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THE CONSERVATION STATUS OF THE SABIE AND GROOT-LETABA RIVERS WITHIN THE KRUGER NATIONAL PARK

by

J H O'KEEFFE

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J.H. O'KEEFFE

INTRODUCTION

A short visit was made to the Kruger National Park in January 1985. The purpose of the visit was to inspect and compare the conservation status of some of the major rivers flowing through the park (see Fig 1.). Since only five days were available for sampling, it was decided to concentrate on the Sabie and Groot-Letaba Rivers, these having been identified by Chutter and de Moor (1983) as respectively the most pristine and one of the most degraded of the large rivers flowing through the park.

The rivers are unusual in that their lower catchments (in the park) are protected and remain relatively pristine, but the upper stretches flow through highly populated, highly industrialised catchments rich in commercially exploited minerals. The downstream stretches are obviously vulnerable to the effects of water abstraction, agricultural, domestic and industrial effluents and mine dump runoff. Should these rivers become irrevocably degraded, the natural state of the Kruger Park will be endangered, since these rivers provide the park's water supply.

Unfortunately, there has been very little research or routine monitoring of the parks' rivers until now, so that a comparative database from which to judge changes in the flow regimes, water chemistry, flora and fauna of the

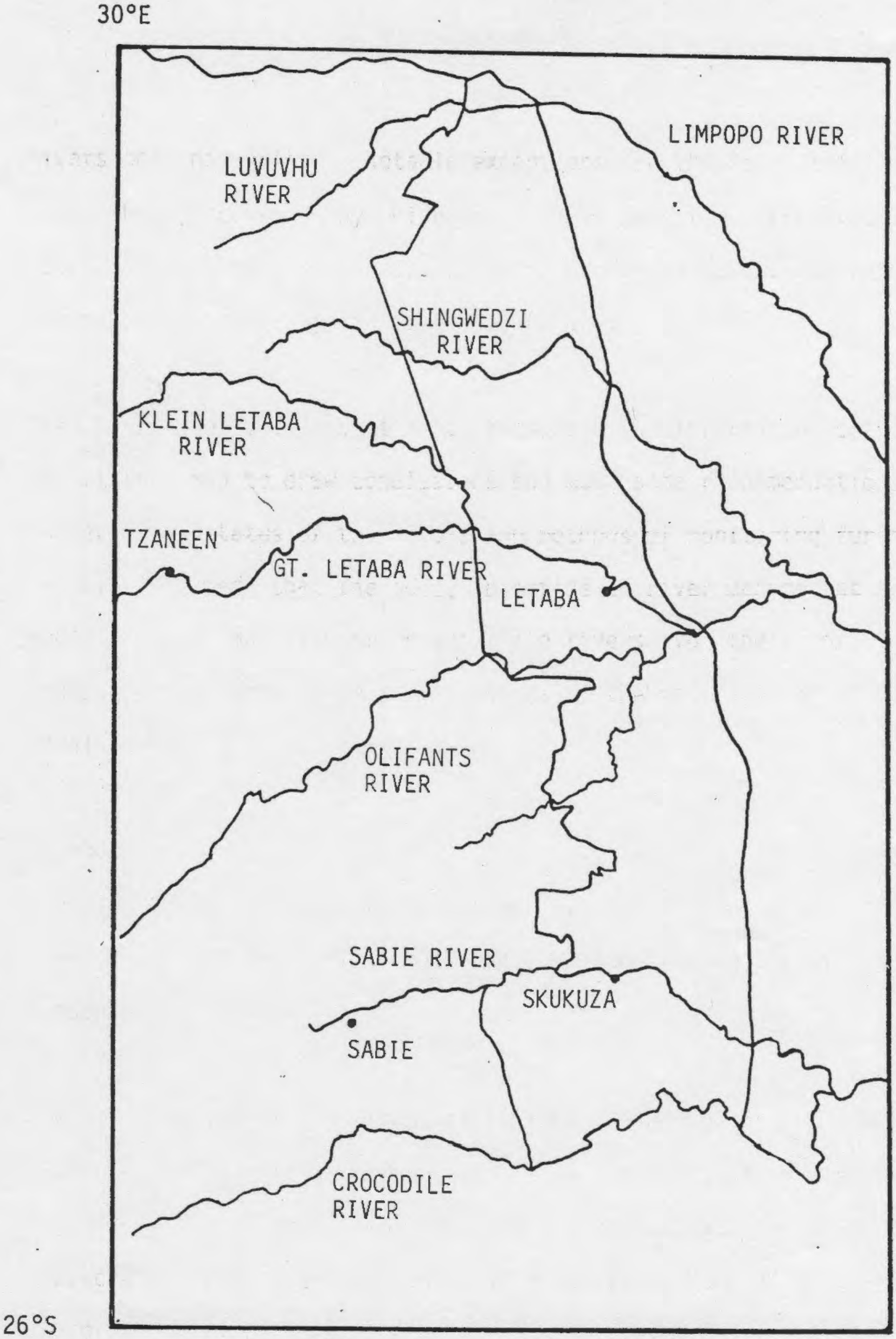

Fig. 1. The main river systems flowing through the Kruger National Park (The park boundaries are shown).

rivers does not exist. Notable exceptions are the fish distributions which have been surveyed by Pienaar (1978) and the freshwater molluscs (particularly those responsible for bilharzia transmission) which have been surveyed by Oberholzer and van Eeden (1967).

