing clearance of the river bank for 1 5 – 20 metres needs to be formulated and implemented (see below)

Where blue-gum and pine plantations have been planted right up to the bank of the Mutshindudi and its tributaries, the plantation trees should be ring-barked and killed for up to 20 metres back from the river bank. However, they should not be felled as this will lead to increased erosion and disturbance of the river. Rather the dead trees should be left standing and the natural succession of the forest should be allowed take place

This practice should also be followed in the plantations around the dam

The present rates of abstraction need to be quantified and regulated so that in the words of the Department of Water Affairs, "There should be some for all, not all for some

The human and environmental reserves should be calculated so that proper planning can be done on how to utilise and conserve the river

SUGGESTED OUTLINE OF A SCHEME TO PRESERVE AND EXTEND THE RIPARIAN FOREST OF THE MUTSHINDUDI RIVER

This outline owes much to the authors observation of a scheme in Belize in central America to conserve and extend the gallery forest on the Belize River.

In order to preserve and extend the gallery forest it is necessary to persuade communities and individuals, that it is in their interest to do so. In order to do this an incentive scheme needs to be devised that is a sufficiently strong inducement without being overly expensive.

In Belize the problem was now to preserve the habitat of the black howler monkey, an obligate riverine gallery forest species and found only in Belize and northern Honduras. The monkev is also strictly arboreal.

In Belize where individuals own land rather than communities, this was achieved by presenting each land owner who joined the conservancy a certificate from the World Wide Fund for Nature (as it then was, signed by the president of the fund, Prince Philip of Britain). I can testify that such certificates were proudly displayed in even the poorest houses and they acquired a high status value. In only a matter of a few years every farmer bordering the river had been signed up in this way.

In order to acquire the certificate the farmer had to agree to conserve his or her stretch of bank, to minimise erosion caused by cattle at drinking points, and to protect corridors of trees that contained food plants of the howler monkey along the fence lines of their fields.

The effects on the monkey population were dramatic with the numbers rapidly doubling and then doubling again. For the farmers erosion quickly ceased to be a major concern and the water quality in the river, which they used for drinking and other domestic purposes, rapidly improved.

If a similar scheme were to be tried in the Mutshindudi basin, the social dynamics would require that communities rather than individuals are signed up. It would also be essential that the forestry companies and Sapekoe agree to join the scheme and should be persuaded to set the example.

South Africa is a far more monetised economy than Belize, and a financial inducement could also be considered, perhaps sponsored by the forestry companies and Sapekoe, Such as a donation toward a community development project in the winning communities or villages.

This could implemented by:

1. Forming a conservancy along the length of the Mutshindudi in consultation with the TLC and the tribal authorities. A certificate signed by the Premier of the province or the State President would be given to all those who agreed to join the conservancy and abide by the recommended practices.

2. Presenting an annual award for the best kept section of river bank to the village which maintained the forest best on their section.

3. Given the already degraded nature of much of the gallery vegetation, another award could be presented for the most improved section of river bank.

The awards could be in two forms; a floating trophy and a financial contribution to a community development project. It would need to be awarded by at least an MEC, possibly for Environmental Affairs, Water Affairs or Agriculture.

The scheme would need to run in conjunction with an environmental awareness programme that would be able to demonstrate the positive effects of the scheme on the river system.

Preserving the river bank should not be seen as inimical to agriculture, but rather as a way of preventing erosion and run off, and so preserving the land. There is no need, for instance, why access to the river should be denied to the river for the watering of livestock. Such access could be managed at certain agreed points and the bank at those points could be fenced and sculpted so as to minimise damage.

However such a scheme were to be designed and implemented, it is essential that the communities, and not just the leaders, are involved in all stages of the process, from design to implementation. This can best be achieved by using the techniques of participatory rural appraisal.

Unless this is done the scheme would in all probability not be accepted, and would be seen as just another imposition from outside by people who do not know or understand the life and problems faced by rural communities.

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ADDENDUM 1

The Olive Woodpecker – *Mesopicos griseocephalus*

The Olive Woodpecker is an afro-tropical endemic species and in South Africa is confined almost exclusively to the afro-montane forest zone. It is occasionally found in coastal forests in Kwazulu-Natal. This distribution tied to afro-montane shows a clinal range, ranging from sea-level in the Cape as it moves northwards it is recorded at increasing altitudes. In the provinces that made up the former Transvaal, and therefor the Northern Province, it is only found above 1 000 m.

Olive woodpeckers can be fairly common and Tarboton recorded a density of 1 pair per 4.5 ha of forest in the Mpumalanga and it is the only woodpecker found in afro-montane forests. Of particular importance is its absence from plantations of alien monocultures.

Although it is not listed in the Red Data Book (Brooke, 1948) the distribution of a species with such specific habitat requirements should be monitored. While it may not be threatened over the whole of it range, it may become threatened locally as a result of the spread of forestry plantations in montane areas.

Although not scarce, it is easily missed as it is a secretive bird frequenting high branches on large trees in the forests of the Northern Province. However, it has a distinctive call which assists in identification in the dense montane forests in the Northern Province, and in the study area of the Mutshindudi.

The specific requirements of the species makes it a good indicator species for the high catchment area of the Mutshindudi River and for the whole of the Zoutpansberg range. However, it must be borne in mind that if it is not calling it is easily overlooked, and any survey intending to use it as a monitor of the integrity of the montane forest, will need to be detailed and comprehensive.

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CHAPTER 15

GENERAL DISCUSSION AND RECOMMENDATIONS

The projects which formed part of this study substantiated the general perception that aquatic systems in the Northern Province (former homeland regions) are rapidly deteriorating due to the pressures of a growing human population. High dependence on natural resources due to a very low per capita income, limited environmental awareness and a general lack of infrastructure and of rational planning for sustainable utilization worsen the situation.

The socio-economic study showed that the per capita income is below R 500 a month with half of this coming from state pensions. The education level is very low and children have to walk long distances to the nearest school. Infra-structure is underdeveloped with roads in a bad state, electricity and telephone services in short supply, inadequate health services, no proper sanitation system, no refuse removal system or a functional recycling process.

Water provision is particularly problematic. Although most inhabitants have access to public taps, water provision is unreliable and inadequate. Women spend long hours waiting for water and often have to carry water over long distances. For these reasons water is often utilized directly from the river for bathing, laundry and even for drinking. It is therefore not surprising that the incidence of schistosomiasis (bilhartzia) is high.

The community in the Mutshindudi River catchment, particularly women, generally have a very low self esteem with almost no decision making skills and a total lack of genuine community involvement for the making of their own destiny.

In the former Venda homeland, the provision of water was used as a political tool with the result that the existing water reticulation network is totally inadequate and does not nearly meet the stipulated RDP requirements. There is a lack of understanding of water provision and therefore no broad participation in the management process.

Due to the high runoff and absence of large industries in the catchment, the water of the Mutshindudi River system is chemically unpolluted. However, due to overgrazing and other disturbances, very high concentrations of inorganic suspended solids occur from time to time. The water is not suitable for human consumption due to faecal contamination, particularly after rains. Despite this, and a pattern of unsafe use of water, the incidence of water-borne diseases is relatively low.

Most of the vegetation of the catchment is secondary, and is highly disturbed by human activities or is occupied by replacement communities such as afforestation, crops and orchards. Noxious weeds are common and are spreading fast. Riparian vegetation is least disturbed in the upper catchment and in the Phipidi Nature Reserve. Pristine vegetation occurs mainly in the upper catchment and along mountain slopes of the lower catchment. Lower down only isolated patches of riverine forest remains

Riparian plants are commonly utilized, mainly for firewood, fence construction, the manufacture of furniture, for medicinal purposes and for food. Inhabitants below 25 years of age have little or no knowledge of indigenous plants indicating that interest in or concern for this resource is decreasing. However, community members expressed concern about over-utilization indicating receptiveness for environmental education.

Twenty seven fish species occur in the Mutshindudi River system. None of these are endemic and only one species, *Opsaridium peringueyi*, is listed in the South African Red Data Book on fishes. Despite the deterioration of the catchment, this species is still common in places, and the Mutshindudi River system is therefore an important sanctuary for this species that is generally declining elsewhere.

The study of niche differentiation in rheophilic fish species showed that food habits overlap but that niches are differentiated by differences in anatomical and histological adaptations and time of feeding. This is supported by calculated indices of food similarity. More research is required to

link the presence or absence of fish to environmental factors or human induced changes.

An index of biotic integrity based on presence and abundance of eleven rheophilic fish species is proposed. Based on the index the middle and lower reaches of the Mutshindudi River is severely degraded, probably mainly due to siltation, increased turbidity and disturbance or destruction of marginal habitats as a result of overgrazing, cultivation, removal of riparian vegetation and physical disturbance of river banks.

The study showed that fish is a popular food item in the catchment with 80% of respondents indicating that fish is eaten at least once a week. Twenty six percent of respondents eat fish from the river. Eighteen fish species are harvested, mostly with fishing lines but also occasionally with small seine or gill nets and with traps. The annual harvest from the system, excluding the impoundments, is estimated at 2500 kg. There are indications of over-exploitation of some species. This is substantiated by the relatively low catch per unit effort (55g per hour per fisher).

A total of 125 bird species were recorded along the Mutshindudi River, 110 of which can be tied to a specific habitat. The highest species diversity was found in the relatively undisturbed upper catchment. The Longtail Wagtail was found to be the most suitable indicator species of riparian disturbance. Other species such as the Emerald Cuckoo, Dusky Flycatcher and Cape Batis are also useful indicator species but these have apparently already disappeared from the area below the Phipidi Falls.

Agriculture is the main economic activity in the Mutshindudi River catchment. The most common agricultural activities are traditional cattle farming, irrigated estates and schemes, rain-fed orchards and fields and irrigated informal gardens. Informal gardens are expanding due to unemployment in the region. A total of 2030 ha are irrigated from the system and a further 440 ha in the catchment is irrigated with water transferred from the Mutale River system. The agricultural water demand from the system is estimated as 21.52 million kl/annum. An estimated 8953 small and 3030 large stock in the catchment use 88960 kl of water per annum.

The former Venda is an extremely rich area as far as the cultural use of water is concerned and includes the water oracle, practice of u phasa, sprinkling of water, etc. In addition, pools feature in indigenous mythology and there are more abstract references to the role of water. Ceremonies to ensure a normal rainy season are also still common. These cultural data could be used in a contemporary context of rural development as educational data aimed at raising awareness on the importance of water resources and related environmental issues.

The study illustrated the importance of involving members of local communities in multidisciplinary studies of this nature. This approach created interaction, not only between disciplines, but also between members of the research team and students (who are from the local community) and thus between the research team and the community. As a result findings could be presented in a more comprehensive manner, and the recommendations are probably more appropriate. Development of local expertise and the involvement of community members in research helps to foster a scientific, problem solving culture that is urgently needed in underdeveloped rural regions.

A management plan for water resource utilization in underdeveloped regions of the Northern Province should be based on the knowledge that the environment is already seriously degraded and that it is rapidly losing its capacity to sustain further utilization for subsistence. The population is not well educated, is unempowered, has a low per capita income and is heavily dependent on natural resources. Infra-structure, including the water reticulation network, are poorly developed and inadequate. There is an urgent need to involve communities in decision making about the improvement of infrastructure and the creation of jobs.

Any approach that denies these factors cannot be successful and it is recommended that three basic aspects be addressed simultaneously namely environmental awareness, community empowerment and conservation of the environment.

Environmental awareness

- Adult literacy classes aimed at creating a true community centered approach should be introduced to educate impoverished people and to improve the efficiency of environmental education programmes. Students at the University of the North and at the University of Venda for Science and Technology should be involved in such programmes.

- Health education programmes should be enhanced to reduce the incidence of water-borne diseases, particularly bilharzia.

- Water provision programmes should be socially sensitive, clear and open and should not be used as political tools to disempower certain villages. Emerging structures such as water committees, development forums and civics could be utilized to create awareness and to disseminate knowledge about reticulation networks.

- Communities should be persuaded to conserve and extend the natural vegetation, particularly in the riparian zones. This could be done by persuading communities and individuals that it is in their interest to do so. One way to achieve this is to form a conservancy along the length of the river in consultation with the TLC and tribal authorities. A certificate signed by the Premier of the province or the State President should be given to all those who agreed to join and abide by the recommended practices. An award could be presented for the most improved section of the river bank. The scheme should be run in conjunction with an environmental awareness programme that would be able to demonstrate the positive effects of conservation.

- The cultural importance of water needs to be further investigated and be used in a contemporary context of rural development as educational data in programmes or campaigns aimed at raising the awareness of the importance of water resources and related environmental issues. Such data could also feature in the national curriculum because of the latter's emphasis in the indigenization of the teaching content.

- A community based action or participatory approach should be used in future research on water related problem in developing regions.

- Existing or planned environmental education centres should be encouraged to include water awareness programmes in their curicula.

Community empowerment

- Income generating activities which are market oriented and sustainable should be stimulated as part of the local development objectives in these regions.

- Infra-structure in these regions should be improved as part of the Reconstruction and Development Programme. Communities should be assisted to inform government of their needs and to participate in the whole process. Electrification should be speeded up to reduce the dependency on indigenous wood for energy.

- More emphasis must be placed on genuine reforms and new approaches for community development in these regions. The apparent apathy of rural communities could be rectified if government agencies, local authorities and RDP officials based their actions and programmes on the premise that improvement in the quality of life is a precondition to productivity, and not a consequence. Only when people have the means to provide for their basic needs, will they have the energy and dedication to utilise their natural resources in a sustainable manner.

- Broad participation and broad educational campaign processes must be part of the planning and implementation of any water delivery network in these regions. The reticulation systems must of necessity be well understood by those benefiting from it, and service rendering rather than political power struggle should be the main objective.

- As part of the RDP there should be a well planned government policy to address the imbalances between the urban and rural delivery modes.

- Water delivery and service must be a win-win process between government/TLC and communities. Water suppliers and beneficiaries must share their responsibilities to ensure a better quality of life.

- Water management plans should be aware of the importance of fish is a source of protein, even from relatively small streams. Existing legislation prohibiting the use of gill or seine nets in rivers should be enforced to prevent over-utilisation. Commercial utilisation of impoundments should be encouraged. Quotas for commercial netting should be allocated to rural communities living in the vicinity of impoundments. The feasibility of aquaculture as a source of protein and income should also be investigated. Staff and students of local universities should be involved in these developments.

- A detailed investigation of all forms of water use needs to be done and regularly monitored to ensure equitable water distribution, conservation of the environment and improved efficiency of water use.

- Local universities and students should become involved in the activities of Water Committees, Catchment Management Authorities, and Water Users Associations.

Environmental Conservation

- Local leaders as well as members of communities should be involved in all stages of environmental conservation programmes through participatory rural appraisal.

- The ecological integrity of rivers in underdeveloped rural regions of the Northern province should be regularly monitored as part of the National Biomonitoring Programme. The numbers and distribution of Longtailed Wagtails and African Black Duck along rivers should be monitored as part of this programme. Students from local communities should become involved in these programmes.

- The centre of expertise on water established through this project should be maintained and encouraged to remain actively involved in research on water.

- More research should be done to determine the direct and indirect effects of man-induced changes on rivers and other aquatic ecosystems. This information should be used in environmental awareness programmes.

- Legislation should be introduced to protect remaining indigenous forests along rivers. No removal of indigenous vegetation should be allowed within a predetermined distance from river banks.

- As part of the work for water programme, all exotic trees in the riparian zones should be killed by ring barking. The trees should not be felled as this will lead to erosion and disturbance of marginal habitats.

- The occurrence and spread of exotic invaders should be monitored. Inhabitants should be made aware of the negative impacts of invaders and be encouraged to remove them.

APPENDIX 1

SPECIES CHECKLIST OF PLANTS

The list contains species recorded during fieldwork and the ones found in the plots. Cultivated species were usually not included. The names accepted by Arnold and De Wet (1993) and more recently by Retief and Herman (1997) are given. An * denotes that the species is an exotic; • the species is a weed according to Wells, Balsinhas, Joffe, Engelbrecht, Harding and Stirton (1986) and Henderson (1995); and # the species is endangered as listed by Hilton-Taylor (1996). The help of Dr. H. Glen and Mrs. R. Glen is thankfully acknowledged.

Abrus laevigatus E.Mey.
Abrus precatorius L. •
Abutilon sonneratianum (Cav.) Sweet •
Acacia ataxacantha DC. •
Acacia karroo Hayne•
Acacia nigrescens Oliv. •
Acacia polyacantha Willd.
Acacia schweinfurthii Brenan & Exell •
Acacia sieberiana DC. •
Acacia welwitschii Oliv. subsp. *delagoensis* (Harms)Ross & Brenan •
Acalypha angustata Sond. var. *glabra* Sond.
Acalypha punctata Meisn.
Acanthospermum hispidum DC.*
Achyranthes aspera L.*
Acroceras macrum Stapf
Adansonia digitata L.
Adenia digitata (Harv.)Engl. •
Adenia gummifera (Harv.)Harms
Aeollanthus suaveolens Mart ex K.Spreng.
Aerangis mystacidii (Reichb.f.)Schltr.
Aerangis somalensis (Schltr.)Schltr.
Afzelia quanzensis Welw.
Agapanthus inapertus Beauv. subsp. *pendulus* (L.Bolus)F.M.Leighton
Ageratum conyzoides L.*
Agrostis sp
Albizia adianthifolia (Schumach.)W.F.Wight
Albizia amara (Roxb.)Boiv.
Albizia versicolor Welw. ex Oliv.
Albuca angolensis Welw.
Albuca sp.
Alectra orobanchoides Benth. •
Alectra sessiliflora (Vahl)Kuntze
Alepidea sp.
Allophyllus africanus Beauv.
Aloe vogtsii Reynolds #
Aloe vossii Reynolds #
Aloe zebrina Bak.
Alternanthera sessilis (L.)DC.*
Andropogon eucomus Nees •
Andropogon schirensis A.Rich.
Andropogon sp.
Annona senegalensis Pers.