The purpose of this report is to summarise the information collected during my visit, and to draw conclusions and make some recommendations about the conservation status of the rivers and methods of monitoring further change. I have assumed that the ideal objective of river management in the park would be to maintain or rehabilitate rivers to their pristine natural condition. Conservation status refers to the magnitude of change from this ideal state.

METHODS

The survey was designed to obtain maximum information on all aspects of the rivers in the short time available. Procedures were kept as simple as possible.

One of the aims of the visit was to test the usefulness of a questionnaire approach to information gathering. At each of 9 points on the Letaba and 11 on the Sabie River (see Fig. 2) a questionnaire was filled out to characterise local conditions (see Appendix). Much of the questionnaire could be filled in with reference to detailed maps (altitude, direction, gradient, etc.). Other sections were completed by questioning Kruger Park and Transvaal Provincial Administration personnel. The section of the questionnaire dealing with upstream catchment disturbances and separate surveys was applicable to the whole catchment being sampled, and could be separated onto a different sheet, which would only need to be filled in once for each river sampled.

During the course of sampling, two further sections were added to the questionnaire, dealing with turbidity and emergent plant species.

At each site a sample of invertebrates was taken from stones-in-current. The species composition and density of the invertebrate community in a river provides indications of the water quality during the previous few months. Invertebrates were collected by scrubbing 5 - 10 stones while holding them in the mouth of a handnet with a mesh size of approximately 300 µm. At several sites no stony runs were available, so samples were either taken by scraping the surface of massive rock, or from emergent vegetation. At two sites, no invertebrate sample was taken.

River orders (sensu Strahler, 1964) were calculated from 1:500,000 scale maps.

RESULTS

The Sabie River

1. General characteristics of the river from its source to the South Africa/Mocambique border: (Information mostly from Pitman et al, 1981)
The river rises at approximately 2130 m. in the Mauchsberg, some 20 km. South West of the town of Sabie, and flows for 175 km. before reaching the Mocambique border at 120 m. Approximately 100 km. of the river is either along the Kruger Park boundary or inside the park. The Sabie is a fourth order river before its junction with the Saringwa tributary on the park boundary. Thereafter it is a fifth order river. Catchment area is 4420

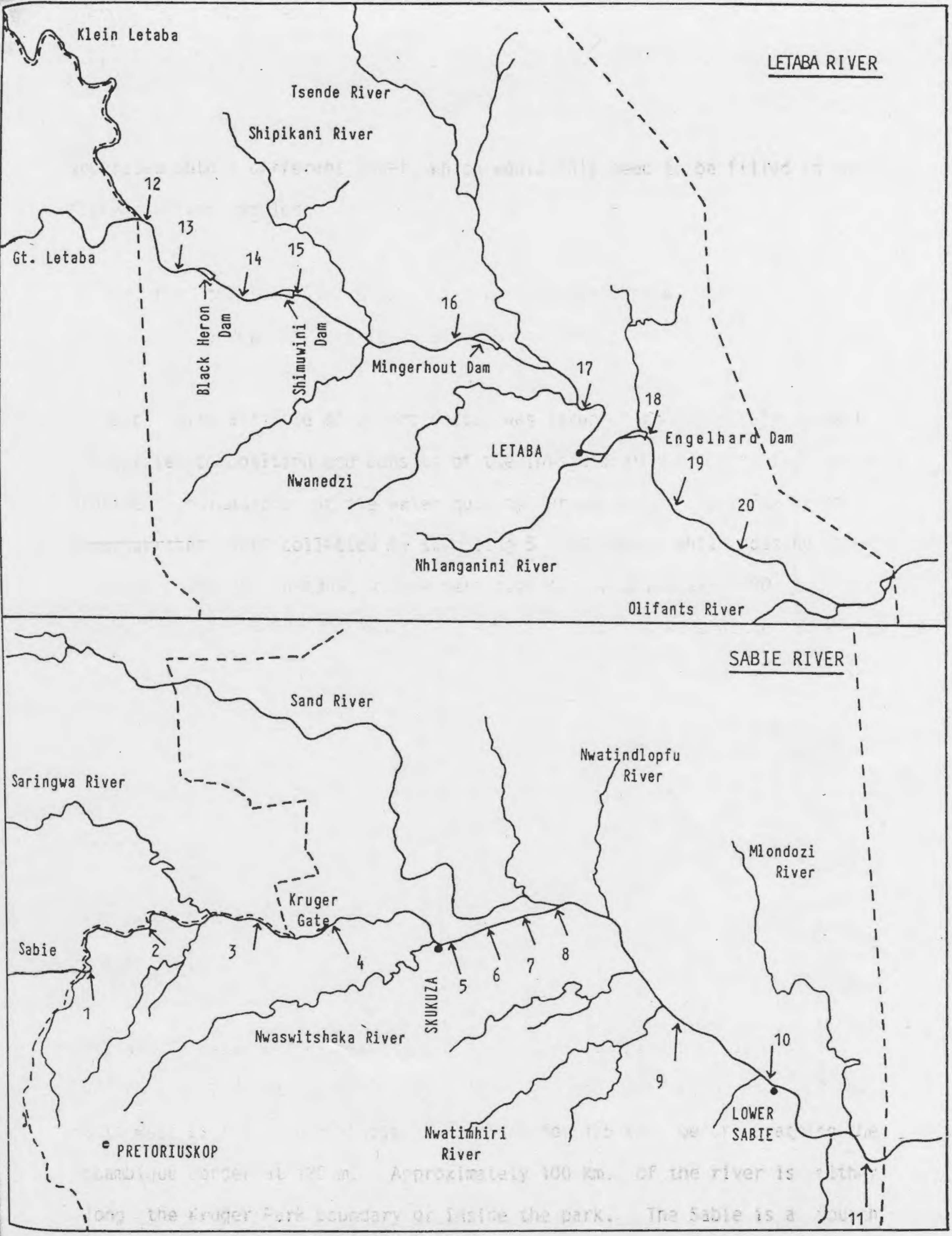

Fig. 2. The Letaba and Sabie River systems, showing sample sites referred to in the text. Dotted lines represent the Park boundaries.

boundary. Thereafter it is a fifth order river. Catchment area is 4420 $km.^2$ and rainfall varies from 1350 mm. $year^{-1}$ at the source to 600 mm. at the junction with the Incomati. Mean annual runoff is 666 $m^3 \times 10^6$.

2. Geology and soils:

The catchment outside the national park is underlain by massive metamorphic rock with some dolomite. Soils are lithosols in the upper catchment changing to ferrallitic clays and arenosols. Sediment yield varies from 400 - 600 tonnes/km^2/year.

In the park the predominant geology is granite/gneiss with dolerite dykes, overlain by sandy shallow soils on crests and sodic duplex soils in hollows and on footslopes. At the western boundary the river flows through gabbro, overlain by moderately deep black and red clays with rocky outcrops. In the Eastern park the catchment is successively Karoo sediments, Sabie river basalt (with moderately deep red clays), followed by Lebombo mountain rhyolite (with lithosols). Sediment yields in the park are mostly around 400 tonnes/km^2/year.

3. Catchment vegetation:

a) Natural vegetation types: Using Acocks (1975) veld types, the Sabie River rises in North Eastern mountain sourveld, grading into lowveld sour bushveld. Some 20 km. West of the park boundary the vegetation type changes to lowveld tropical bush and savannah.

Gertenbach (1983) provides a more detailed description of vegetation within the park: The western boundary gabbro is characterised by thornveld on gabbro (type 19) vegetation (dominated by Sclerocarya caffra and Acacia nigrescens). The mid-park granite/gneiss correlates with thickets of the Sabie and Crocodile Rivers (type 4) (Acacia nigrescens/Combretum apiculatum). The Eastern part of the catchment is vegetated successively by Acacia welwitschi thickets on Karroo sediments (type 13), S. caffra/A. nigrescens savanna (type 17) on basalt, and Lebombo South (type 29) (Combretum apiculatum/Boscia albitrunca/Acacia exuvialis etc.) on rhyolite.

b) Exotic plants noticed during this survey: Extensive growths of Lantana camara were seen at all sample points except the easternmost one. In addition, the following introduced plant species were noted at one or more sites: Tagetes minuta (Khakibos), Bidens pilosa and/or bipinnata(Blackjack), Xanthium strumarium (Kankeroos), Alternantha sessilis, Bauhinea sp., Melia azedarach, Psidium guajava (Guava) and Mangifera indica (Mango). At sites S_8 and S_{10} mats of Pistia stratiotes were seen. This floating macrophyte is at the southern limit of its range (A. Jacot Guillarmod, pers. comm.) and cannot be considered truly introduced, but may be extending its range.

N.B. This list cannot be considered comprehensive, since only eleven sites were visited and even at these sites, no complete vegetation survey was carried out.