Anthocleista grandiflora Gilg
Anthospermum herbaceum L.f.
Anthospermum hispidulum E.Mey. ex Sond.
Anthospermum sp.
Antidesma venosum E.Mey. ex Tul.
Aphloia theiformis (Vahl)Benn.
Apodytes dimidiata E.Mey. ex Arn.
Argyrolobium sp..
Aristea angolensis Bak.
Aristea woodii N.E.Br.
Aristida congesta Roem. & Schult. subsp. *barbicollis* (Trin. & Rupr.) De Winter •
Aristida sp.
Aristida transvaalensis Henr.
Artabotrys monteiroae Oliv.
Asclepias physocarpa (E.Mey.)Schltr.
Asparagus africanus Lam. (= Protasparagus africanus)
Asparagus falcatus L.(= Protasparagus falcatus)
Asparagus rigidus Jessop (= Protasparagus rigidus)
Asparagus setaceus Kunth (= Protasparagus setaceus)
Asparagus sp.
Asplenium aethiopicum (Burm.f.)Becherer
Asplenium splendens Kunze var. *splendens*
Asystasia gangetica (L.)T.Anders.
Asystasia sp.

Barleria obtusa Nees•
Barleria sp.
Bauhinia galpinii N.E.Br. •
Batrachospermum sp. (Rhodophyceae)
Becium obovatum (E.Mey ex Benth.) N.E.Br.
Behnia reticulata (Thunb.)Didr.
Berchemia discolor (Klotzsch)Hemsl.
Berchemia zeyheri (Sond.)Grubov
Berkheya setifera DC.
Berkheya sp.
Bersama transvaalensis Turrill
Bidens bipinnata L.*
Bidens pilosa L.*
Blechnum attenuatum Swartz)Mett.
Blechnum sp.
Bothriochloa insculpta (A.Rich.)A.Camus•
Brachiaria deflexa (Schumach.)C.E.Hubb. ex Robyns

Brachiaria eruciformis (J.E.Sm.)Griseb.•
Brachiaria nigropedata (Fical. & Hiern) Stapf•
Brachiaria serrata (Thunb.)Stapf•
Brachylaena transvaalensis Phill. & Schweich (= B.discolor subsp. transvaalensis)
Breonadia salicina (Vahl)Hepper & Wood
Bridelia cathartica Bertol.f.
Bridelia micrantha (Hochst.)Baill.
Bridelia mollis Hutch.
Bulbostylis burchellii (Fical & Hiern)C.B.Cl.•
Bulbostylis hispidula (Vahl)R.Haines
Burkea africana Hook.•

Caesalpinia decapetala (Roth)Alston*
Calpurnia aurea (Ait.)Benth.
Canavalia virosa (Roxb.)Wight & Arn.
Canthium ciliatum (Klotzsch)Kuntze
Canthium inerme (L.f.)Kuntze
Canthium cf. *kuntzeanum*
Canthium mundianum Cham. & Schlecht.
Canthium spinosum (Klotzsch)Kuntze
Cardiospermum halicacabum L.*
Carex spicato-paniculata C.B.Cl.
Carica papaya L.*
Carissa bispinosa (L.)Desf. ex Brenan subsp. *spinosa*•
Carissa bispinosa (L.)Desf. ex Brenan subsp. *zambesiensis* Kupicha•
Carissa edulis Vahl.
Cassia abbreviata Oliv.
Cassine aethiopica Thunb.
Cassine peragua L.
Cassytha filiformis L.
Catharanthus roseus (L.)G.Don*
Celtis africana Burm.f.•
Centella asiatica (L.)Urb.
Centella sp.
Cephalanthus natalensis Oliv.
Cereus jamacaru DC.*
Ceropegia racemosa N.E.Br.
Chaetachme aristata Planch.
Chamaecrista sp.
Chelianthes viridis (Forssk.) Swartz var. *glauca* (Sim)Schelpe & N.C.Anthony
Cheilanthes viridis (Forssk.) Swartz var. *macrophylla* (Kunze) Schelpe & N.C.Anthony•
Chionanthus foveolatus (E.Mey.)Stearn subsp. *foveolatus*
Chloris virgata Swartz•
Choristylis rhamnoides Harv.
Chromolaena odorata (L.)R.M.King & H.Robinson*
Chrysanthemoides monilifera (L.)T.Norl. subsp. *canescens* (DC.)T.Norl.•
Chironia sp.
Chrysanthemum segetum L.*
Cissampelos torulosa E.Mey. ex Harv.
Citrus lemon (L.)Burm.f.*
Clausena anisata (Willd.)Hook.f. ex Benth.•
Clematis brachiata Thunb.•
Clerodendrum glabrum E.Mey.
Cliffortia nitidula (Engl.)R.E. & Th. Fries Jr.
Clutia abyssinica Jaub. & Spach
Clutia monticola S.Moore
Clutia pulchella L. var. *obtusata* Sond.
Clutia pulchella L. cf. var. *rotundata*
Clutia pulchella L. var. *pulchella*
Cocculus hirsutus (L.)Diels
Corchorus kirkii N.E.Br.
Coddia rudis (E.Mey. ex Harv.)Verdc.•
Colocasia esculenta (L.) Schott
Combretum collinum Fresen. subsp. *gazense* (Swynn. & Bak.f.)Okafor
Combretum edwardsii Exell
Combretum erythrophyllum (Burch.)Sond.
Combretum hereroense Schinz
Combretum imberbe Wawra•
Combretum kraussii Hochst.
Combretum microphyllum Klotzsch
Combretum molle R.Br. ex G.Don
Combretum zeyheri Sond.•
Commelina africana L.•
Commelina sp.
Conostomium natalense (Hochst.)Brem. var. *glabrum* Brem.•
Convolvulus arvensis L.*
Conyza cf. *ageratoides* *
Conyza bonariensis (L.)Cronq.*

Conyza sp.
Crassula capitella Thunb.
Crinum bulbispermum (Burm.f.)Milne-Redh. & Schweick.
Crinum macowanii Bak.
Croton megalobotrys Müll.Arg.
Croton sylvaticus Hochst.
Cryptocaryra liebertiana Engl.
Cussonia spicata Thunb.
Cyanotis speciosa (L.f.)Hassk. •
Cyathea dregei Kunze
Cymbopogon excavatus (Hochst.)Stapf ex Burtt Davy •
Cynodon dactylon (L.)Pers.
Cyperus albostriatus Schrad.
Cyperus articulatus *L.*
Cyperus digitatus Roxb. subsp. *auricomus*(Sieber ex Spreng.) Kuekenth
Cyperus esculentus L.
Cyperus immensus C.B.Cl. •
Cyperus latifolius L. •
Cyperus leptocladus Kunth
Cyperus sexangularis Nees •
Cyperus texatilis Thunb. •
Cyperus sp.
Cyperus rubicundus Vahl
Cyphia elata Harv.
Cyphostemma sp.
Cytorchis arcuata (Lindl.)Schltr.
Cytorchis praetermissa Summerh.

Dactylis glomerata L.*
Dalbergia melanoxylon Guill. & Perr. •
Dalbergia nitidula Bak.
Dalechampia sp.
Datura stramonium L. •
Dicerocaryum eriocarpum (Decne.)Abels
Dichrostachys cinerea (L.)Wight & Arn •
Dicliptera clinopodia Nees
Dicliptera sp.
Dietes iridioides (L.)Sweet ex Klatt
Digitaria eriantha Steud. •
Digitaria sp.
Diheteropogon amplectens (Nees)Clayton
Dioscorea cotinifolia Kunth
Dioscorea sylvatica (Kunth)Eckl.
Diospyros lycioides Desf. subsp. *guerkei* (Kuntze)De Winter
Diospyros lycioides Desf. subsp. *lycioides*
Diospyros lycioides Desf. subsp. *sericea* (Bernh.)De Winter •
Diospyros mespiliformes Hochst. ex A.DC.
Diospyros whyteana (Hiern)F.White
Dissotis canescens (E.Mey. ex R.A.Grah.)Hook.f.
Dissotis princeps (Kunth)Triana
Dombeya rotundifolia (Hochst.)Planch.
Dovyalis zeyheri (Sond.)Warb.
Drimiopsis sp.
Drosera sp.
Dryopteris cf. *dentata*
Dryopteris sp

Ehretia amoena Klotzsch
Ehretia obtusifolia Hochst. ex DC.
Ehretia rigida (Thunb.)Druce •
Ekebergia capensis Sparrm.
Ekebergia pterophylla (C.DC.)Hofmeyr
Englerodaphne pilosa Burtt Davy
Englerodaphne sp.
Englerophytum magalismontanum (Sond.)T.D.Penn.
Englerophytum natalense (Sond.) T.D.Penn.
Eragrostis acreae De Winter
Eragrostis curvula (Schrad.)Nees •
Eragrostis racemosa (Thunb.)Steud. •
Eragrostis sp.
Eragrostis superba Peyr. •
Eriochloa meyeriana (Nees)Pilg.
Eriosema salignum E.Mey.
Eriosema sp.
Eriospermum sp.
Erythrina humeana Spreng.
Erythrina lysistemon Hutch.
Erythroxylum emarginatum Thonn.
Eucalyptus grandis W.Hill ex Maiden*
Eucalyptus spp.
Euclea crispa (Thunb.)Guerke
Euclea divinorum Hiern
Euclea natalensis A.DC. var. *angustifolia* F.White
Euclea schimperi (A.DC.)Dandy
Eugenia natalitia Sond.

Eugenia woodii Drümmer
Eucomis autumnalis (Mill.)Chitt.
Eulophia ensata Lindl.
Euphorbia ingens E.Mey. ex Boiss.•
Euryops laxus (Harv.)Burtt Davy
Evolovulus alsinoides (L.)L.

Fadogia homblei De Wild. (= F. monticola)
Fadogia tetraquetra Krause•
Falckia sp.
Faurea rochetiana (A.Rich.)Pic.Serm.
Faurea saligna Harv.
Ficus capreifolia Del.
Ficus natalensis Hochst.
Ficus sp.
Ficus sur Forssk.•
Ficus sycomorus L.
Ficus thonningii Blume
Flueggea virosa (Roxb. ex Willd.)Voigt (= Securinega virosa)
Freesia grandiflora (Bak.)Klatt (=Anomatheca grandiflora; Lapeirousia grandiflora)

Galopina circaeoides Thunb.
Gerbera jamesonii Adam.
Gerbera viridifolia (DC.)Sch.Bip. subsp. *viridifolia*
Geranium *sp.*

Genlisea *sp.*

Gladiolus dalenii Van Geel
Gleichenia sp.
Gleichenia umbraculifera (Kunze)T.Moore
Gloriosa superba L.
Gomphrena celosioides Mart.*
Grewia caffra Meisn.
Grewia flavescens Juss.•
Grewia sp.
Gunnera sp.
Halleria lucida L.•
Hebenstretia sp.
Helichrysum adenocarpum DC. subsp. *adenocarpum*
Helichrysum cf. *aureonitens* Sch.Bip.•
Helichrysum cephaloideum DC.
Helichrysum crysargyrum Moeser
Helichrysum cf. *mimetes* S.Moore
Helichrysum kraussii Sch.Bip.•
Helichrysum lepidissimum S.Moore
Helichrysum nudifolium (L.)Less.
Helichrysum pallidum DC.
Helichrysum splendidum (Thunb.)Less.
Helichrysum sp.
Helinus integrifolius (Lam.)Kuntze
Hemarthria altissima (Poir.)Stapf C.E.Hubb.
Hemizygia canescens (Guerke)Ashby•
Hemizygia obermeyerae Ashby
Hemizygia petiolata Ashby
Hemizygia petrensis (Hiern)Ashby
Hemizygia sp.
Hermannia sp.
Heteromorpha trifoliata (Wendl.)Eckl. & Zeyh.
Heteropogon contortus (L.)Roem. & Schult.•
Heteropyxis natalensis Harv.
Hexalobus monopetalus (A.Rich.)Engl. & Diels
Hibiscus diversifolius Jacq. subsp. *diversifolius*
Hibiscus engleri K.Schum.
Hibiscus micranthus L.f.
Hibiscus meeusei Exell•
Hibiscus sp.
Hibiscus trionum L.•
Homalium dentatum (Harv.)Warb.
Hoslundia opposita Vahl
Hydrocotyle sp.
Hymenocardia ulmoides Oliv.
Hyparrhenia hirta (L.)Stapf
Hyparrhenia tamba (Steud.)Stapf
Hyperacanthus amoenus (Sims)Bridson (=Gardenia amoena)
Hypericum lalandii Choisy
Hypericum revolutum Vahl•
Hyperthelia dissoluta (Nees ex Steud.)Clayton•
Hypoestes aristata (Vahl)Soland. ex Roem & Schult.
Hypoestes forskaolii (Vahl)R.Br (=H. verticillaris)
Hypoxis filiformis Bak.
Hypoxis sp.

Ilex mitis (L.)Radlk.
Impatiens hochstetteri Warb. subsp. *hochstetteri*
Imperata cylindrica (L.)Raeuschel•

Indigofera sanguinea N.E.Br. •
Indigofera sp.
Indigofera swaziensis H.Bol.
Ipomoea crassipes Hook. •
Ipomoea sp.
Ischaemum fasciculatum Brongn. •
Isoglossa woodii C.B.Cl.
Isolepis fluitans (L.)R.Br.(= Scirpus fluitans)•

Jasminum breviflorum Harv. ex C.H.Wr.
Jasminum fluminense Vell.
Jasminum multipartitum Hochst. •
Jasminum sp.
Juncus lomatophyllus Spreng.
Juncus oxycarpus E.Mey. ex Kunth
Justicia betonica L.
Justicia sp.

Kalanchoe crundallii Verdoorn #
Kalanchoe rotundifolia (Haw.)Haw. •
Keetia gueinzii (Sond.)Bridson
Kirkia acuminata Oliv.
Knowltonia transvaalensis Szyszyl.
Kohautia sp.
Kotschya thymodora (Bak.f.)Wild
Kraussia floribunda Harv.

Lagynias dryadum (S.Moore)Robyns
Landolphia kirkii T.Dyer
Lannea discolor (Sond.)Engl.
Lantana camara L.*
Lantana rugosa Thunb.
Ledebouria cf. *papillata*
Ledebouria sp.
Leersia hexandra Swartz•
Leonotis nepentifolia (L.)R.Br. •
Leptactina delagoensis K.Schum.
Leucas martinicensis (Jacq.)R.Br. •
Liparis bowkeri Harv.
Lippia javanica (Burm.f.)Spreng. •
Lobelia erinus L. •
Lonchocarpus capassa Rolfe•
Lotononis laxa Eckl. & Zeyh.
Lotononis sp.*Loudetia flavida* (Stapf)C.E.Hubb.
Loudetia simplex (Nees)C.E.Hubb. •
Lythrum sp.
Lycopodium sp.

Maesa lanceolata Forssk.
Mangifera indica L.*
Marchantia sp.
Margaritaria discoidea (Baill.)Webster
Mariscus sp.
Maytenus acuminata (L.f.)Loes
Maytenus heterophylla (Eckl. & Zeyh.)N.K.B. Robson•
Maytenus mossambicensis (Klotzsch)Blakelock var. *mossambicensis*•
Maytenus peduncularis (Sond.)Loes.
Maytenus senegalensis (Lam.)Exell•
Maytenus undata (Thunb.)Blakelock
Melia azerdarach L*
Melhania prostrata DC.
Melinus repens (Willd.)Zizka
Memecylon natalense Markg.
Mentha aquatica L.
Mimusops obovata Sond.
Mimusops zeyheri Sond.
Monanthotaxis caffra (Sond.)Verdc.
Monocymbium ceresiiforme (Nees)Stapf
Mucuna coriacea Bak. subsp. *irritans* (Burtt Davy)Verdc. •
Mundulea sericea (Willd.)A.Chev.
Musa paradisiaca More x *M. sapientum* Kuntze
Myrsine africana L. •
Mystacidium braybonae Summerh.#
Mystacidium venosum Harv. ex Rolfe

Nuxia congesta R.Br. ex Fresen.
Nuxia floribunda Benth.
Nymphoides thunbergiana (Griseb.Kuntze
Nymphaea nouchali Burm.f. var. *caerulea* (Sav.)Verdc.

Ochna arborea Burch. ex DC.
Ochna arborea Burch. ex DC. var. *arborea*
Ochna arborea Burch. ex DC. var. *oconnorii* (Phil.)Du Toit
Ochna natalitia (Meisn.)Walp. •
Ocimum canum Sims•
Ocotea kenyensis (Choiv.)Robyns #

Olax dissitiflora Oliv.
Oldenlandia herbacea (L.)Roxb. •
Olea capensis L.
Olinia emarginata Burtt Davy
Olinia rochetiana Juss.
Oplismenus hirtellus (L.)Beauv.
Opuntia ficus-indica (L.)Mill.*
Orthosiphon labiatus N.E.Br.
Osmunda regalis L.
Otiophora sp.
Oxalis depressa Eckl. & Zeyh. •
Oxalis obliquifolia Steud. ex A.Rich. •
Oxyanthus speciosus DC. subsp. *stenocarpus* (K.Schum.)Bridson
Ozoroa sp.