4. Land Use (outside the national park):

The upper catchment is extensively used for pine and eucalyptus forestry, (altogether 1027 $km.^2$ of the catchment is forested). The upper catchment has also been the scene of extensive gold mining. (Leaching of cyanide from

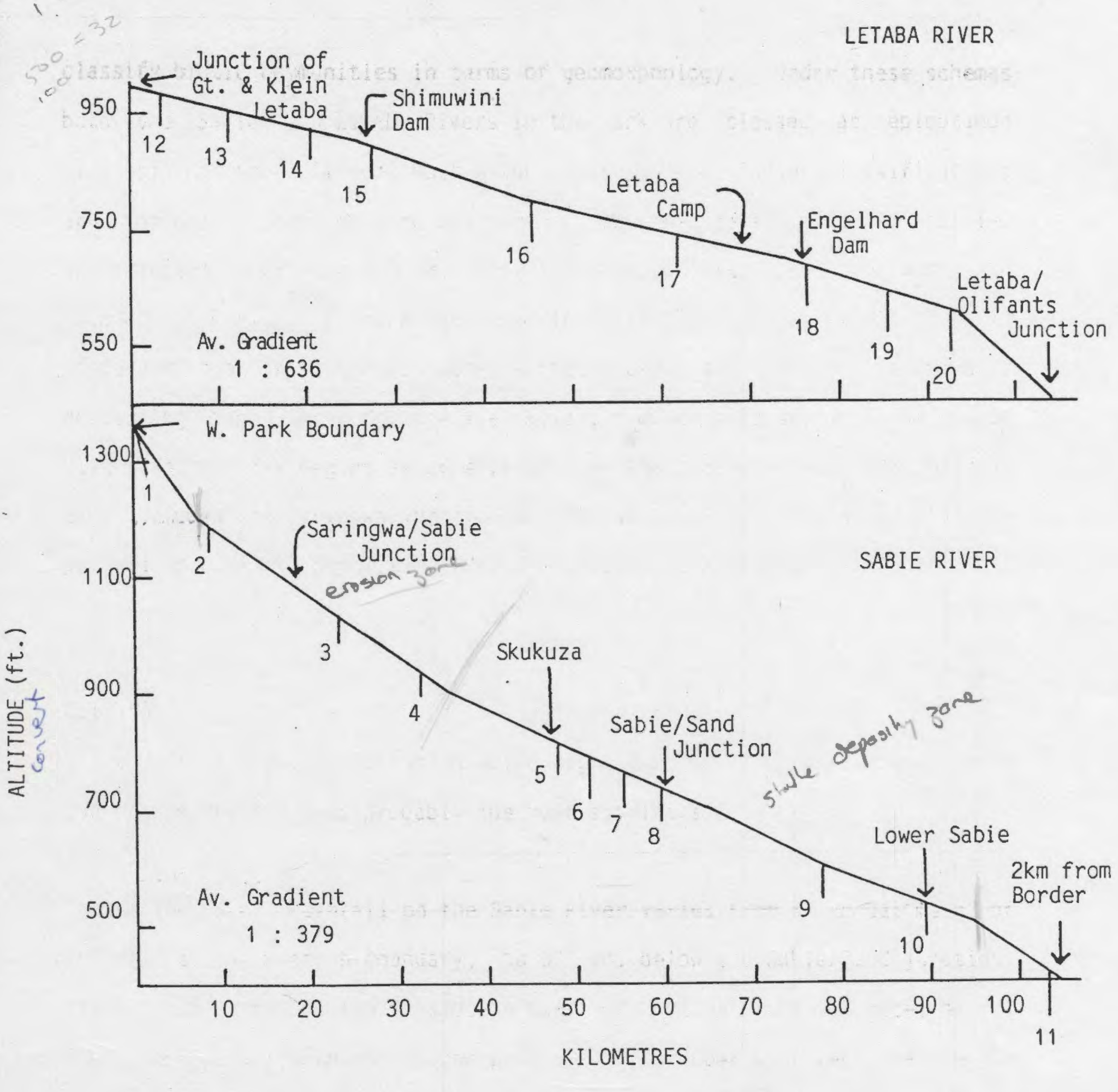

Fig. 3. Gradients of the Letaba and Sabie Rivers within the Kruger National Park. (The positions of sampling sites are marked).

TABLE 1. SAMPLES OF INVERTEBRATES FROM THE SABIE RIVER. COLUMN HEADINGS ARE SAMPLE SITE NUMBERS. SAMPLES WERE FROM STONES-IN-CURRENT UNLESS OTHERWISE INDICATED.

	S2	S3	S4	* S5	S6	** S7	* S8	S9	S10	** S11
Ephemeroptera										
Baetidae				6	2					
Acentrella sp.		1								
Baetis sp. a		1	4							
Baetis sp. b								3		
Baetis sp. c						46				448
Baetis sp. d							18			
Centroptiloides sp.										84
Baetis(?)latus/quintus				55		31	146		7	56
Baetis(?)bellus				22			9			
Centroptilum flavum							18		16	
Centroptilum medium					1	15			15	
(?)Adenophlebia sp.								3		
Afronurus harrisoni	31	3	6	11	7		6	4	55	
Euthraulus elegans		1	8		3		3	3	8	
Trichorythus sp.			2		1	16		15	211	89
Caenidae		3	2				22	8		
Ephemeridae	1									
Trichoptera										
Cheumatopsyche sp.	7	1	4		4	1		3	49	117
(?)Goera hageni			1		1					
Ecnomidae								1	7	
Leptoceridae			1	5	1			1		
Philopotamidae								4	22	157
Odonata										
Anisoptera		1				2			3	69
Zygoptera				1			6			
Coleoptera										
Elmidae	9	1						1		
(?)Stenelmis sp.									1	
Gyrinidae							1	2		
Plecoptera										
Neoperla spio	1								2	
Lepidoptera						6			13	13
Hemiptera										
(?)Micronecta sp.			1	1			10			
	50	12	38	118	23	168	284	56	419	1171

site code

	S2	S3	S4	* S5	S6	** S7	* S8	S9	S10	** S11
Naucoridae				3			8			
Notonectidae				2						
Diptera										1
Atherix sp.	1									
Ceratopogonidae					1					
Chaoborinae				3			4			
Chironominae			5	1		40	9	4		110
Tanypodinae				1	2					
Simuliidae				1		11	1	3		16
Tabanidae									1	
Crustacea										
Caridina sp.				6			23			
Oligochaeta			3							
Branchiura sowerbi								1		
Mollusca										
Bulinus(?)globosus			1							
Pisidium sp.									9	
Bivalves										11
TOTAL	50	12	38	119	23	168	281	56	419	1171
No. of taxa	6	8	12	15	9	9	15	15	15	12
Chutter's B.I.V.	0.0	-	1.4	-	-	0.2	-	1.0	0.0	0.1

* Marginal vegetation.

** Scrapings from rock in current.

TABLE 3. THE RELATIVE DOMINANCE OF THE MAJOR GROUPS OF BENTHIC FAUNA IN THE SABIE AND LETABA RIVERS

	% of all samples grouped	
	Sabie River	Letaba River
Baetidae	43	6
Other Ephemeropterans	22	13
Trichopterans	17	19
Chironominae	7	6
Simuliidae	1	53

old mine dumps is the probable cause of the absence of fish for 20 km. below Sabie town, C.J. Kleynhans, pers. comm.). 28 $km.^2$ of the catchment is irrigated, but there are no major reservoirs on the main river. The largest town in the catchment is Sabie, with a population of 5 - 10,000. Population densities are also high in Gazankulu, which borders the North bank of the river as it first enters the park. There is very little heavy industry, with the exception of a sawmill on the Little Sabie, which has caused sawdust pollution (C.J. Kleynhans, pers. comm.).

5. The fish fauna of the river:

Pienaar (1978) gives species distribution maps for 48 fish species known from the park. Of these, 32 have been recorded in the Sabie River. All are indigenous species and one, *Serranochromis meridianus* is endemic to the Sabie/Sand River system. There is only one record of an introduced species in the Sabie River within the park, that of a carp (*Cyprinus carpio*).

Outside the park *Varicorhinus nelspruitensis* (endemic to Transvaal) occurs in the river. Trout (mostly rainbow) have been introduced and are established in the upper catchment.

The Groot Letaba River

1. General characteristics from its source to its junction with the Olifants River: (Information mostly from Pitman et al, 1981)

The Letaba River rises at approximately 1830 m. in the Broederstroom-Woodbush forest reserve, 20 km. North West of Tzaneen. It flows for 280 km. to a junction with the Olifants River at 140 m. The final 90 km. of the river are within the Kruger Park. The Groot Letaba is a fifth order river until its junction with the Klein Letaba at the Western park boundary, when it becomes a sixth order river. Catchment area is 8,370 $km.^2$ and rainfall varies from 780 mm. $year^{-1}$ at source to 510 mm. $year^{-1}$ at the Olifants River junction. Mean annual runoff is 614 $m.^3 \times 10^6$.

2. Geology and soils:

Outside the park, the catchment is underlain by massive metamorphic rock. Lithosols are dominant with occasional clays and arenosols. Sediment yield varies from 400 - 600 tonnes/$km.^2$/year.

Inside the park the river flows successively through amphibolite and schists with dolerite dykes (giving rise to moderately deep sandy clay soils); granite/gneiss with dolerite dykes (under shallow to moderately deep sands and loams grading to shallow sands and lithosols); and Letaba basalt (shallow clay soils). Below Letaba camp the geology is granophyre (giving rise to lithosols).