Pachystigma macrocalyx (Sond.)Robyns
Padaeria bojeriana (A.Rich.)Drake
Panicum coloratum L. •
Panicum deustum Thunb. •
Panicum maximum Jacq. •
Panicum natalense Hochst. •
Panicum schinzii Hack. •
Panicum sp.
Pappea capensis Eckl. & Zeyh. •
Parinari curatellifolia Planch. ex Benth.
Passerina montana Thoday•
Passiflora edulis Sims*
Pavetta kotzei Brem.
Pavetta lanceolata Eckl.
Pavetta schumanniana F.Hoffm. ex K.Schum. •
Pavonia burchellii (DC.)R.Dyer (= P. patens)
Pavonia columella Cav.
Peddiea africana Harv.
Pellaea calomelanos (Swartz)Link
Pellaea pectiniformis Bak.
Peltophorum africanum Sond.
Pentanisia angustifolia (Hochst.)Hochst.
Pentanisia sp.
Pentarrhinum insipidum E.Mey.
Peperomia blanda (Jacq.)H.B.K. var. *leptostachya* (Hook. & Arn.)Duell
Perotis patens Gand. •
Persicaria sp.
Polygala africana Chodat
Petopentia natalensis (Schtlr.)Bullock
Phaulopsis sp.
Phragmites mauritianus Kunth. •
Phyllanthus reticulatus Poir. •
Phyllanthus sp.
Phymaspermum sp.
Piliostigma thonningii (Schumach.)Milne-Redh.
Pinus patula Schlechtd. & Cham.*
Pinus taeda L.*
Pittosporum viridiflorum Sims
Plectranthus ciliatus E.Mey ex Benth.
Plectranthus fruticosus L'Hérit
Plectranthus grandidentatus Guerke
Plectranthus hereroensis Engl.
Plectranthus sp.
Pleopeltis excavata (Bory ex Willd.)Sledge
Pogonarthria squarrosa (Roem & Schult.)Pilg. •
Polygala amatymbica Eckl. & Zeyh.
Polygala uncinata E.Mey. ex Meisn.
Polystachya ottoniana Reichb.f.
Polystachya pubescens Reichb.f.
Polystachya sandersonii Harv.
Potamogeton thunbergii Cham. & Schlectd.
Pseudolachnostylis maprouneifolia Pax.
Psidium guajava L.*
Psychotria capensis (Eckl.)Vatke subsp. *capensis* var. *capensis*
Psychotria zombamontana (Kuntze)Petit
Psydrax livida (Hiern)Bridson (= Canthium huillense)
Psydrax locuples (K.Schum.)Bridson (= Canthium locuples)
Pteleopsis myrtifolia (Laws.)Engl. & Diels
Pteridium aquilinum (L.)Kuhn•
Pteris catoptera Kunze
Pteris sp.
Pterocarpus angolensis DC.
Pterocarpus rotundifolius (Sond.)Druce•
Pterocelastrus echinatus N.E.Br.
Pterolobium stellatum (Forssk.)Brenan•
Pupalia lappacea (L.)Juss.*
Pycreus polystachyos (Rottb.)Beauv.
Pycnostachys urticifolia Hook.
Quisqualis parviflora Gerr. ex Sond.

Rabdosiella calycina (Benth.)Codd
Ranunculus multifidus Forssk.•
Ranunculus sp.
Rapanea melanophloeos (L.)Mez.
Raphionacme galpinii Schltr.
Rauvolfia caffra Sond.
Rawsonia lucida Harv. & Sond.
Rhoicissus revoilii Planch.
Rhoicissus rhomboidea (E.Mey. ex Harv.)Planch.
Rhoicissus tomentosa (Lam.)Wild & Drum.•
Rhoicissus tridentata (L.f.)Wild & Drum.•
Rhus chirindensis Bak.f.
Rhus dentata Thunb.
Rhus pentheri Zahlbr.
Rhus pyroides Burch.
Rhus pyroides Burch. var. *integrifolia* (Engl.)Mofett
Rhus transvaalensis Engl.•
Rhus tumulicola S.Moore
Rhynchosia spectabilis Schinz
Rhynchosia caribaea (Jacq.)DC.
Rhynchosia longiflora Schinz
Rhynchosia totta (Thunb.)DC.
Ricinis communis L.*
Rinorea angustifolia (Thouars.)Baill.
Riocreuxia picta Schltr.
Rothmannia capensis Thunb.
Rothmannia globosa (Hochst)Keay (= Gardenia globosa)
Rubia horrida Thunb.
Rubus cuneifolius Pursh.*
Rubus rigidus J.E.Sm.•
Ruellia sp.
Rumex crispus L.*
Rumex sp.

Saccharum officinarum L.•
Sarcostemma viminale (L.)R.Br.•
Scabiosa columbaria L.
Scadoxus multiflorus (Martyn)Raf.
Schefflera umbellifera (Sond.)Baill.
Schistostephium sp.
Schoenoplectus sp.
Schoenoxiphium madagascariense Cherm.
Schrebera alata (Hochst)Welw.
Scilla natalensis Planch.•
Scirpus sp.
Sclerocarya birrea (A.Rich.)Hochst. subsp. *caffra* (Sond.)Kokwaro•
Scolopia mundii (Eckl. & Zeyh.)Warb.
Scolopia zeyheri (Nees)Harv.
Secamone alpini Schult.
Secamone filiformis (L.f.)J.H.Ross (= S.frutescens)
Secamone sp.
Selaginella kraussiana (Kunze)A.Br. ex Kuhn
Senecio barbetonicus Klatt
Senecio erubescens Ait.
Senecio inornatus DC.•
Senecio rhomboideus Harv.
Senecio ruwenzoriensis S.Moore
Senecio spp.
Senecio tamoides DC.•
Senna didymobotrya (Fresen.)Irwin & Barnaby
Senna petersiana (Bolle)Lock
Senna sp.
Sericanthe andongensis (Hiern)Robbrecht
Sericanthe andongensis (Hiern)Robbrecht var. *andongensis* (= Neorosea andongensis)
Sesamum triphyllum Welw. ex Aschers.•
Sesbania sesban (L.)Merr.
Setaria cf. *homonyma* (Steud.)Choiv.
Setaria megaphylla (Steud.)Dur. & Schinz •
Setaria sphacelata (Schumach.)Moss•
Sida cordifolia L.•
Sida dregei Burtt Davy•
Sida rhombifolia L.•
Smilax anceps Willd. (= S. kraussiana)•
Solanum elaeagnifolium Cav.*
Solanum mauritianum Scop.*
Solanum nigrum L.*
Sopubia cana Harv.
Sorghum bicolor (L.)Moench*
Sphedamnocarpus pruriens (Juss.)Szyszyl.
Sphedamnocarpus pruriens (Juss.)Szyszyl. var. *pruriens*
Sporobolus africanus (Poir.)Robyns & Tournay•
Stenoglottis fimbriata Lindl.
Stenoglottis zambesiaca Rolfe
Streptocarpus cyaneus S.Moore

Strophanthus petersianus Klotzsch
Strychnos madagascariensis Poir. •
Strychnos spinosa Lam.
Strychnos usambarensis Gilg
Stylochiton natalensis Schott
Synadenium cupulare (Boiss.)L.C.Wheeler
Syzygium cordatum Hochst.
Syzygium cordatum x *guineense*
Syzygium gerrardii (Harv. ex Hook.f.)Burtt Davy
Syzygium guineense (Willd.)DC.
Syzygium legatii Burtt Davy & Greenway

Tabernaemontana elegans Stapf
Tacazzea apiculata Oliv. •
Tagetes minuta L.*
Tarchonanthus trilobus DC.
Tarenna sp.
Tarenna zimbabwensis Bridson
Taxodium distichum (L.) Rich.*
Tecomaria capensis (Thunb.)Spach
Tenrhynea phylicifolia (DC.)Hilliard &Burtt
Tenrhynea sp.
Tephrosia rhodesica Bak.f.
Terminalia sericea Burch. ex DC. •
Tetradenia riparia (Hochst.)Codd (= Iboza riparia)
Tetraselago nelsonii (Rolfe)Hilliard & Burtt
Teucrium sp.
Thelypteris dentata (Forrsk.)E.St.John
Themeda triandra Forssk. •
Thesium sp.
Thunbergia atriplicifolia E.Mey. ex Nees•
Thunbergia sp.
Tithonia diversifolia (Hemsl.)A.Gray*
Toddalia asiatica (L.)Lam.
Todea barbara (L.)T.Moore
Trachyandra saltii (Bak.)Oberm.
Trachypogon spicatus (L.f.)Kuntze•
Tragia sp.
Tragia rupestris Sond.
Trema orientalis (L.)Blume•
Tricalysia lanceolata (Sond.)Burtt Davy
Tricalysia sp.
Trichilia emetica Vahl
Trichopteryx sp.
Tridactyle tricuspis (H.Bol.)Schltr.
Trilepisium madagascariense Thouars
Trimeria grandifolia (Hochst.)Warb.
Tristachya leucothrix Nees•
Triumfetta pilosa Roth. •
Triumfetta rhomboidea Jacq.•
Tylosema esculentum (Burch.)A.Schreib.
Tylosema fassoglense (Schweinf.)Torre & Hillc.
Typha capensis (Rohrb.)N.E.Br.

Urochloa mossambicensis (Hack.)Dandy•

Vangueria cyanecens Robyns
Vangueria infausta Burch. subsp. *infausta*
Vangueria randii S.Moore
Vepris lanceolata (Lam.)G.Don
Verbena bonariensis L.*
Vernonia colorata (Willd.)Drake
Vernonia natalensis Sch.Bip. ex Walp.
Vernonia neocorymbosa Hilliard
Vernonia poskeana Vatke & Hildebr.•
Vernonia sp.
Vitex ferruginea Schmach & Thonn. subsp. *amboniensis* (Guerke)Verdc. var. *amboniensis* (= V. amboniensis)

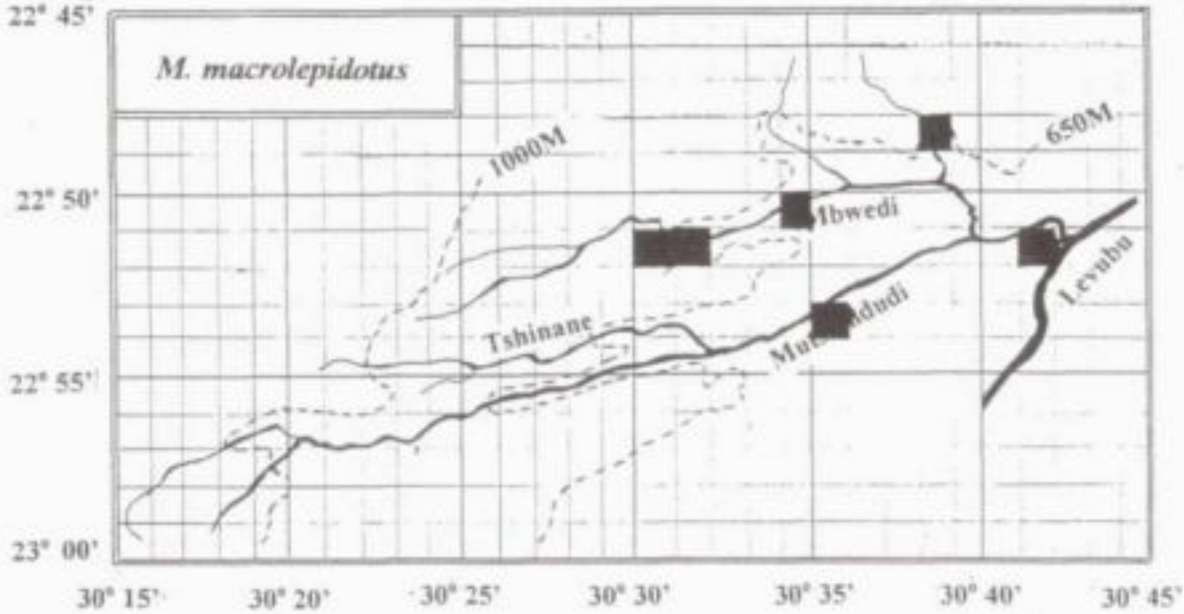
Waltheria indica L.*

Xanthium strumarium L.*
Ximenia americana L.
Ximenia caffra Sond.
Xylopia odoratissima Welw. ex Oliv.
Xylopia parviflora (A.Rich.)Benth.
Xymalos monospora (Harv.)Baill.

Zanthoxylum capense (Thunb.)Harv.
Zanthoxylum davyi (Verdoorn)Waterm.
Ziziphus mucronata Willd.
Zornia capensis Pers