3. Catchment vegetation:

a) Natural vegetation types: Acocks' (1975) vegetation types shows the Letaba rising in North Eastern mountain sourveld, changing to lowveld sour bushveld East of Tzaneen, then to arid lowveld and finally to Mopane veld some 20 km. East of the Kruger Park.

Gertenbach's (1983) more detailed descriptions within the park give the following types: Letaba River rugged veld (type 10) (*Colophospermum mopane*, *Combretum apiculatum*, *Terminalia prunioides*, etc) corresponding with the amphibolite/schist and granite/gneiss geology. After Mingerhout dam this changes to *Colophospermum mopane* (type 15) on Letaba basalt, then to

Combretum/C. mopane rugged veld (type 22) and Lebombo North (type 31) on granophyre below Letaba camp.

b) Exotic plants noted during this survey: Extensive growths of kankeroos (Xanthium strumarium) were seen at most sample sites. Castor oil bush (Ricinus communis) was also prevalent in the Western park.

4. Land use (outside the national park):

The Groot Letaba rises in a large forest reserve, and 674 km^2 of the catchment is forested. Agriculture is mainly sub-tropical arable, including citrus fruits, tea and coffee. The entire catchment to the Groot/Klein Letaba junction is government water control area. There are four reservoirs on the Klein Letaba system and twelve on the Groot Letaba system including the Ebenezer dam (67.19 $m^3 \times 10^6$) and the Fanie Botha dam (156.7 $m^3 \times 10^6$). However, the furthest downstream of these dams is 60 km. upstream of the park boundary. The largest town in the catchment is Tzaneen (population 15 - 20,000). The river passes through heavily populated parts of Gazankulu just before reaching the park, and major tributaries drain parts of Venda, Lebowa and Gazankulu.

5. The fish fauna of the river:

Pienaar (1978) shows 33 indigenous fish species recorded from the Letaba River in the Kruger Park, although none are endemic. Upstream of Tzaneen exotic species include rainbow and brown trout, large- and small-mouth bass, and Cheatia flaviventrus (species indigenous to South Africa but introduced in the Letaba). Downstream of the Fanie Botha dam there may be introduced carp, but no other exotic species. (C.J. Kleynhans, pers. comm.)

Geomorphology and its effects on the biota

Fig. 3. shows the gradients of the Sabie and Letaba Rivers within the park. It is obvious that the Sabie has a gradient 1.7 times as steep as the Letaba. Both rivers rejuvenate (increase in gradient) as they enter the Lebombo mountains. The position of the 'nick point' before the rivers flow through the more resistant rhyolite of the Lebombo mountains is surprising, since an increasing gradient through the softer basalts downstream of the rhyolite would be expected. This may be a consequence of the superposed drainage of the region, following the plio-pleistocene tectonic arching of the region. The rivers have since been cutting back from the raised coastline, and the nick points will continue to move westward as the rivers approach an equilibrium gradient.

The slope of a river tends to decrease exponentially downstream (Hynes, 1970), although this may be modified by geological changes. The steeper gradient of the Sabie in the park is therefore a consequence of the river being nearer to its source than the Letaba. The Sabie is 175 km. from its source when it enters the park, compared to the Letaba, which flows for 280 km. before entering the park. The Sabie is a fourth order river at this point, becoming a fifth order river at the Saringwa junction. The Groot Letaba is a sixth order river from its junction with the Klein Letaba.

Zonation:

The above differences influence flow rates, sediment loads, and substrata which should in turn be reflected in the biota of the river. Illies (1961) and Harrison (1965), among others, have proposed zonation schemes to classify biotic communities in terms of geomorphology. Under these schemes both the Sabie and Letaba Rivers in the park are classed as epipotamon (Illies) and foothill soft bottom zone (Harrison). These classifications are too coarse to be of much use here (e.g. the Sabie River is classified as epipotamon from 2 - 3 km. from its source to its junction with the Incomati River). A more useful classification is Chutter's (1967) differentiation of an erosion zone, a stable depositing zone and an unstable depositing zone, used for the Vaal River. Under this system, the Sabie River in the park begins as an erosion zone and becomes a stable depositing zone between the Saringwa junction and Skukuza. The Letaba River in the park is an unstable depositing zone, in which shifting sand banks alternate with small stony runs.

Climate:

Of the other physical variables which might lead to differences between the two rivers, rainfall is probably the most significant.

Inside the park, rainfall on the Sabie River varies from an annual mean of 757 mm. at the Western boundary, to 575 mm. below the Sabie/Sand junction, rising to 620 mm. at the Mocambique border. The Letaba River receives 500 mm. along its length inside the park. In its upper catchment the Letaba also receives less rainfall than the Sabie, so that the virgin mean annual runoff is 92% of the Sabie's, from a catchment area 1.9 times as large.