APPENDIX 2

FISH DISTRIBUTION IN THE MUTSHINDUDI RIVER SYSTEM


M. macrolepidotus
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650M
Mbwedi
Levubu
Tshinane
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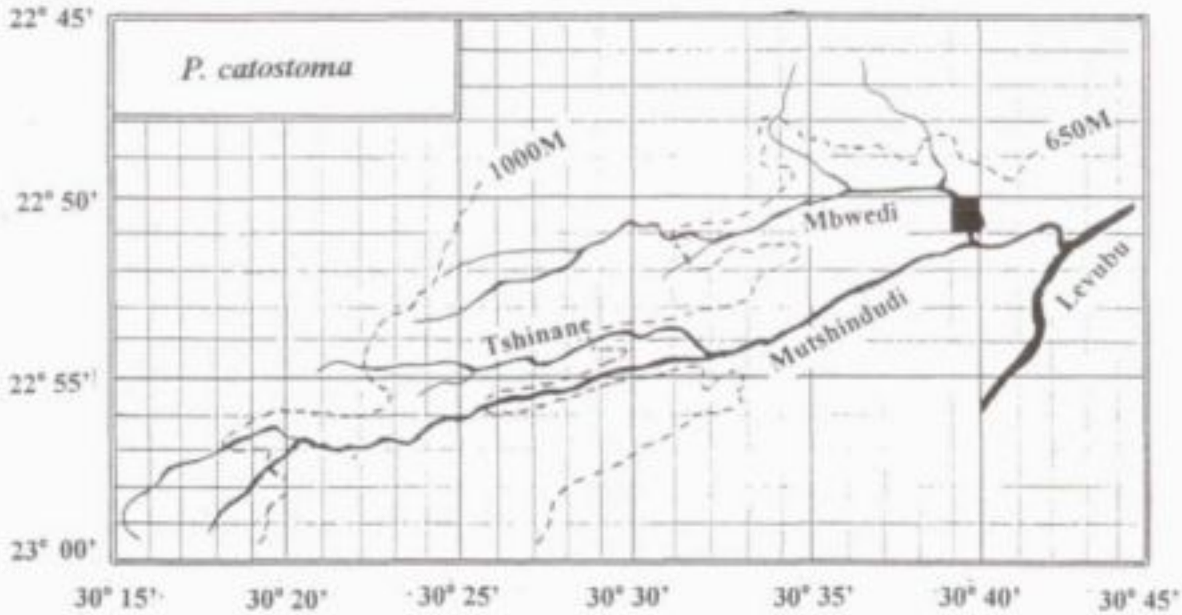
30° 45'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Mutshindudi
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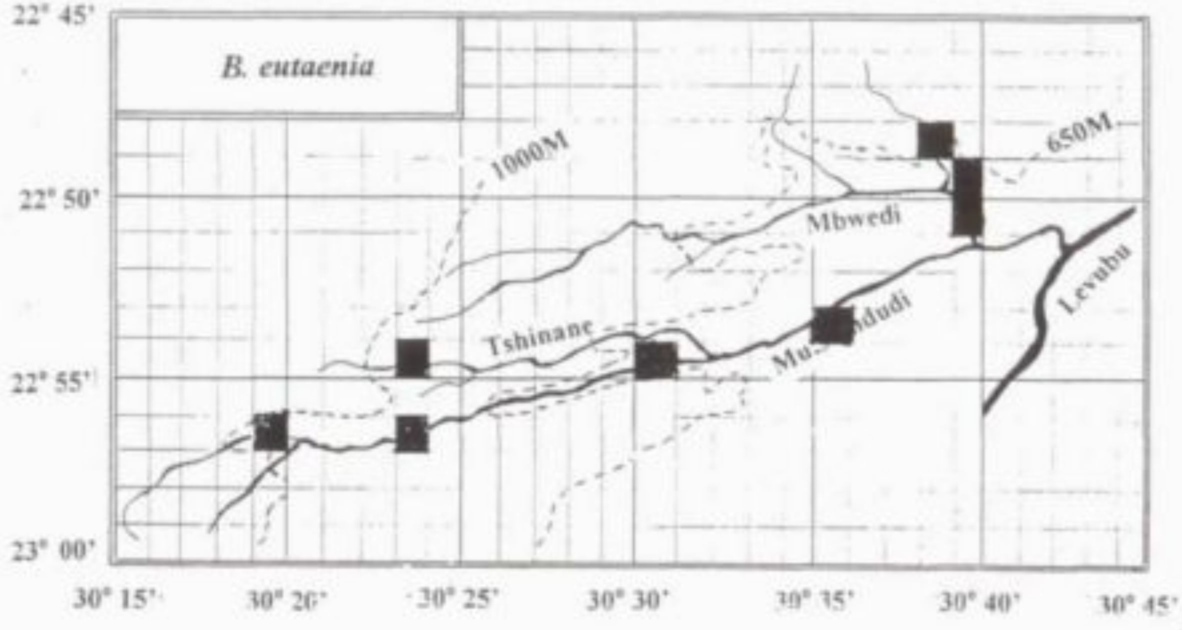
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650M
Mbwedi
Levubu
Tshinane
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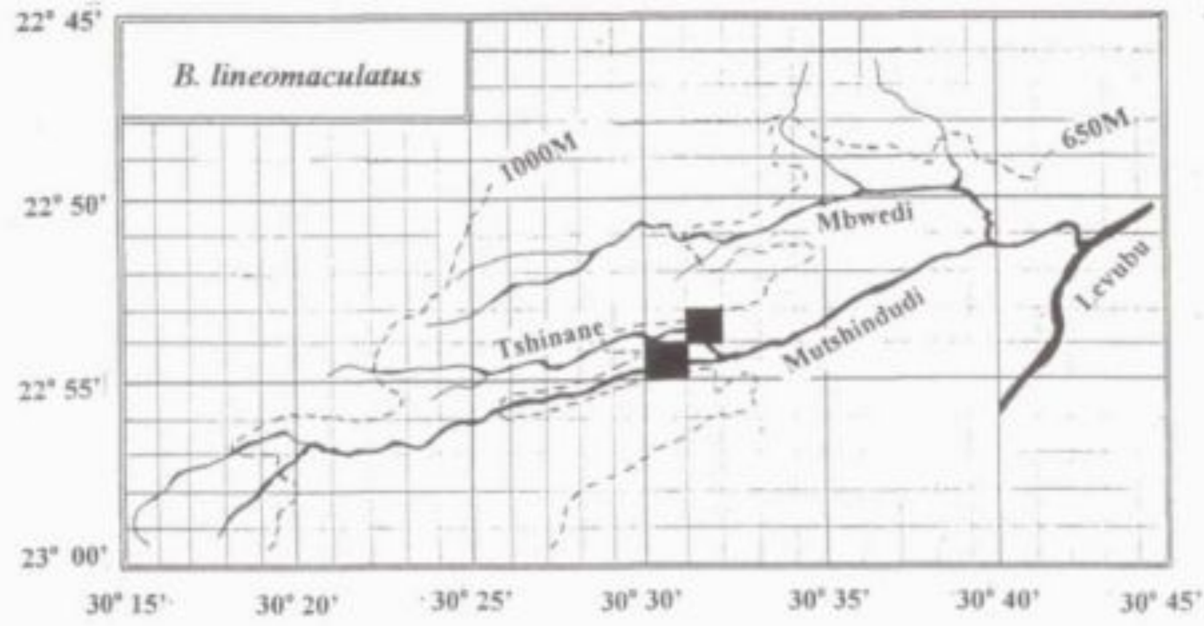
30° 45'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Levubu
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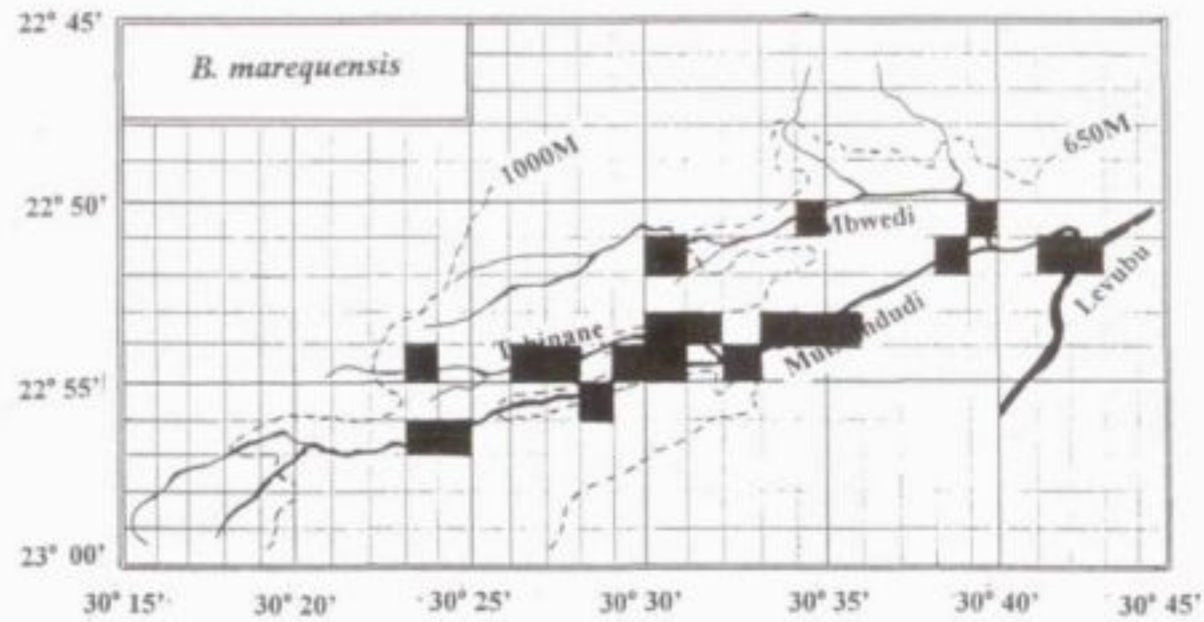
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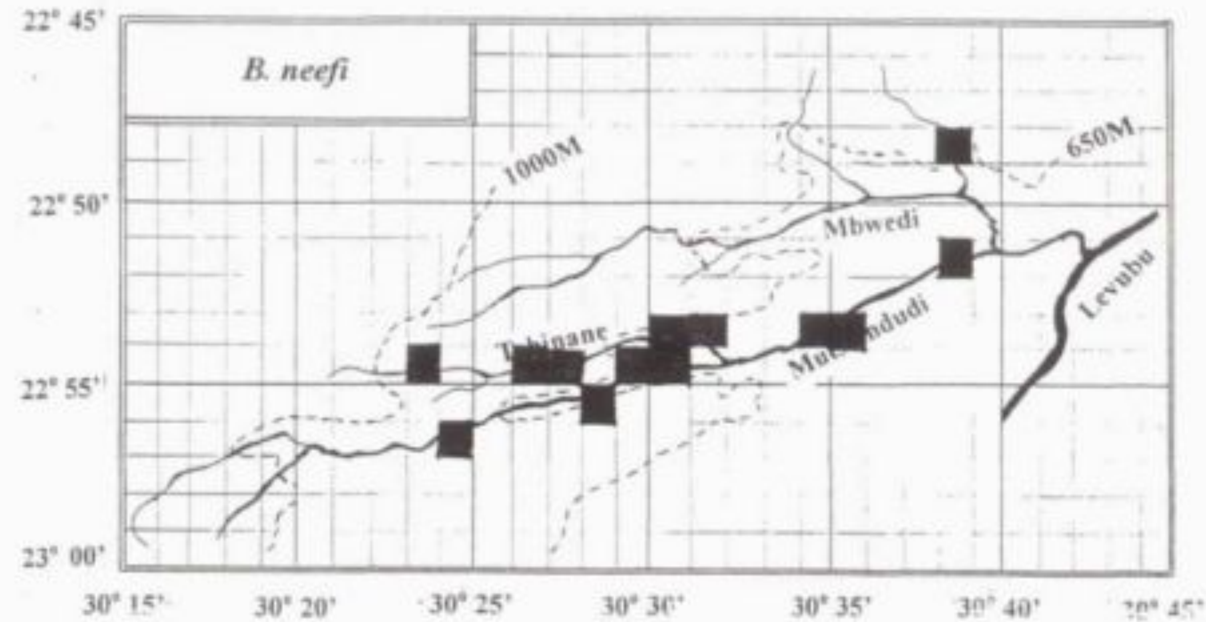
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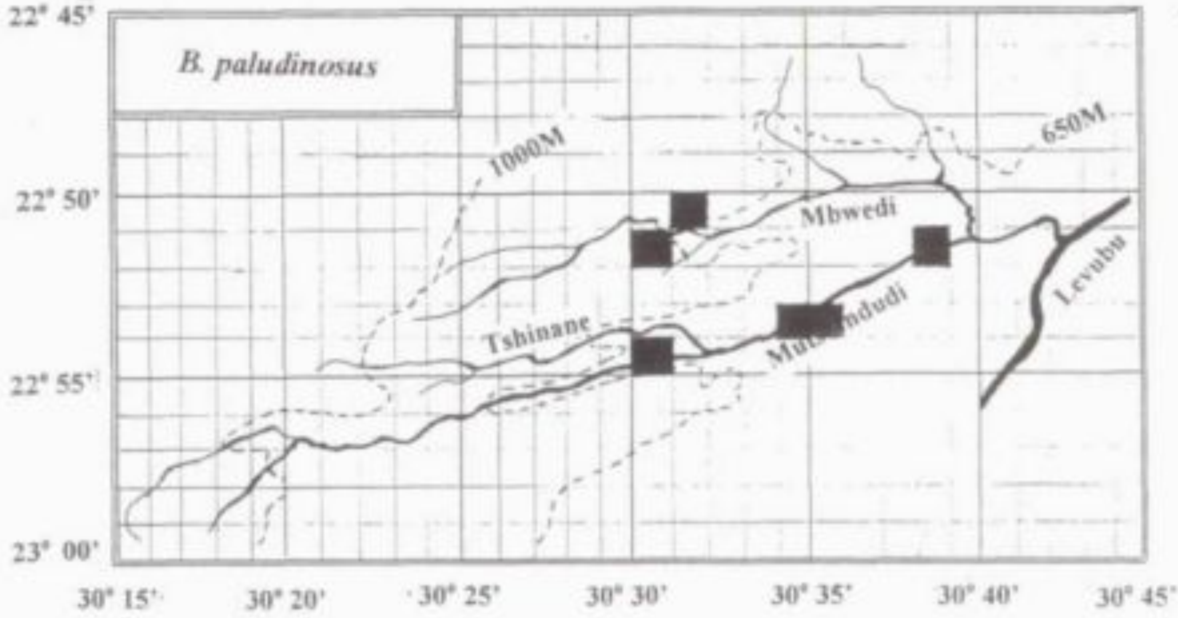
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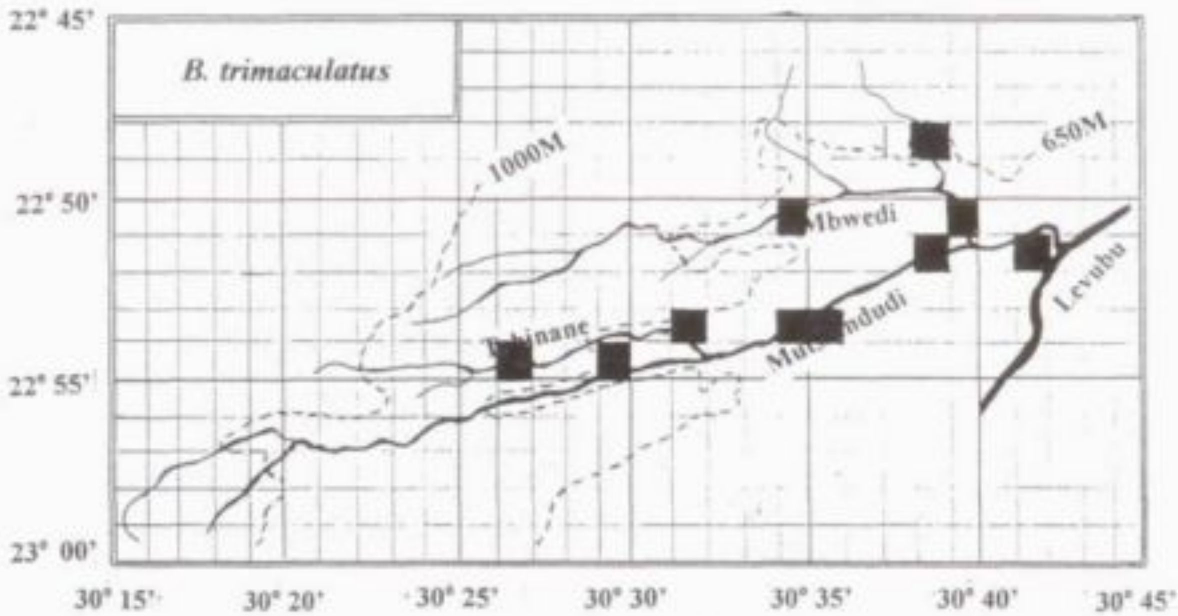
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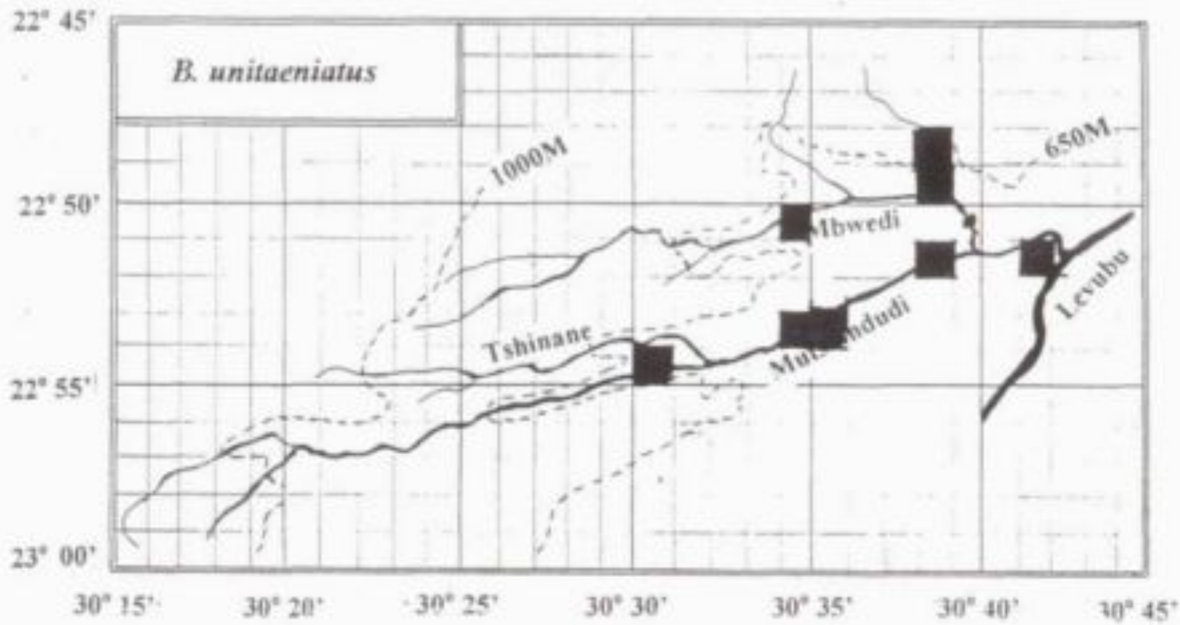