The Benthic Invertebrate Fauna

I have made a preliminary analysis of the invertebrate samples from the

Sabie and Letaba Rivers. The identifications given here are tentative and must await confirmation or correction by expert taxonomists. The collections are being passed on to the Albany Museum, Grahamstown for this purpose. Since this area has not previously been investigated in detail, it is likely that rare and even new species will be identified. With these caveats, it has been possible to identify the samples to a level at which useful information emerges.

Tables 1 and 2 show the density and distribution of the different taxa in the two rivers, from the westernmost sites on the left of the table to the easternmost on the right. Both the numbers and species composition of the samples are very variable, (as might be expected from small sample numbers in a heterogeneous environment). However, some patterns are clearly evident:

a) In both rivers, the density of invertebrates at the Western park boundary was low, and increased with distance into the park.
b) The fauna in the Sabie River was more populous, and more diverse than in the Letaba River.
c) The fauna in the Letaba River was dominated by Simuliidae (Blackflies), while in the Sabie River the Ephemeroptera (Mayflies) (particularly Baetidae) were most numerous (see Table 3).
d) Chutter's (1972) biotic index has been calculated for stones-in-current samples (where sufficient individuals were collected) (see Tables 1 and 2). The index provides an integrated empirical measure of the organic enrichment levels of the water over the life-span of the fauna. Scores of 0-2 indicate clean unpolluted waters, while 7-10 indicate a high level of organic pollution. Scores for the Sabie

River indicate clean water throughout, while the higher scores for the Letaba River sites (3.4 and 2.5) indicate mild enrichment.

In addition to the above samples, searches were made at a number of sites for molluscs and mollusc shells in the calmer backwaters of the rivers and in the sediments. The species found are listed in Table 4.

CONCLUSIONS

It should be stated initially that both of the rivers considered here are generally in an excellent state of conservation within the Kruger Park. The levels of degradation of the rivers from their natural state are not such as to threaten the operation of the park as a conserved unit. The major dangers are posed from outside the park, where one-off releases of poisons and other effluents could threaten the aquatic flora and fauna, and more gradual changes in the hydrological regime can be caused by impoundment, water extraction, and catchment degradation. Within this general perspective, it is possible to identify some attributes of the rivers which may provide an increased understanding of their functioning.

The Sabie and Letaba Rivers within the park are different in form, and in biota. Some of these differences are a result of the natural state of the rivers, but some have occurred as a result of artificial perturbations. In general, the Sabie is a faster flowing river, with predominantly rocky substrata, clearer water and considerably more bankside vegetation. The gradient and zonation of the rivers and the difference in rainfall and runoff are responsible for the faster flow, the greater clarity of the water

TABLE 4. MOLLUSC SPECIES FOUND AS LIVE INDIVIDUALS OR AS EMPTY SHELLS.

Sabie River	Letaba River
(?) Aspatharia wahlbergi	(?) Aspatharia wahlbergi
Corbicula africana	Corbicula africana
Bulinus (?) globosus	Bulinus (?) globosus
Pisidium sp	Bulinus forskalii
	Melanoides tuberculata
	(?) Unio framesi

and the more luxuriant vegetation. The greater diversity and density of fauna in the river can also partly be explained by the availability of stable rocky substrata in the Sabie River, compared to the shifting sand/gravel which characterises the Letaba. How far the channel of the Letaba River has been altered by the upstream impoundment, water extraction and catchment degradation outside the park is not clear, since records are sparse. The Letaba has recently stopped flowing during dry periods, but there appears to be some disagreement as to the cause of this phenomenon, which may be caused by cyclical climatic events (F. Venter, pers. comm.).

The construction of four dams/weirs across the Letaba has probably made some fundamental changes to the river. Ward (1982) and Ward & Stanford (1983) have summarised a number of the changes caused by impoundments. Chief among these are a reduction in suspended sediments, detritus, and associated nutrients; an increase in phytoplankton, and variable changes in the hydrological and temperature regimes downstream. I would tentatively suggest that the predominance of simuliid larvae is a consequence of increased phytoplankton levels in the river. Simuliid larvae feed by filtering particles (chiefly algal cells) from the current, and Colbo and Wotton (1981) quote instances of high densities at lake outlets where food density is high. A second consequence of the dams has been to increase the local abundance of hippos. This in turn will have increased the transport of nutrients from the immediate catchment into the river, and may well be responsible for the indications of enrichment found at some of the Letaba sample sites. (Chutter and de Moor (1983) reported very high C.O.D. values from a hippo pool near the Letaba River, and measured phosphate and dissolved organic nitrate levels an order of magnitude higher than for any river in the park.) Other specific effects of the impoundments remain to be investigated, but the overall effect will have been to reduce the 'naturalness' of the system. It would be interesting to know if the change in river conditions have affected the distribution or species composition of the fish. Obviously, dams and weirs present a barrier to dispersal, but this has been overcome at least at Engelhard dam, by the provision of a fish ladder. Large numbers of fish could be observed moving up and/or down the ladder during my visit.