30° 45'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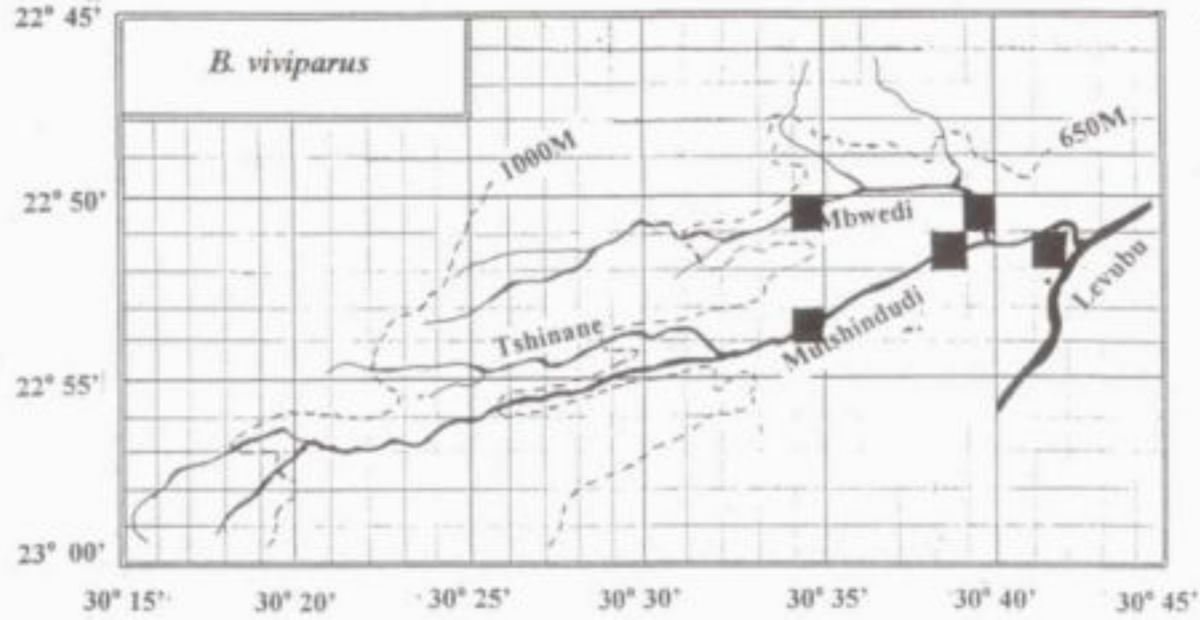
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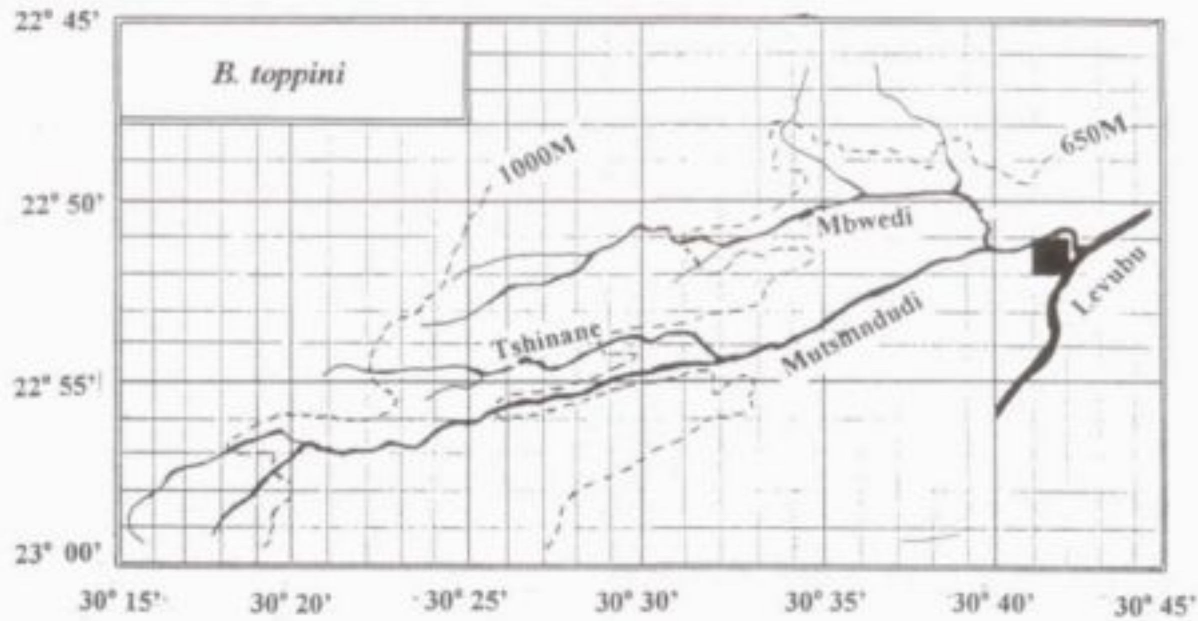
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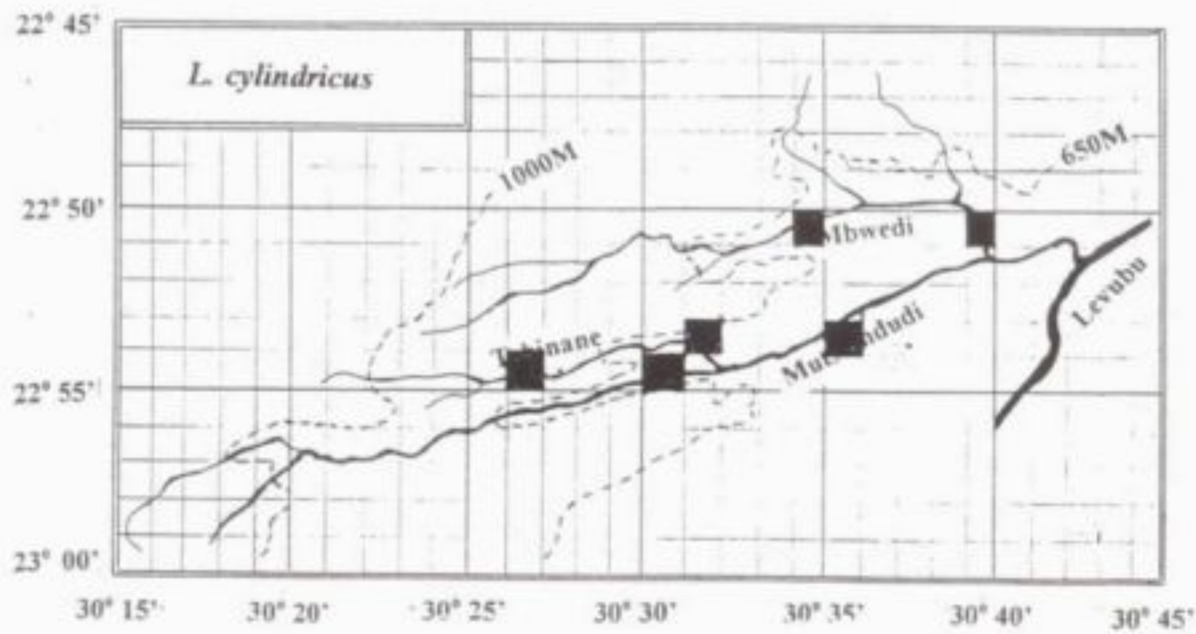
30° 40'
30° 45'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Levubu
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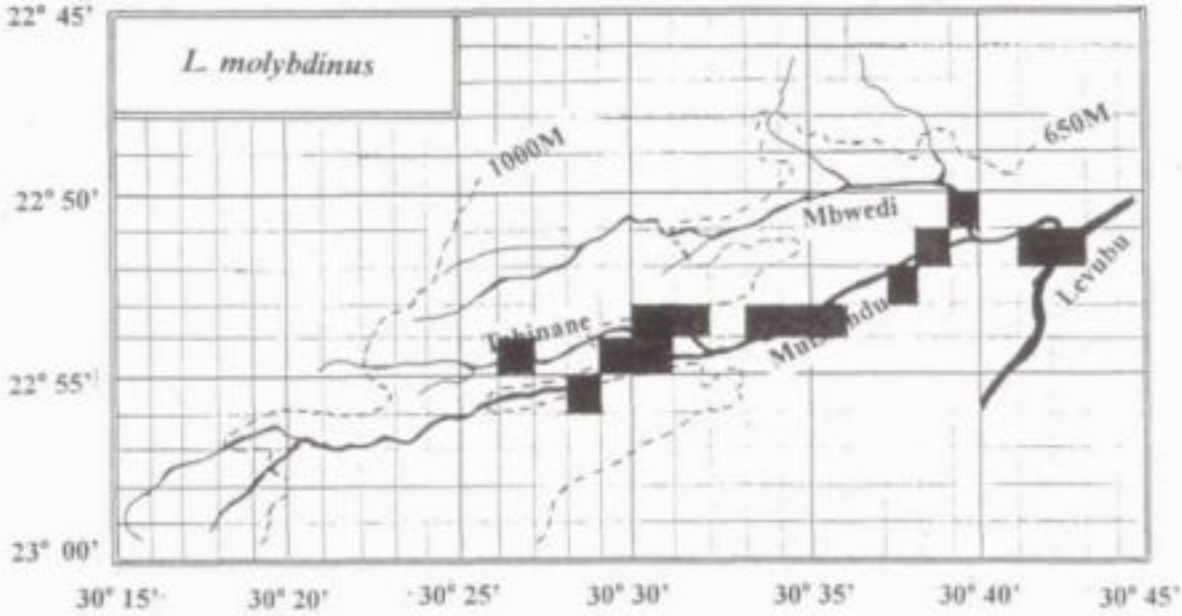
30° 45'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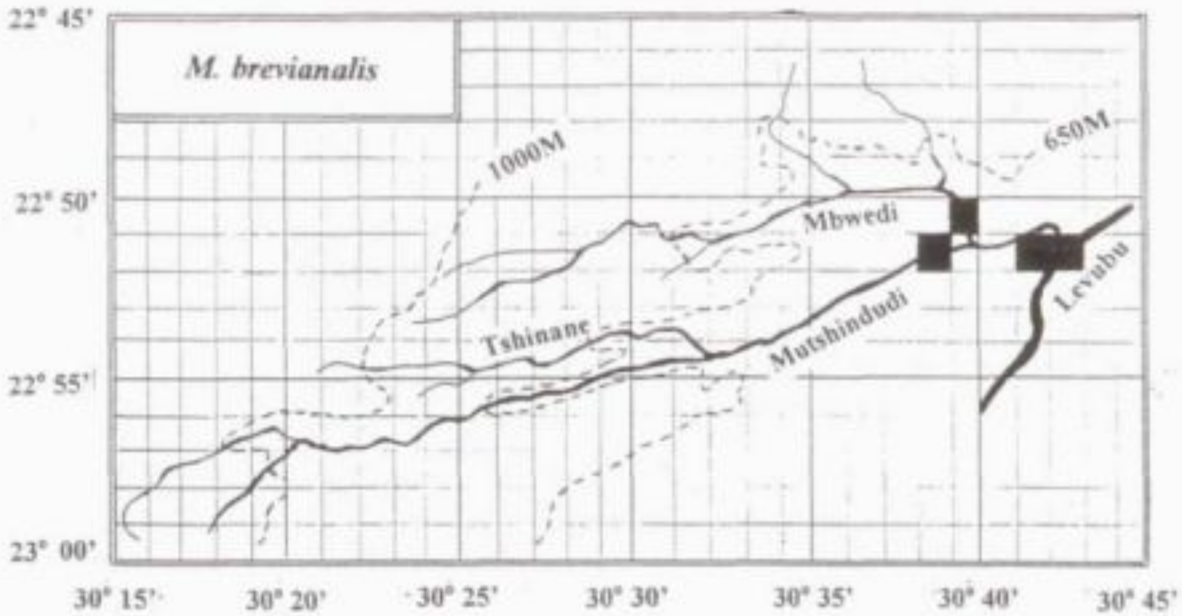
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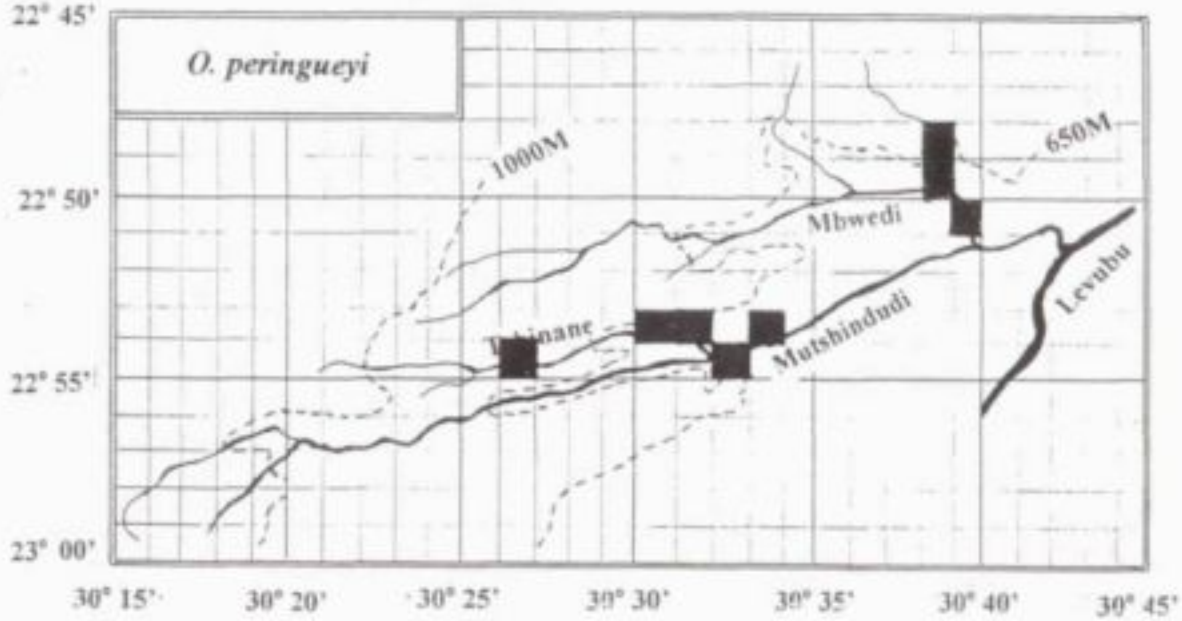
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Mutshindudi
Levubu
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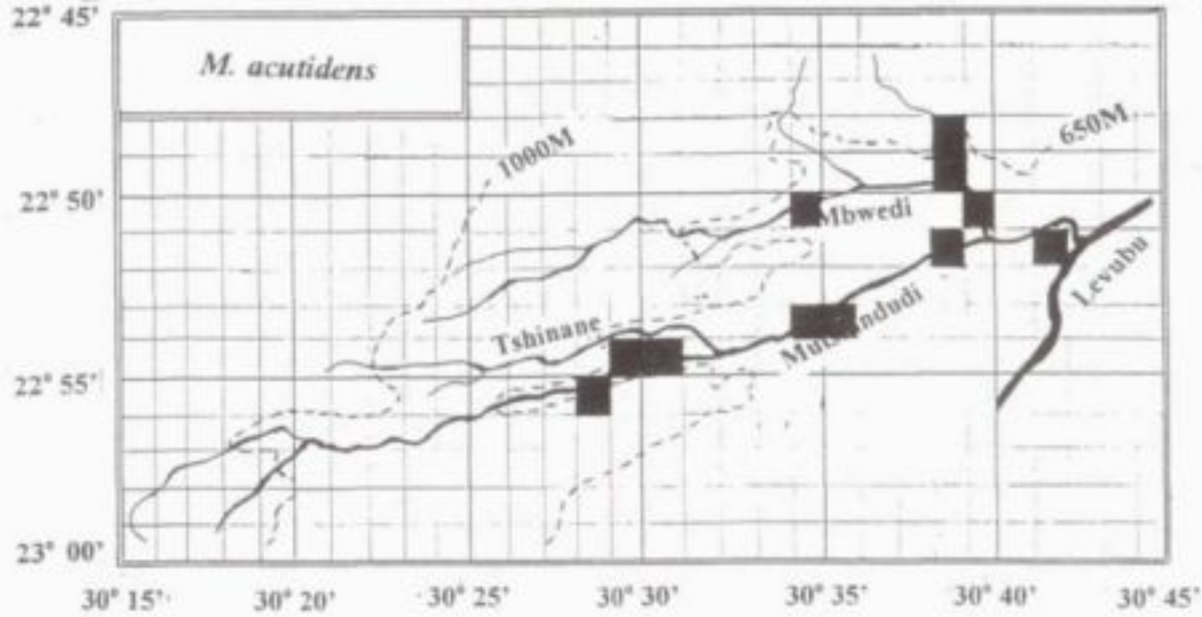
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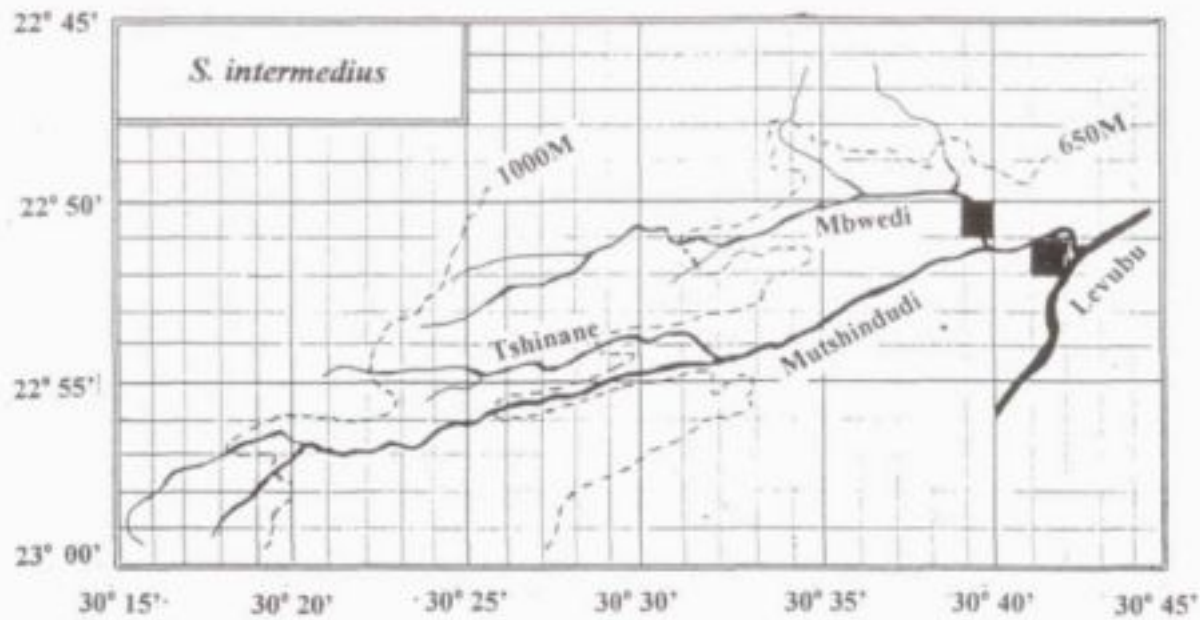
Tshinane
Levubu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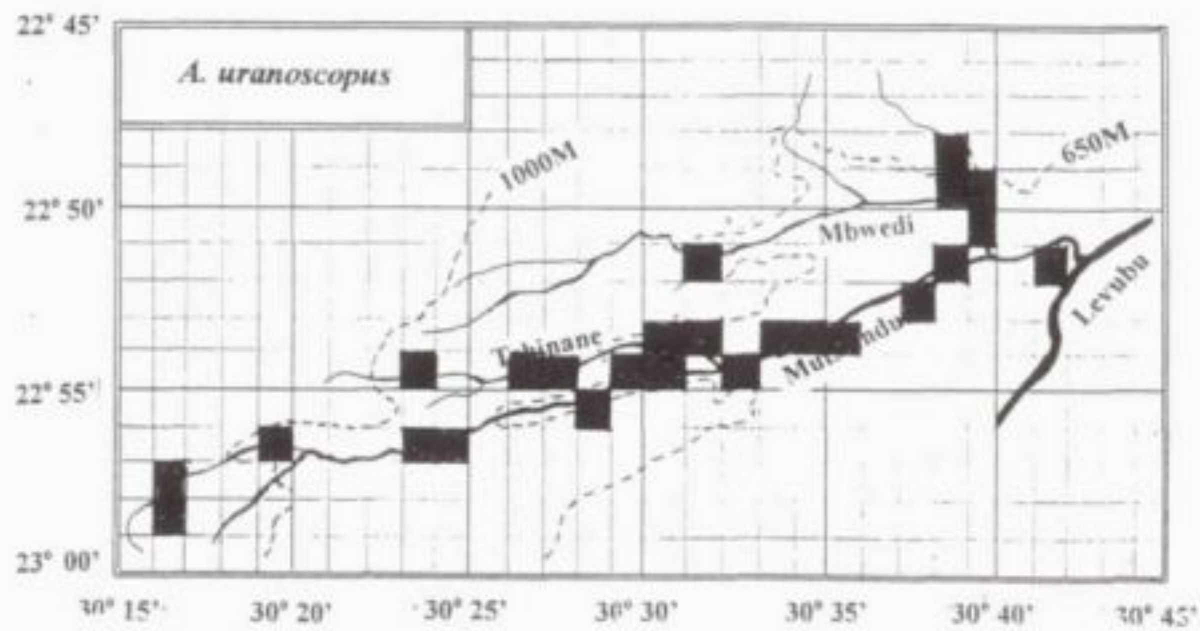
Mutshindudi
Levubu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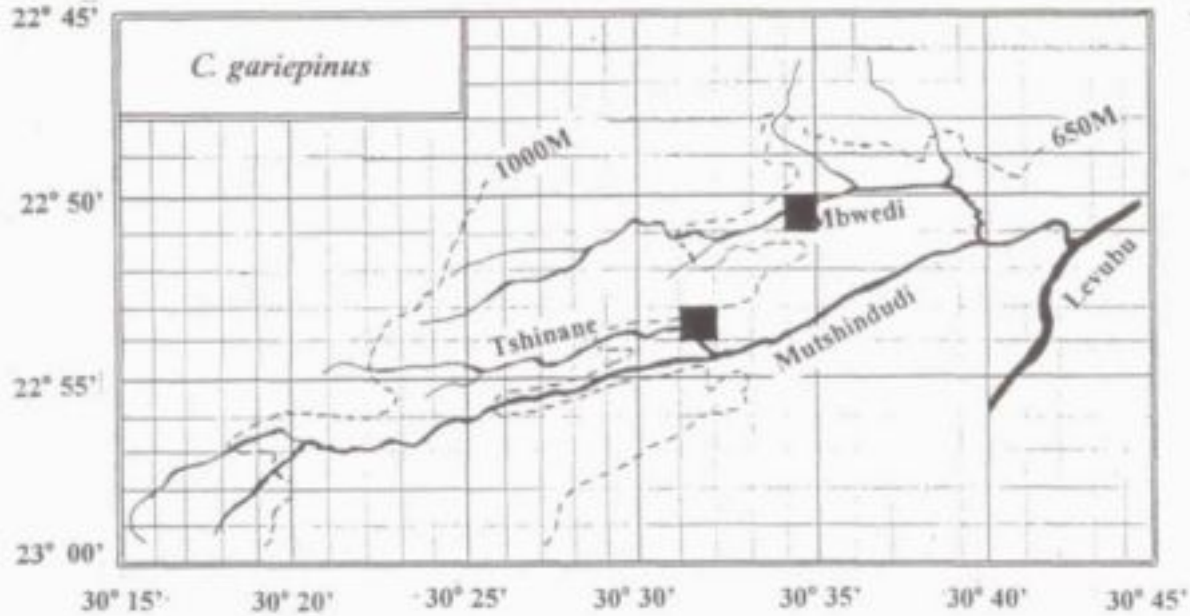
Mbwedi
Levubu


C. gariepinus
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Tshinane
Mutshindudi
Levubu
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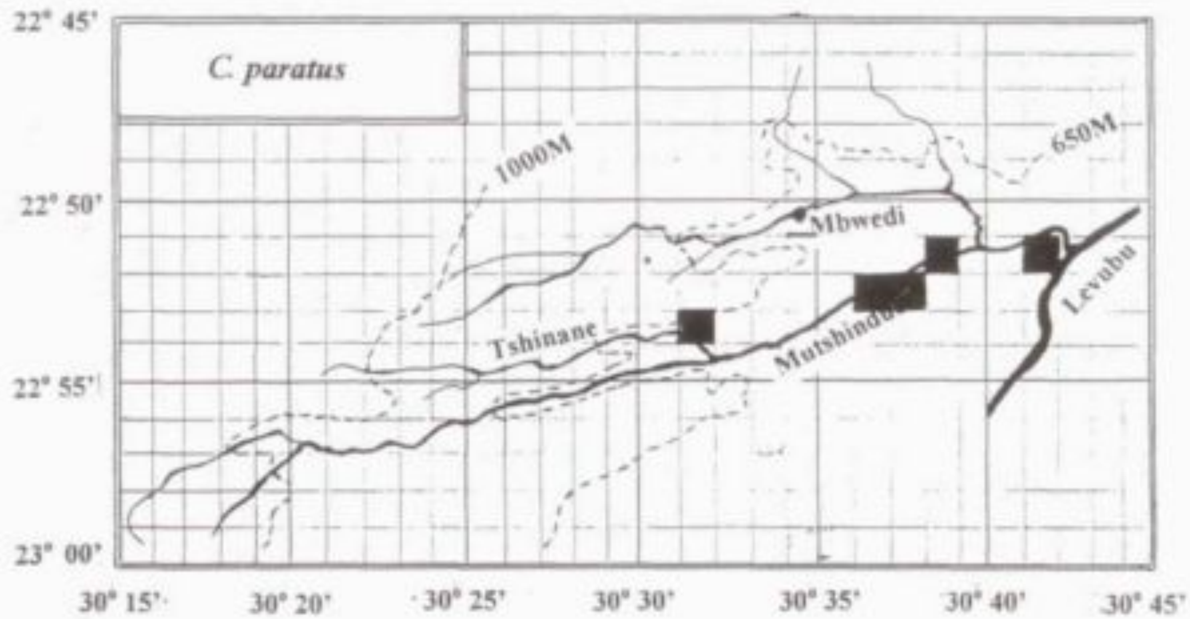
C. paratus
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Tshinane
Levubu
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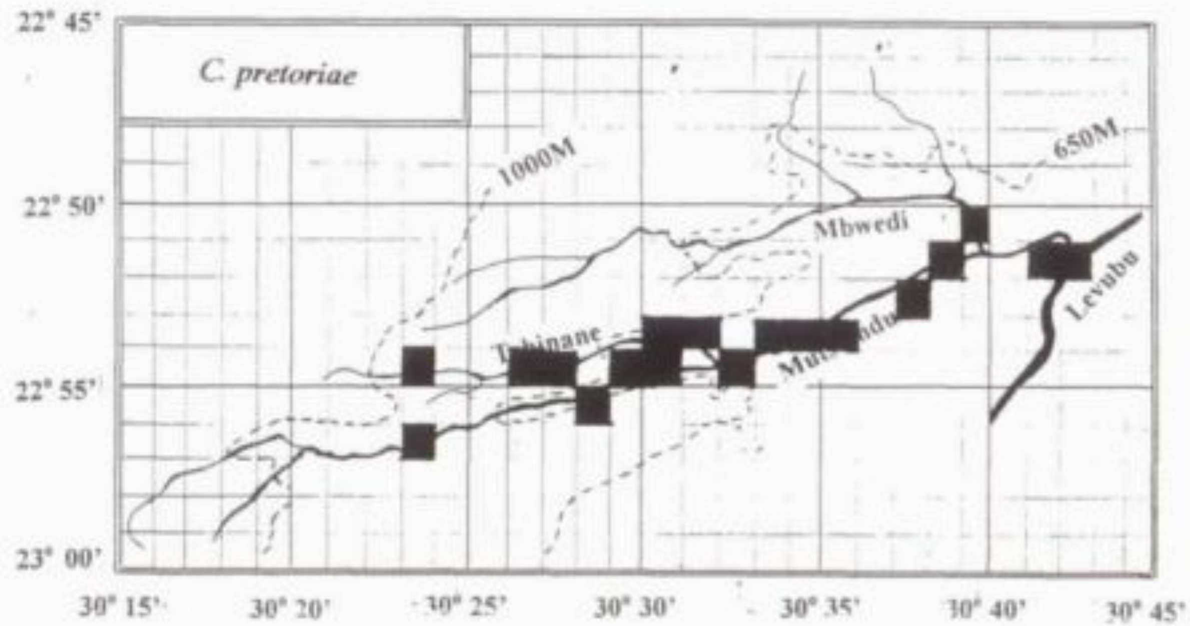
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Levubu
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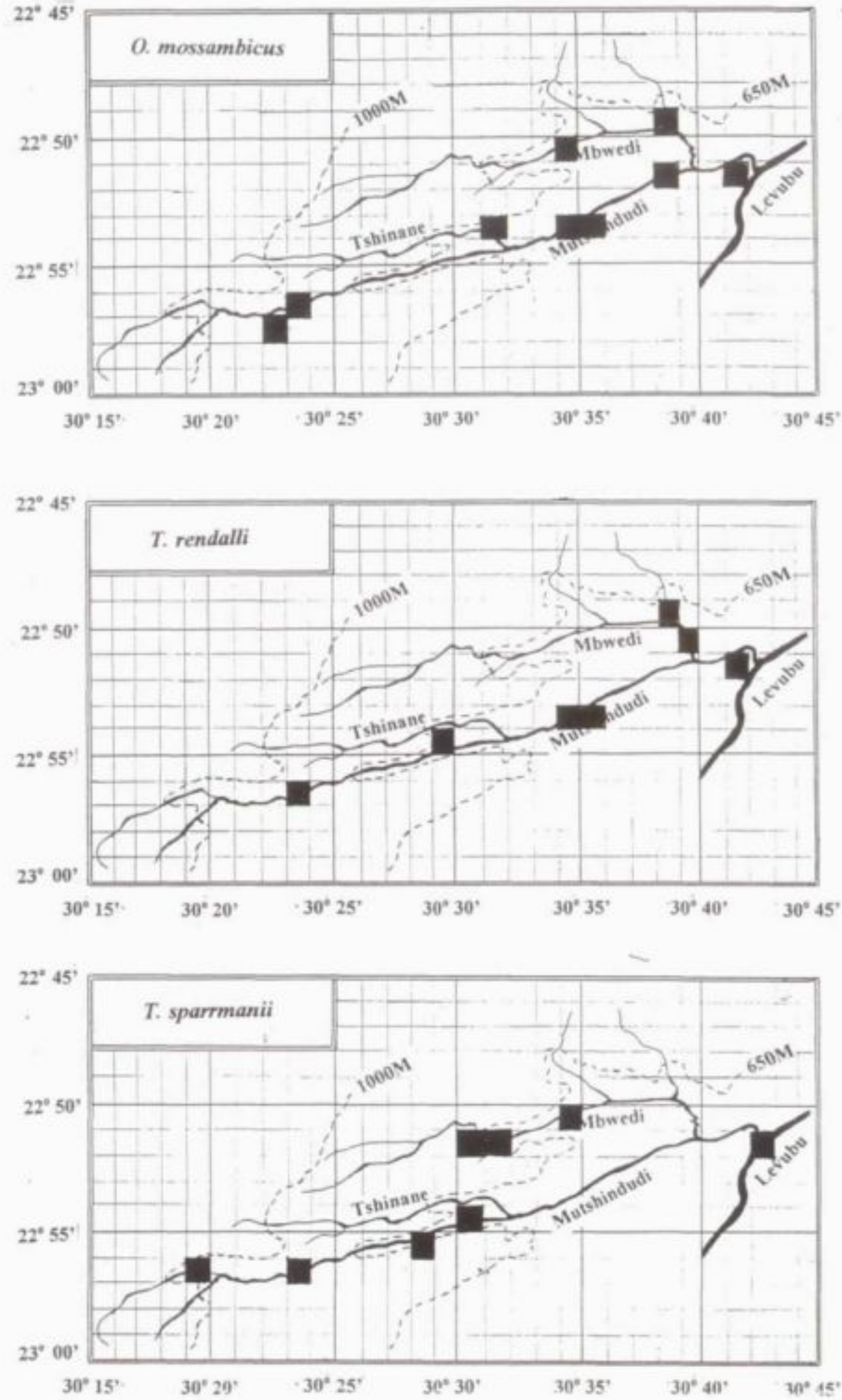
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30° 40'
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1000M
650M
Mbwedi
Tshinane
Levubu
T. rendalli
22° 45'
22° 50'
22° 55'
23° 00'
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30° 20'
30° 25'
30° 30'
30° 35'
30° 40'
30° 45'
1000M
650M
Mbwedi
Tshinane
Levubu
T. sparrmanii
22° 45'
22° 50'
22° 55'
23° 00'
30° 15'
30° 29'
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1000M
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Tshinane
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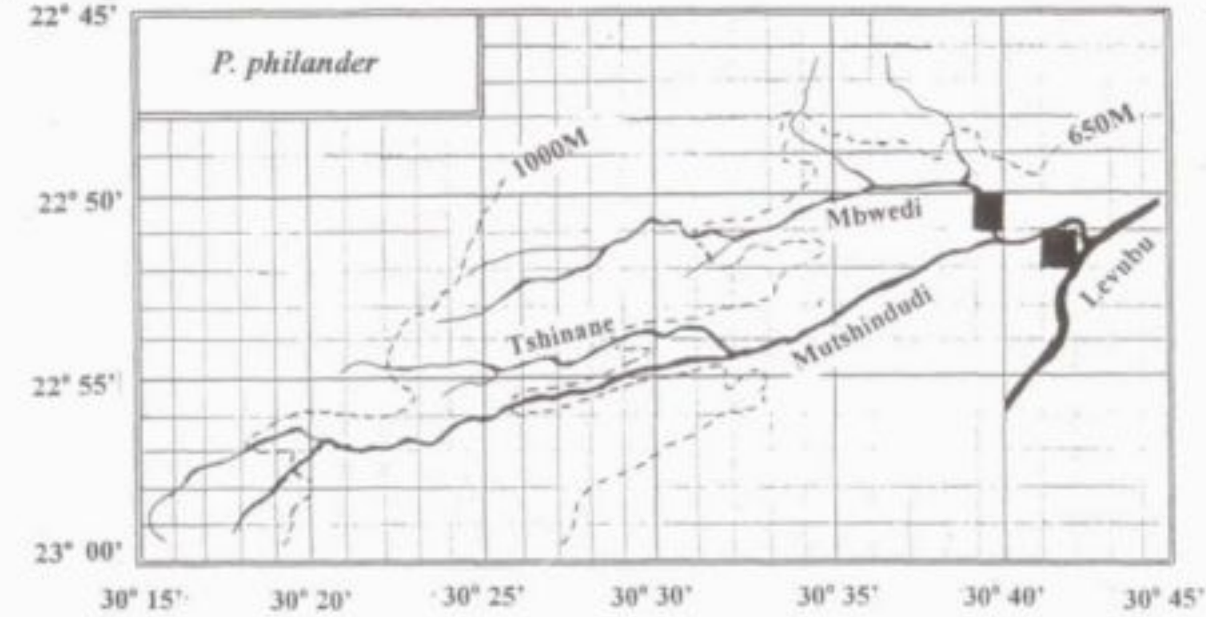
Levubu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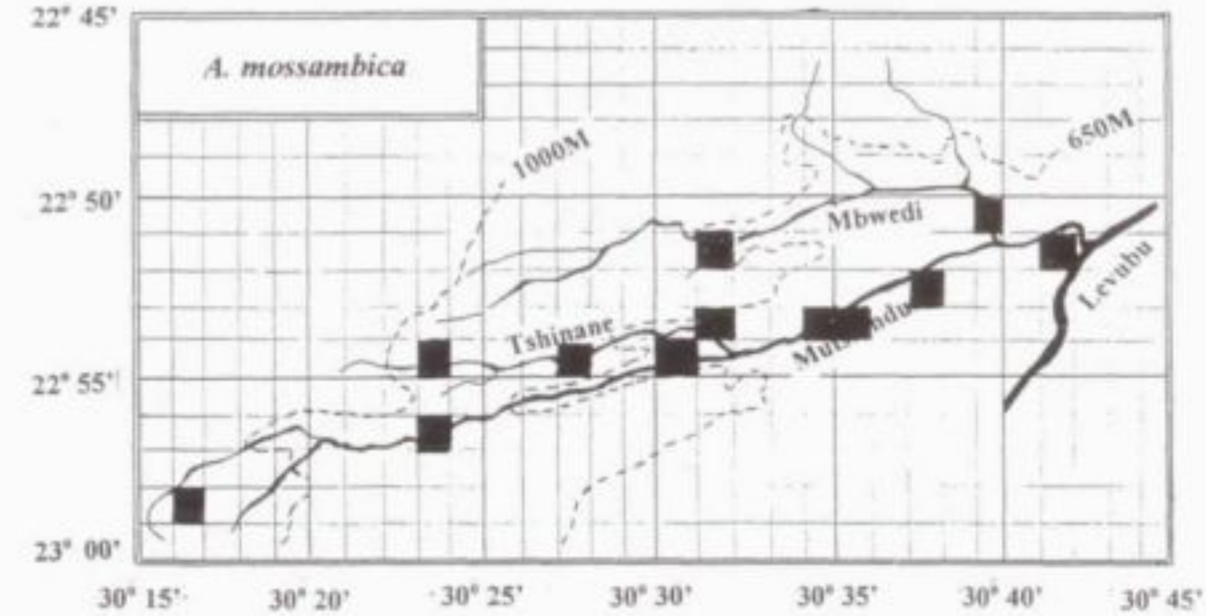
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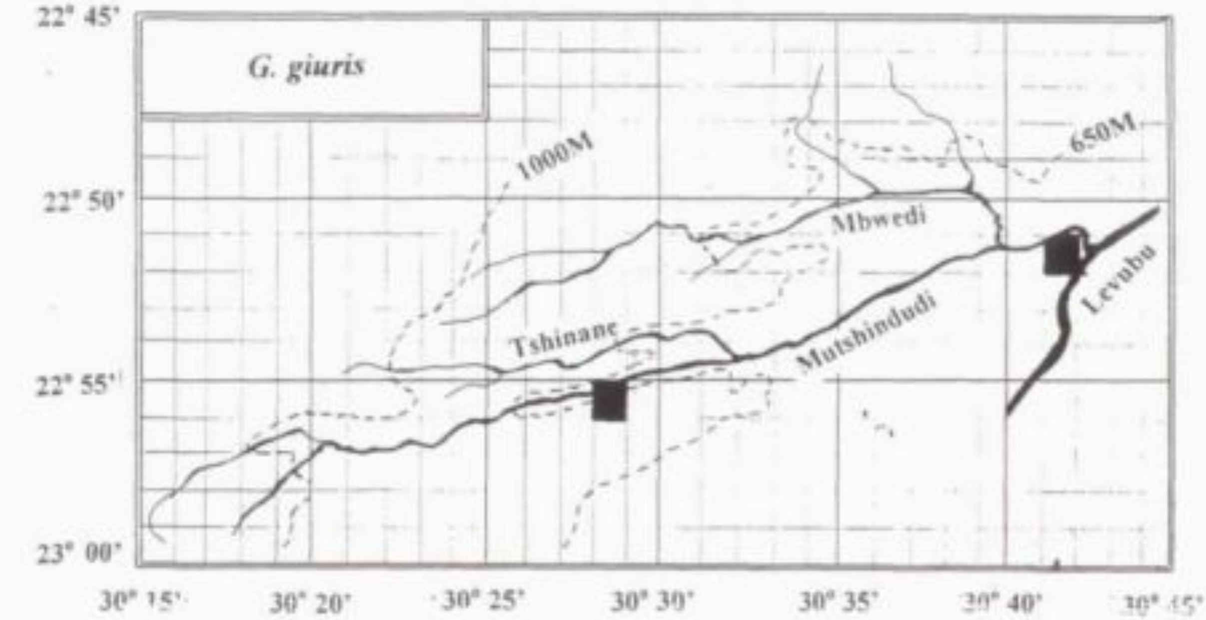
Tshinane
Levubu