The generally low density and diversity of benthic fauna in both rivers at the Western end of the park could be an indication that upstream river use is affecting conditions in the park. However, it is encouraging to note that the diversity recovers rapidly. and appears to reach an equilibrium by the third (Sabie River) and fourth (Letaba River) sampling sites (see number of taxa in Tables 1 & 2). This indicates the ability of the rivers to recover from upstream perturbations. An important aspect of river ecology which has received very little attention in South Africa, the recovery distance of rivers in response to different perturbations, is a vital aspect of the maintenance of the Kruger Park rivers. Persistant degradation of the rivers outside the park is likely to increase the length of river required to recycle a given volume of effluent, or to reverse any other perturbation.

The presence of a diverse (if low density) community of molluscs in the rivers is an indication that neither is receiving serious metal pollution (to which snails are particularly susceptible).

In summary, the conservation status of the Sabie River within the park appears to be excellent and it carries a diverse and healthy fauna. The river downstream from the Western park boundary appears to have been little altered from its natural state. There does, however, appear to be some adverse effect from outside the park, and the riverine vegetation has been invaded by a number of exotic species. The Letaba River cannot be said to be in its natural state, mainly because of upstream hydrological effects, and the consequences of impoundments within the park. Possible changes have been: a reduction in the river flow, destabilization of river banks, an impoverished invertebrate fauna, slight eutrophication and other water chemistry changes. The riverine vegetation has also been invaded by exotic species.

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APPENDIX

River: Date:

Description of location:

Sample site no: Name: Ref:

Altitude: Order: Direction:

Gradient: Width: Depth:

Approx. flow: Temp/Constant flow :

Zone:

Substrate type(s):

Habitats:

Bank stability: Erosion:

Road crossing (type):

Geology:

Soil type:

Catchment vegetation type:

Major components:

% Natural cover:

Known exotics:

Fish species (*= endemic):

Known exotic fish species:

Macrophyte species:

Known exotic macrophytes:

Special aquatic vertebrates:

Other special vertebrates:

Special features:

Marshes/Pans/Pools:

Upstream catchment disturbances Distance from sampling point

Forestry:

Agriculture:

Mining:

Industrial:

Urban:

Upstream water manipulation | Distance from sampling point

Weirs:

Dams:

Water transfers:

Effluents:

Abstractions:

Canalisation:

Catchment population density:

Planned developments:

Separate surveys | Frequency | Length of time available

Water chemical analysis:

Flow measurements:

Temperature measurements:

Action taken

Invertebrates collected?: Sample no: Biotope:

Macrophytes collected?:

Photo taken?:

TABLE 2. SAMPLES OF INVERTEBRATES FROM THE LETABA RIVER. COLUMN HEADINGS ARE SAMPLE SITE NUMBERS. SAMPLES WERE ALL TAKEN FROM STONES-IN-CURRENT.

	L12	L13	L14	L16	L17	L18	L19	L20
Ephemeroptera								
Baetidae		3	2					1
Acentrella sp.	1		2		1			
Baetis (?) glaucus				8	2		1	2
Centroptilum flavum							2	2
Centroptilum medium					4		3	5
Afronurus harrisoni		1						
Euthraulus elegans			1	8	2	(1)	1	
(?)Polymitarcys sp.						(1)		
Trichorythus sp.			1	52			1	2
Caenidae							1	
Oligoneuridae			8			(2)	1	
Trichoptera								
Hydropsychidae			19	24	8	(1)	1	2
Cheumatopsyche sp.	1			42	7	(1)	1	1
Macronema sp.					1	(15)		
Philopotamidae		1						
Odonata								
Anisoptera		1			1			
Coleoptera					1			
Stenelmis sp.				1				
Megaloptera				1	1		1	
Diptera								
Ceratopogonidae				1				
Chironominae	2	12	1	20		(2)		1
Simuliidae		1	15	232	21		64	6
Tabanidae		1	1					
Hirudinea								2
Crustacea								
Ostracoda				1			1	
Copepoda						2		
Mollusca								
Corbicula africana						(1)	1	
TOTAL	4	19	49	391	50	(24+)	79	26
No. of taxa	3	6	8	12	12	(7)	13	11
Chutter's B.I.V.	-	-	1.7	3.4	1.4	-	2.5	-

* Sample L18 was inadequately preserved and some invertebrates were lost due to decomposition.