G. giuris
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30° 30'
30° 35'
30° 40'
1000M
650M
Mbwedi
Tshinane
Mutshindudi
Levubu

APPENDICES 3 - 12

Note

The number given for each species is the Roberts number from the 5th edition.

A= Associate status
I = Indicator status

The habitats are divided into a hierarchy of habitat caterogies and a species can fall into all three. Thus a species may fall into forest. **FR** (a primary category), indigenous, **I** (secondary) and riverine, **RV** (tertiary). The symbols of these used in the tables are:

PRIMARY	SECONDARY	TERTIARY
AQ-Aquatic	LC-Lacustrine	WX-Open water
FR-Forest	MN-Montane Forest	WP-Emergent/Marginal
WO-Woodland	EG-Forest edge	BR-Broadleaved
GR-Grassland	IN-Indigenous	TH-Thicket
RC-Montane & Rocky		RV-Riverine
		GR-Grassland
		NT-Natural Grassland
		SW-Sweet
		SU-Sour
		SC-Scrub Habitats

The numbers 1,2,3, refr to the status of the category, e.g. primary, secondary or tertiary.

APPENDIX 3

AREA		Combined Species: Indicator & Associate Status																																			
		Lower river forest						Lower river - woods						Thathe Vondo Dam						High Catchment						Middle river - grass						Phiphidi Falls - forest						Indig-enous	
		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat			
		A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I
COMBINED SPECIES LIST																																							
SPECIES	**No.**																																						
Dabchick	6																		X																				
Cormorant, white breast	47																	X																					
Cormorant, reed	50												X																										
Heron, grey	54																	X																					
Egret, little	59																	X																					
Egret, yellowbilled	60																		X																				
Hamerkop	72						X																																
Duck, African black	95																		X						X														
Eagle, black	133																																						
Eagle, African hawk	141										X																												X
Bateleur (eagle)	151																						X																X
Buzzard, forest	155																				X																		
Goshawk, african	160																			X		X																	
Francolin, natal	183																						X															X	
Guineafowl, crested	193																			X		X																X	
Flufftail, buffspotted	206														X																								
Pigeon, rameron	312	X																		X												X							
Dove, redeyed	314			X																		X																	
Dove, tambourine	319	X		X				X		X										X		X																X	
Dove, greenspotted	321				X						X						X																						
Pigeon, green	323							X			X																												
Lourie, knysna	336																				X																		
Lourie, purplecrested	337				X												X						X												X			X	
Lourie, grey	339										X																												
Cuckoo, redchested	343													X		X				X		X																	
Cuckoo, Jacobin	348																X																						
Cuckoo, emerald	350																				X																		
Cuckoo, Diederik	352			X																																			
Coucal, Burchals	356			X												X																						X	
Mousebird, speckled	390				X												X																						
Mousebird, redfaced	392										X						X																						
Trogon, narina	393	X		X																																		X	
Kingfisher, pied	394					X												X																					

Combined Species: Indicator & Associate Status

AREA		Lower river - forest						Lower river - woods						Thathe Vondo Dam						High Catchment						Middle river - grass						Phiphidi Falls - forest						Indig-enous	
		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat			
		A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I
Kingfisher, giant	395											X																				X							
Kingfisher, malachite	397						X																																
Kingfisher, brownhooded	402				X					X																			X										
Kingfisher, striped	403																X																						X
Bee-eater, little	410										X																												X
Woodhoopoe, Scim.bill	412																						X																X
Hoopoe	418															X																							
Woodhoopoe, redbilled	419													X		X				X		X																	
Barbet, blackcollared	431	X		X												X						X																X	
Barbet, pied	432																X																						
Barbet, crested	439										X																												
Woodpecker, cardinal	450										X																												
Woodpecker, olive	452																				X																		X
Wryneck, redthroated	453																X																						
Swallow, mosque	500																					X																	X
Swallow, black sawwing	511													X						X																			
Cuckooshrike, black	513																			X		X																	
Drongo, forktailed	517																			X		X																	
Oriole, blckheaded	521																			X		X																	
Bulbul, blackeyed	545				X						X						X						X						X						X				
Bulbul, yellowbellied	550	X		X										X		X				X		X																X	
Bulbul, sombre	551	X		X				X		X				X		X				X		X										X		X				X	
Thrush, kurrichane	552																						X												X				
Thrush, olive	553																			X		X																	
Stonechat	576																																						
Robin, chorister	578																				X																		
Robin, natal	579																																						
Robin, Heuglin's	580				X																																	X	
Robin, Cape	581	X		X										X		X				X		X										X							
Robin, whitethroated	582				X						X																											X	
Robin, starred	589																				X																		
Crombec, longbilled	621															X																							
Apalis, bar-throated	622													X		X																						X	
Neddicky	637									X												X																	
Cisticola, rattling	642										X																												X

Combined Species: Indicator & Associate Status

AREA		Lower river - forest						Lower river - woods						Thathe Vondo Dam						High Catchment						Middle river - grass						Phiphidi Falls - forest						Indig-enous	
		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat			
		A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I
Cisticolla, redfaced	644									X																												X	
Flycatcher, spotted	654																X						X																
Flycatcher, dusky	655																				X																		
Batis, Cape	672																				X																		
Batis, chinspot	673				X						X						X						X																X
Flycatcher, bluemantled	680																			X		X																X	
Flycatcher, paradise	682	X		X										X		X				X		X																X	
Wagtail, African pied	685						X						X												X						X								
Wagtail, Cape	686											X						X														X							
Wagtail, Longtailed	688																				X												X						
Boubou, Southern	709	X		X				X		X				X		X				X		X				X		X										X	
Puffback	712	X		X				X		X				X		X				X		X				X		X											
Tchagra, threestreaked	714				X						X												X																X
Tchagra, blackcrowned	715				X																																		
Shrike, olive bush	717																				X																		
Shrike, orangebr. bush	719	X		X																X		X																X	
Shrike, gorgeous bush	721				X																		X																X
Shrike, greyheaded bush	723																X																					X	
Brubru	731				X																																		X
Starling, plumcoloured	736				X						X																												X
Starling, glossy	737									X																		X											
Sunbird, L. dblecollerd	760																			X																			
Sunbird, whitebellied	763				X						X						X						X						X										
Sunbird, black	772													X		X				X		X																	
Sunbird, scarletchest.	774				X					X							X						X												X				
White-eye, Cape	775	X		X				X		X				X		X				X		X										X		X					
Weaver, spottedbacked	797			X																																		X	
Weaver, golden	801									X																												X	
Weaver, masked	803																																						
Quelea, redbilled	805																																						
Bishop, red	808																																						
Widow, yellowrumped	810																																						
Bishop, golden	812													X																									
Widow, redcollared	813																					X																X	
Waxbill, swee	825																																						

Combined Species: Indicator & Associate Status

AREA		Lower river - forest						Lower rive. - woods						Thathe Vondo Dam						High Catchment						Middle river - grass						Phiphidi Falls - forest						Indig-enous	
		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat		Forest		Wood		Aquat			
		A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I
Finch, melba	830			X						X																												X	
Firefinch, bluebilled	833																					X																	
Firefinch, Jameson's	835			X						X																												X	
Firefinch, redbilled	837			X						X																												X	
Waxbill, blue	839			X						X																												X	
Waxbill, common	843																							X															
Canary, yelloweyed	859				X						X																												
TOTAL		12	10	19	16	1	3	6	10	15	16	2	2	13	[illegible]	15	14	5	3	22	10	25	12	1	3	2	0	3	2	0	1	5	1	2	4	0		26	13
GENERALISTS																																							
Heron, blackheaded	55																																						
Egret, cattle	61																																						
Ibis, hadedah	84																																						
Kite, yellowbilled	128																																						
Kite, blackshouldered	130																																						
Buzzard, jackal	152																																						
Buzzard, steppe	154																																						
Bee-eater, european	404																																						
Swallow, european	493																																						
Crow, pied	522																																						
Shrike, fiscal	707																																						
Sparrow, house	784																																						
Weaver, masked	803																																						
Quelea, redbilled	805																																						
Whydah, pintailed	846																																						

APPENDIX 4

species	No.	Site	AQ	RP	LC	WX	WP	RC	FR	MN	EG	WO	IN	BR	TH	RV	GR	NT	SW	SU	SC
			HIGH CATCHMENT TO SOURCE																		
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
N = 56																					
Duck, African duck	95	HC	I																		
Eagle, black	133	HC						I													
Bateleur (eagle)	151	HC										I	I								
Buzzard, forest	155	HC							I												
Goshawk, african	160	HC							A			A									
Francolin, natal	183	HC										I	A	A	A						
Guineafowl, crested	193	HC							A		A	A	A	A							
Pigeon, rameron	312	HC							A												
Dove, redeyed	314	HC										A									
Dove, tambourine	319	HC							A			A	A		A	A					
Lourie, knysna	336	HC							I												
Lourie, purplecrested	337	HC										I	A			A					
Cuckoo, redchested	343	HC							A			A									
Cuckoo, emerald	350	HC							I												
Woodhoopoe, Scim.bill.	412	HC										I	I								
Woodhoopoe, redbill.	419	HC							A			A									
Barbet, blackcollared	431	HC										A									
Woodpecker, olive	452	HC							I												
Swallow, mosque	500	HC										I	I								
Swallow, blk sawwing	511	HC							A												
Cuckooshrike, black	513	HC							A			A									
Drongo, forktailed	517	HC							A			A									
Oriole, blckheaded	521	HC							A			A									
Bulbul, blackeyed	545	HC										I									
Bulbul, yellowbellied	550	HC							A			A	A			A					
Bulbul, sombre	551	HC							A			A	A			A					
Thrush, kurrichane	552	HC										I									
Thrush, olive	553	HC							A			A									
Robin, chorister	578	HC							I	A											
Robin, Cape	581	HC							A		A	A									A
Robin, starred	589	HC							I	A											
Neddicky	637	HC										A									I
Flycatcher, spotted	654	HC										I									
Flycatcher, dusky	655	HC							I												
Batis, Cape	672	HC							I												

APPENDIX 5

			THATHE VONDO DAM																		
Slopes immediatly surrounding the dam, gallery vegetation and !ake itself																					
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
N = 41			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Dabchick	6	D1	I	A	A		A														
Cormorant, white breast.	47	D1	A	A	A		A														
Heron, grey	54	D1	A		A																
Egret, little	59	D1	A		A																
Egret, yellowbilled	60	D1	I		I																
Duck, African black	95	D1	I	I																	
Flufftail, buffspotted	206	D1							I												
Dove, greenspotted	321	D1										I									
Lourie, purplecrested	337	D1										I	A			A					
Cuckoo, redchested	343	D1							A			A									
Cuckoo, Jacobin	348	D1										I									
Coucal, Burchals	356	D1										A	A		A						
Mousebird, speckled	390	D1										I									
Mousebird, redfaced	392	D1										I									
Kingfisher, pied	394	D1	A	A	A		A														
Kingfisher, striped	403	D1										I	I								
Hoopoe	418	D1										A									
Hoopoe, redbilled	419	D1							A			A									
Barbet, blackcollared	431	D1										A									
Barbet, pied	432	D1										I									
Wryneck, redthroated	453	D1										I									
Swallow, black sawwing	511	D1							A												
Bulbul, blackeyed	545	D1										I									
Bulbul, yellowbellied	550	D1							A			A	A		A	A					
Bulbul, sombre	551	D1							A			A	A			A					
Stonechat	576	D1															A				A
Robin, cape	581	D1							A		A	A									A
Crombec, longbilled	621	D1										A									A
Apalis, bar-throated	622	D1							A			A	A		A						A
Flycatcher, spotted	654	D1										I									
Batis, chinspot	673	D1										I	I								
Flycatcher, paradise	682	D1							A			A	A		A	A					
Wagtail, cape	686	D1	A		A	A															
Boubou, southern	709	D1							A		A	A	A		A						
Puffback	712	D1							A			A									

			THATHE VONDO DAM																	
Slopes immediatly surrounding the dam, gallery vegetation and lake itself																				
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
N = 41			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Shrike, greyheaded bush	723	D1										I	A		A	A					
Sunbird, whitebellied	763	D1										I									
Sunbird, black	772	D1							A		A	A									
Sunbird, scarletchested	774	D1										I									
White-eye, cape	775	D1							A			A									A
Bishop, golden	812	D1	A		A												A	A			
GENERALISTS																					
Heron, blackheaded	55	D1																			
Weaver, masked	803	D1																			
Quelea, redbilled	805	D1																			

APPENDIX 6

			SIBASA/NZHELELE ROAD TO SIBASA/MUTALE ROAD																	
			Grassland and gallery woodland																	
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EC**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
N = 13			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
			APPENDIX 4: SIBASA/NZHELELE ROAD TO SIBASA MUTALE ROAD																	
			Grassland and gallery woodland																	
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EC**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
N = 13			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Kingfisher, brownhooded	402											I									
Bulbul, blackeyed	545											I									
Wagtail, African pied	685		I			A															
Boubou, southern	709								A		A	A	A		A						
Puffback	712								A			A									
Starling, glossy	737											A									
Sunbird, whitebellied	763											I									
Bishop, red	808		A		A																
Bishop, golden	812		A		A												A	A			A
Widow, redcollared	813											A	A				A				
Widow, whitewinged	814																				
Waxbill, blue	839											A	A								
Canary, yelloweyed	859											I									
Egret, cattle	61		G	E	N	E	R	A	L	I	S	T									
Sparrow, house	784		G	E	N	E	R	A	L	I	S	T									
Quelea, redbilled	805		G	E	N	E	R	A	L	I	S	T									
Weaver, masked	803		G	E	N	E	R	A	L	I	S	T									
Kite, yellowbilled	128		G	E	N	E	R	A	L	I	S	T									
Bee-eater, european	404		G	E	N	E	R	A	L	I	S	T									
Swallow, european	493		G	E	N	E	R	A	L	I	S	T									
Crow, pied	522		G	E	N	E	R	A	L	I	S	T									

APPENDIX 7

									PHIPHIDI FALLS												
		Riverine forest																			
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
N = 12			**1**	**3**	**2**	**3**	**3**	**1**	**1**	**2**	**2**	**1**	**2**	**3**	**3**	**3**	**1**	**2**	**3**	**3**	**1**
Pigeon, rameron	312								A												
Lourie, purplecrested	337											I	A		A						
Kingfisher, giant	395		A	A																	
Bulbul, blackeyed	545											I									
Bulbul, sombre	551								A			A	A								
Thrush, kurrichane	552											I									
Robin, natal	579								A			A	A		A						
Robin, cape	581								A		A										A
Wagtail, cape	686		A			A															
Wagtail, longtailed	688		I																		
Sunbird, scarletchested	774											I									
White-eye, cape	775								A			A									

APPENDIX 8

			FROM SIBASA/MUTALE ROAD TO LEVUVHU RIVER																		
			OPEN WOODLAND TO GRASSLAND																		
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
N = 42																					
Cormorant, reed	50	LM6	I		A		A														
Eagle, African hawk	141	LM6										I	I								
Dove, tambourine	319	LM4							A			A	A		A	A					
Dove, greenspotted	321	LM4										I									
Pigeon, green	323	LM6							A		A	I									
Lourie, grey	339	LM16										I									
Mousebird, redfaced	392	LM6										I									
Kingfisher, giant	395	LM7	A		A		A														
Kingfisher, brownhoode	402	LM4										A	A								
Bee-eater, little	410	LM7										I	I								
Barbet, crested	439	LM9										I									
Woodpecker, cardinal	450	LM15										I	I								
Bulbul, blackeyed	545	LM15										I									
Bulbul, sombre	551	LM7							A			A	A		A						
Robin, whitethroated	582	LM6										I	A		A						
Neddicky	637	LM7										A									I
Cisticolla, rattling	642	LM13										I	I								
Cisticolla, redfaced	644	LM4	A		A							A	A			A					
Batis, chinspot	673	LM6										I	I								
Wagtail, African pied	685	LM15	I		A	A															
Wagtail, Cape	686	LM1	A		A	A															
Boubou, southern	709	LM1							A		A	A	A		A						
Puffback	712	LM15							A			A									
Tchagra, threestreaked	714	LM9										I	I								
Starling, plumcoloured	736	LM6										I	I			A					
Starling, glossy	737	LM16										A									
Sunbird, whitebellied	763	LM13										A									
Sunbird, scarletchested	774	LM4										I									
White-eye, Cape	775	LM4							A			A									
Weaver, golden	801	LM7										A	A			A					
Widow, yellowrumped	810	LM1															A	A			A
Finch, melba	830	LM16										A	A								
Firefinch, Jameson's	835	LM16										A	A		A						
Firefinch, redbilled	837	LM9										A	A								

	FROM SIBASA/MUTALE ROAD TO LEVUVHU RIVER																			
				OPEN WOODLAND TO GRASSLAND																
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Waxbill, blue	839	LM9										A	A								
Waxbill, common	843	LM1	A		A																
Canary, yelloweyed	859	LM7										I									
GENERALISTS																					
Ibis, hadedah	84																				
Kite, yellowbilled	129																				
Kite, blackshouldered	130																				
Bee-eater, European	404																				
Sparrow, house	784																				

APPENDIX 9

						LOWER MUTSHINDUDI, LEVUVHU TO SIBASA/MUTALE ROAD																
						FORESTED & HEAVILY WOODED AREAS ONLY																
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
N = 45																					
Hamerkop	72	LM11	I		A																
Pigeon, rameron	312	LM10							A												
Dove, redeyed	314	LM2										A									
Dove, tambourine	319	LM11							A			A	A		A	A					
Dove, greenspotted	321	LM12										I									
Lourie, purplecrested	337	LM5										I	A			A					
Cuckoo, Diederik	352	LM2										A					A				
Coucal, Burchell's	356	LM2										A	A		A						
Mousebird, speckled	390	LM3										I									
Trogon, narina	393	LM8							A			A	A			A					
Kingfisher, pied	394	LM5	A		A		A														
Kingfisher, malachite	397	LM10	I		A		A														
Kingfisher, brownhooded	402	LM10										I									
Barbet, blackcollared	431	LM8							A			A	A								
Bulbul, blackeyed	545	LM10										I									
Bulbul, yellowbellied	550	LM5							A			A	A		A	A					
Bulbul, sombre	551	LM11							A			A	A								
Robin, Heuglin's	580	LM10										I	A		A	A					
Robin, Cape	581	LM17							A		A	A									A
Robin, whitethroated	582	LM10										I	A		A						
Batis, chinspot	673	LM11										I	I								
Flycatcher, paradise	682	LM5							A			A	A		A	A					
Wagtail, African pied	685	LM12	I		A	A															
Boubou, southern	709	LM11							A		A	A	A		A						
Puffback	712	LM3							A			A	A								
Tchagra, threestreaked	714	LM12										I	I								
Tchagra, blackcrowned	715	LM8										I									
Shrike, orangebreasted bus	719	LM2							A		A	A	A		A						
Shrike, gorgeous bush	721	LM5							A		A	A	A		A						
Brubru	731	LM12										I	I								
Starling, glossy	737	LM8										A									
Sunbird, whitebellied	763	LM12										I									
Sunbird, scarletchested	774	LM10										I									
White-eye, Cape	775	LM5							A			A									

			LOWER MUTSHINDUDI, LEVUVHU TO SIBASA/MUTALE ROAD																		
					FORESTED & HEAVILY WOODED AREAS ONLY																
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Weaver, spottedbacked	797	LM3										A	A			A					
Widow, yellowrumped	810	LM10															A	A			A
Finch, melba	830	LM11										A	A								
Firefinch, Jameson's	835	LM10										A	A		A						
Firefinch, redbilled	837	LM11										A	A								
Waxbill, blue	839	LM12										A	A								
Canary, yelloweyed	859	LM2										I									
GENERALISTS																					
Heron, blackheaded	55	LM8																			
Kite, blackshouldered	130	LM12																			
Bee-eater, European	404	LM10																			
Whydah, pintailed	847	LM10																			

			HIGH CATCHMENT TO SOURCE																		
species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Batis, chinspot	673	HC										I	I								
Flycatcher, bluemantled	680	HC							A			A	A			A					
Flycatcher, paradise	682	HC							A			A	A		A	A					
Wagtail, African pied	685	HC	I		A	A															
Wagtail, Longtailed	688	HC	I																		
Boubou, Southern	709	HC							A		A	A	A		A						
Puffback	712	HC							A			A									
Tchagra, threestreaked	714	HC										I	I								
Shrike, olive bush	717	HC							I												
Shrike, orangebr. bush	719	HC							A		A	A	A		A						
Shrike, gorgeous bush	721	HC										I	I		I						
Sunbird, L. dblecollerd	760	HC							A		A										A
Sunbird, whitebellied	763	HC										I									
Sunbird, black	772	HC							A		A	A									
Sunbird, scarletchest.	774	HC										I									
White-eye, Cape	775	HC							A			A									
Bishop, golden	812	HC	A		A												A	A			
Widow, redcollared	813	HC										A	A				A				
Waxbill, swee	825	HC						A		A											
Firefinch, bluebilled	833	HC						A		A	A	A		A							
Waxbill, common	843	HC	A		A																
GENERALISTS																					
Kite, yellowbilled	128	HC																			
Buzzard, jackal	152	HC																			
Buzzard, steppe	154	HC																			
Bee-eater, european	404	HC																			
Shrike, fiscal	707	HC																			
Whydah, pintailed	846	HC																			

			LOWER MUTSHINDUDI, LEVUVHU RIVER TO SIBASA/MUTALE ROAD																		
			BY SITE																		
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Starling, glossy	737	LM4										A									
Sunbird, scarletchested	774	LM4										A									
White-eye, Cape	775	LM4							A			A									
Lourie, purplecrested	337	LM5										I	A			A					
Kingfisher, pied	394	LM5	A		A		A														
Bulbul, yellowbellied	550	LM5							A			A	A		A	A					
Flycatcher, paradise	682	LM5							A			A	A		A	A					
Boubou, southern	709	LM5							A		A	A	A		A						
Shrike, gorgeous bush	721	LM5							A		A	A	A		A						
Starling, glossy	737	LM5										A									
White-eye, Cape	775	LM5							A			A									
Firefinch, Redbilled	837	LM5										A	A								
Cormorant, reed	50	LM6	I		A		A														
Ibis, hadedah	84	LM6			G	E	N	E	R	A	L	I	S	T							
Eagle, African hawk	141	LM6										I	I								
Pigeon, green	323	LM6							A		A	I									
Mousebird, redfaced	392	LM6										I									
Kingfisher, brownhooded	402	LM6										I									
Bulbul, blackeyed	545	LM6										I									
Robin, whitethroated	582	LM6										I	A		A						
Batis, chinspot	673	LM6										I	I								
Boubou, southern	709	LM6							A		A	A	A		A						
Tchagra, threestreaked	714	LM6										I	I								
Starling, plumcoloured	736	LM6										I	I			A					
Kingfisher, giant	395	LM7	A		A		A														
Bee-eater, European	404	LM7				G	E	N	E	R	A	L	I	S	T						
Bee-eater, little	410	LM7										I	I								
Bulbul, sombre	551	LM7							A			A	A		A						
Neddicky	637	LM7										A									I
Tchagra, threestreaked	714	LM7										I	I								
White-eye, Cape	775	LM7							A			A									
Weaver, golden	801	LM7										A	A			A					

							LOWER MUTSHINDUDI, LEVUVHU RIVER TO SIBASA/MUTALE ROAD														
			BY SITE																		
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Finch, melba	830	LM7										A	A								
Waxbill, blue	839	LM7										A	A								
Canary, yelloweyed	859	LM7										I									
Heron, blackheaded	55	LM8				G	E	N	E	R	A	L	I	S	T						
Mousebird, speckled	390	LM8										I									
Trogon, narina	393	LM8							A			A	A			A					
Barbet, blackcollared	431	LM8							A			A	A								
Bulbul, blackeyed	545	LM8										I									
Tchagra, blackcrowned	715	LM8										I									
Starling, glossy	737	LM8										A									
Sunbird, whitebellied	763	LM8										A									
White-eye, Cape	775	LM8							A			A									
Kite, yellowbilled	129	LM9				G	E	N	E	R	A	L	I	S	T						
Dove, greenspotted	321	LM9										I									
Barbet, crested	439	LM9										I									
Bulbul, blackeyed	545	LM9										I									
Cisticolla, rattling	642	LM9										I	I								
Boubou, southern	709	LM9							A		A	A	A		A						
Tchagra, threestreaked	714	LM9										I	I								
Starling, glossy	737	LM9										A									
Finch, melba	830	LM9										A	A								
Firefinch, redbilled	837	LM9										A	A								
Waxbill, blue	839	LM9										A	A								
Pigeon, rameron	312	LM10							A												
Coucal, Burchell's	356	LM10										A	A		A						
Mousebird, speckled	390	LM10										I									
Kingfisher, malachite	397	LM10	I		A		A														
Kingfisher, brownhooded	402	LM10										I									
Bee-eater, European	404	LM10				G	EN	E	R	A	L	I	S	T							
Bulbul, blackeyed	545	LM10										I									
Robin, Heuglin's	580	LM10										I	A		A	A					
Robin, whitethroated	582	LM10										I	A		A						

			LOWER MUTSHINDUDI, LEVUVHU RIVER TO SIBASA/MUTALE ROAD																			O/
			BY SITE																			
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**	**T**
			1	**3**	**2**	**3**	**3**	**1**	**1**	**2**	**2**	**1**	**2**	**3**	**3**	**3**	**1**	**2**	**3**	**3**	**1**	**2**
Flycatcher, paradise	682	LM10							A			A	A		A	A						
Boubou, southern	709	LM10							A		A	A	A		A							
Puffback	712	LM10							A			A										
Shrike, orangebreasted bu	719	LM10							A		A	A	A		A							
Sunbird, scarletchested	774	LM10										I										
Widow, yellowrumped	810	LM10															A	A			A	
Firefinch, Jameson's	835	LM10										A	A		A							
Firefinch, redbilled	837	LM10										A	A									
Whydah, pintailed	847	LM10				G	E	N	E	R	A	L	I	S	T							
Hamerkop	72	LM11	I		A																	
Dove, tambourine	319	LM11							A			A	A		A	A						
Bulbul, blackeyed	545	LM11										I										
Bulbul, sombre	551	LM11							A			A	A									
Batis, chinspot	673	LM11										I	I									
Boubou, southern	709	LM11							A		A	A	A		A							
Finch, melba	830	LM11										A	A									
Firefinch, redbilled	837	LM11										A	A									
Kite, blackshouldered	130	LM12				G	E	N	E	R	A	L	I	S	T							
Dove, greenspotted	321	LM12										I										
Kingfisher, brownhooded	402	LM12										I										
Bulbul, blackeyed	545	LM12										I										
Wagtail, African pied	685	LM12	I		A	A																
Boubou, southern	709	LM12							A		A	A	A		A							
Puffback	712	LM12							A			A										
Tchagra, threestreaked	714	LM12										I	I									
Brubru	731	LM12										I	I									
Starling, glossy	737	LM12										A										
Sunbird, whitebellied	763	LM12										I										
Firefinch, redbilled	837	LM12										A	A									
Waxbill, blue	839	LM12										A	A									
Bee-eater, European	404	LM13		G	E	N	E	R	A	L	I	S	T									
Starling, glossy	737	LM13										A										

			LOWER MUTSHINDUDI, LEVUVHU RIVER TO SIBASA/MUTALE ROAD																		
			BY SITE																		
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	**3**	**2**	**3**	**3**	**1**	**1**	**2**	**2**	**1**	**2**	**3**	**3**	**3**	**1**	**2**	**3**	**3**	**1**
Waxbill, blue	839	LM13										A	A								
Firefinch, Jameson's	835	LM13										A	A		A						
Bulbul, blackeyed	545	LM13										I									
Cisticolla, rattling	642	LM13										I	I								
Finch, melba	830	LM13										A	A								
Sunbird, whitebellied	763	LM13										A									
Barbet, crested	439	LM13										I									
Dove, tambourine	319	LM14							A			A	A		A	A					
Bulbul, blackeyed	545	LM14										I									
Bulbul, sombre	551	LM14							A			A	A								
Batis, chinspot	673	LM14										I	I								
Boubou, southern	709	LM14							A		A	A	A		A						
Finch, melba	830	LM14										A	A								
Firefinch, Redbilled	837	LM14										A	A								
Waxbill, blue	839	LM14										A	A								
Kite, blackshouldered	130	LM15		G	E	N	E	R	A	L	I	S	T								
Lourie, grey	320	LM15										I									
Kingfisher, brownhooded	402	LM15										I									
Woodpecker, cardinal	450	LM15										I	I								
Bulbul, blackeyed	545	LM15										I									
Wagtail, African pied	685	LM15	I		A	A															
Puffback	712	LM15							A			A									
Tchagra, threestreaked	714	LM15										I	I								
Starling, glossy	737	LM15										A									
Lourie, grey	320	LM16										I									
Bulbul, blackeyed	545	LM16										I									
Wagtail, Cape	686	LM16	A		A	A															
Starling, glossy	737	LM16										A									
Finch, melba	830	LM16										A	A								
Firefinch, Jameson's	835	LM16										A	A		A						
Waxbill, blue	839	LM16										A	A								
Waxbill, common	843	LM16	A		A																

			LOWER MUTSHINDUDI, LEVUVHU RIVER TO SIBASA/MUTALE ROAD																		
			BY SITE																		
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	**3**	**2**	**3**	**3**	**1**	**1**	**2**	**2**	**1**	**2**	**3**	**3**	**3**	**1**	**2**	**3**	**3**	**1**
Dove, greenspotted	321	LM17										I									
Lourie, purplecrested	337	LM17										I	A			A					
Coucal, Burchell's	356	LM17										A	A		A						
Kingfisher, malachite	397	LM17	I		A		A														
Bulbul, blackeyed	545	LM17										I									
Bulbul, sombre	551	LM17							A			A	A								
Robin, Cape	581	LM17							A		A	A									A
Flycatcher, paradise	682	LM17							A			A	A		A	A					
Boubou, southern	709	LM17							A		A	A	A		A						
Puffback	712	LM17							A			A									
Sunbird, whitebellied	763	LM17										I									

APPENDIX 10

			LOWER MUTSHINDUDI, LEVUVHU RIVER TO SIBASA/MUTALE ROAD																		
			BY SITE																		
Species	**No.**	**Site**	**AQ**	**RP**	**LC**	**WX**	**WP**	**RC**	**FR**	**MN**	**EG**	**WO**	**IN**	**BR**	**TH**	**RV**	**GR**	**NT**	**SW**	**SU**	**SC**
			1	3	2	3	3	1	1	2	2	1	2	3	3	3	1	2	3	3	1
Bulbul, blackeyed	545	LM1										I									
Cisticolla, rattling	642	LM1										I	I								
Wagtail, Cape	686	LM1	A		A	A															
Boubou, southern	709	LM1							A		A	A	A		A						
Sparrow, house	784	LM1			G	E	N	E	R	A	L	I	S	T	S						
Widow, yellowrumped	810	LM1															A	A			A
Finch, melba	830	LM1										A	A								
Firefinch, Jameson's	835	LM1										A	A		A						
Waxbill, blue	839	LM1										A	A								
Waxbill, common	843	LM1	A		A																
Dove, redeyed	314	LM2										A									
Cuckoo, Diederik	352	LM2										A					A				
Coucal, Burchell's	356	LM2										A	A		A						
Kingfisher, brownhooded	402	LM2										I									
Boubou, southern	709	LM2							A		A	A	A		A						
Shrike, orangebreasted bu	719	LM2							A		A	A	A		A						
Firefinch, Redbilled	837	LM2										A	A								
Canary, yelloweyed	859	LM2										I									
Dove, greenspotted	321	LM3										I									
Coucal, Burchell's	356	LM3							I												
Mousebird, speckled	390	LM3										I									
Bulbul, blackeyed	545	LM3										I									
Wagtail, African pied	685	LM3	I		A	A															
Puffback	712	LM3										I	I								
Weaver, spottedbacked	797	LM3										A	A			A					
Dove, tambourine	319	LM4							A			A	A		A	A					
Dove, greenspotted	321	LM4										I									
Kingfisher, brownhooded	402	LM4										A	A								
Bulbul, blackeyed	545	LM4										I									
Bulbul, sombre	551	LM4							A			A	A			A					
Cisticolla, redfaced	644	LM4	A		A							A	A			A					
Boubou, southern	709	LM4							A		A	A	A		A						

APPENDIX 11

Species in Phiphidi Falls and Forest Areas of Lower River									
				Sites					
	LM10	LM2	LM3	LM5	LM8	LM11	LM12	LM17	PF
	18	8	7	9	9	8	13	11	12
					55				
						72			
							130		
	310								
									312
		314							
						319			
			321				321	321	
				337				337	337
		352							
	356	356	356					356	
	390		390		390				
					393				
				394					
									395
	397							397	
	402	402					402		
	404								
					431				
	545		545		545	545	545	545	545
				550					
						551		551	551
									552
									579
	580								
								581	581
	582								
						673			
	682			682				682	
			685				685		
									686
									688
	709	709		709		709	709	709	
	712		712				712	712	
							714		
					715				
	719	719							
				721					
							731		
				737	737		737		
					763		763	763	
	774								774
				775	775				775
			797						
	810								
						830			
	835								
	837	837		837		837	837		
							839		
	847								
		859							
Overlap		5	4	3	2	3	5	6	2
Similarity		0.38	0.32	0.22	0.15	0.23	0.32	0.41	0.13

APPENDIX 12

AREA		Species Associated with Forest Habitats																					
		Lower river - forest				Lower river - woods				Thathe Vondo Dam				High Catchment				Middle river - grass				Indig-enous	
		Forest		Wood		Forest		Wood		Forest		Wood		Forest		Wood		Forest		Wood			
		A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I
N = 26																							
Goshawk, african	160													X		X							
Guineafowl, crested	193													X		X						X	
Pigeon, rameron	312	X												X									
Dove, tambourine	319	X		X		X		X						X		X						X	
Pigeon, green	323					X			X														
Cuckoo, redchested	343									X		X		X		X							
Trogon, narina	393	X		X																		X	
Woodhoopoe, redbilled	419									X		X		X		X							
Barbet, blackcollared	431	X		X								X				X						X	
Swallow, black sawwing	511									X				X									
Cuckooshrike, black	513													X		X							
Drongo, forktailed	517													X		X							
Oriole, blckheaded	521													X		X							
Bulbul, yellowbellied	550	X		X						X		X		X		X						X	
Bulbul, sombre	551	X		X		X		X		X		X		X		X						X	
Thrush, olive	553													X		X							
Robin, Cape	581	X		X						X		X		X		X							
Apalis, bar-throated	622									X		X										X	
Flycatcher, bluemantled	680													X		X						X	
Flycatcher, paradise	682	X		X						X		X		X		X						X	
Boubou, Southern	709	X		X		X		X		X		X		X		X		X		X		X	
Puffback	712	X		X		X		X		X		X		X		X		X		X			
Shrike, orangebr. bush	719	X		X										X		X						X	
Sunbird, black	772									X		X		X		X							
White-eye, Cape	775	X		X		X		X		X		X		X		X							
Bishop, golden	812									X													
		12		11		6		5		13		12		21		20		2		2		11	